healthcare

MDPI

Article

Intraoperative Tension Pneumothorax in a Trauma Patient: An Adult Simulation Case for Anesthesia Residents

David Ryusuke Okano [1,*], Andy W. Chen [2], Sally A. Mitchell [1], Johnny F. Cartwright [1], Christopher Moore [1] and Tanna J. Boyer [1]

[1] Department of Anesthesia, Indiana University School of Medicine, Indianapolis, IN 46202, USA
[2] Indiana University School of Medicine, Indianapolis, IN 46202, USA
* Correspondence: dokano@iu.edu

Abstract: Anesthesiologists may encounter multiple obstacles in communication when attempting to collect information for emergency surgeries. Occult tension pneumothorax that was asymptomatic in the emergency department (ED) could become apparent upon positive pressure ventilation and pose a critical threat to the patient intraoperatively. Here, we describe a simulation exercise that was developed as a curriculum module for the Indiana University (IU) Anesthesiology residency program. It is primarily designed for first-year clinical anesthesia residents (CA-1/PGY-2). It is a 50 min encounter with two scenarios. The first scenario focuses on information collection and communication with a non-cooperative patient with multiple distractors. The second scenario focuses on the early diagnosis of tension pneumothorax and subsequent treatment. The residents were given formative feedback and met the educational objectives. Commonly missed critical actions included misdiagnosing the tension pneumothorax as mainstem intubation, bronchospasm, pulmonary thromboembolism, and anaphylaxis. Residents rated the feedback and debriefing as "extremely useful" or "very useful." Time constraints limit the number of residents who can sit in the "hot seat." The structure of the mannequin limits the ability to diagnose pneumothorax by auscultation and ultrasound. In the future, the scenarios may also be utilized to educate student anesthesiologist assistants and other non-physician anesthesia learners.

Keywords: simulation; anesthesiology; pneumothorax; crisis resource management; communication

Citation: Okano, D.R.; Chen, A.W.; Mitchell, S.A.; Cartwright, J.F.; Moore, C.; Boyer, T.J. Intraoperative Tension Pneumothorax in a Trauma Patient: An Adult Simulation Case for Anesthesia Residents. *Healthcare* **2022**, *10*, 1787. https://doi.org/10.3390/healthcare10091787

Academic Editor: Raffaele Giordano

Received: 20 August 2022
Accepted: 14 September 2022
Published: 16 September 2022

1. Introduction

Trauma patients who require emergency surgery are often not optimized for anesthesia. There will be many challenges for the anesthesiologist in the emergency department (ED), such as surgeons wanting to rush the patient to the operating room (OR). Additionally, the patient may be agitated, intoxicated, or unconscious. A detailed medical history is not always available. Information from the emergency medical technician (EMT) could be lost or misunderstood during multiple hand-offs. Focused exams and lab work are often incomplete or unable to be obtained. Minor issues could be missed due to issues that require immediate attention. Anesthesiologists must collect as much information as possible to evaluate and plan for the safest anesthesia plan in a short timeframe. Despite the best effort, unanticipated complications may present in the OR.

Tension pneumothorax is a life-threatening complication that has been suggested to occur in 5.4% of major trauma patients in the prehospital environment [1]. It is a type of pneumothorax with pleural damage acting as a check-valve, resulting in air trapping in the ipsilateral thoracic cavity that displaces the mediastinum and compresses the contralateral lung. This causes an acute onset of hypoxia and a critical compromise of the cardiovascular system. Patients with chest trauma with adequate ventilation and oxygenation may later develop tension pneumothorax intraoperatively under positive pressure ventilation [2]. Tension pneumothorax is known to have a high mortality rate; one retrospective cohort

study in an ICU setting found mortality to be 38 times higher for tension pneumothorax patients on mechanical ventilation compared to those who were not [3]. Another more recent retrospective cohort study also in an ICU setting found the development of tension pneumothorax among mechanically ventilated patients to be associated with an increase in mortality by a hazard ratio of 7.4 [4]. Needle decompression provides immediate relief of the trapped air and achieves the restoration of oxygenation and circulation.

This simulation was developed to train anesthesiology residents on how to quickly collect relevant information in a distracting environment and establish the safest anesthetic plan for emergency surgery. Residents also learned how to recognize the clinical manifestation of tension pneumothorax, make the diagnosis, and properly treat this life-threatening complication in a timely manner while maintaining efficient communication with the perioperative team.

2. Materials and Methods

The case is fully presented for facilitators in the Simulation Case file (Appendix A). The Simulation Case file consists of Simulation Case Overview (Table A1), Initial Presentation (Table A2), Instructor Notes—Changes and Case Branch Points (Table A3), and Instructor Notes—Ideal Scenario Flow and Anticipated Management Mistakes (Table A4). A critical actions checklist (Appendix B) is included for learners to reference during the simulation. A debriefing handout (Appendix C) is included to facilitate the post-assessment session.

2.1. Educational Objectives

By the end of this activity, learners will be able to:

1. Collect pertinent medical history from a trauma patient that is not optimized for the proposed surgery, where the patient–physician interaction occurs in the ED with a distracting environment.
2. Communicate effectively with surgeons who are trying to rush the patient to the operating room (OR).
3. Communicate with family members if the patient is considered not eligible to consent.
4. Diagnose the intraoperative tension pneumothorax by identifying the signs and symptoms and discuss the differential diagnosis of tension pneumothorax.
5. Perform a needle decompression to treat the critical cardiopulmonary decompensation caused by tension pneumothorax.

2.2. Equipment and Environment

This two-part simulation required two rooms: an ED patient holding area for the first scene, and an OR for the second scene. For the first scene, the patient holding area can be any room similar to an ED room with a patient bed and a simulated monitor. For the second scene, the OR can be either real (in situ) or a simulated laboratory. We used an in-hospital decommissioned space with a mock OR and patient room for the ED. The mannequin, operating table, monitors, and equipment were available in the room, while the programming and monitoring of the scenario were accomplished via wireless audio, video feed, and remote control.

For the ED scene, the patient actor wore a hospital gown and lay on the ED bed with bandages around their head and right thigh. The patient had one prop peripheral IV in the upper extremity and wore a neck collar and simple oxygen mask. An EKG monitor, blood pressure cuff, and pulse oximeter were hooked up to the patient, and the data were displayed on the simulated monitor. A cordless phone was available to call the patient's family member (embedded participant) to obtain anesthesia consent. A prop food tray was prepared and set outside the ED room.

For the OR scene, the mannequin was positioned supine on the operating table with a neck collar and one peripheral IV in the upper extremity. To save time, the surgical drape was already in place over the mannequin with a fenestration at the right femoral region.

We used the Laerdal SimMan 3G simulation model connected to IngMar ASL 5000 Lung Solution.

In the OR, an anesthesia machine for simulation was available, as well as a fully equipped anesthesia cart with a video laryngoscope, stethoscope, and standard set of prop anesthesia drugs. A chest drain and chest tube were made available to the surgeon actor. A code cart was available in the hallway just outside of the OR.

2.3. Personnel

Role assignments for the simulation can be very flexible depending on the number of participants. At a minimum, three participants/roles are required: one simulation learner as the anesthesia provider, one embedded participant as the patient actor in the trauma bay, and one embedded participant as the surgeon actor. In our program, we typically had 3 to 4 anesthesiology residents participate as a group. One resident was in the "hot seat" as the anesthesiologist and the others chose an embedded participant role. The number of participants could be increased to add realism and value to the simulation as a multidisciplinary educational activity. Extra participants could be assigned as resident surgeons, scrub nurses, circulator nurses, or a meal service aid. Simulation operation specialists programmed and ran the high-fidelity mannequin and simulated patient monitors. The instructor was behind the scenes during the simulation scenario to give cues and instructions through the headset worn by the surgeon.

2.4. Implementation

First, the patient actor was prebriefed on their role (Appendix D) and then waited in the ED holding area. The surgeon actor was prebriefed (Appendix E), donned the headset, and waited outside the holding area. The learner anesthesiologist was prebriefed (Appendix F) and instructed to become familiar with the simulated OR, including setting up the anesthesia equipment and drugs for the proposed emergency surgery. Next, the learner was instructed to evaluate and consent the patient in the ED holding area.

The trauma patient reported riding a motorcycle under the influence of illicit drugs with their "buddy" when involved in a traffic accident, suffering a compound fracture of the right femur with moderate damage to the femoral vein. Temporary hemostasis was achieved by EMS during transfer to the ED. As the learner anesthesiologist entered the room, the patient was awake and alert, complaining of some pain in the head, neck, chest, and the open wound of the right thigh, but is not in apparent distress. The patient is restless and appears to be more concerned about their "buddy" who was riding on the back seat of the motorcycle. The patient is a very poor historian and cannot give detailed past medical history but admits to habitual use of illicit drugs. A preoperative chest X-ray (Appendix G) was available upon request.

Multiple distractions occurred while the anesthesiologist attempted to evaluate the patient and obtain consent. The surgeon entered the room and began talking to the patient, interrupting the anesthesiologist. A "Code Blue" was announced overhead, and the patient became agitated suspecting it might be about their "buddy." A food tray was delivered to the room by mistake and the hungry patient tried to reach for it. The circulator nurse called the anesthesiologist's cell phone to ask how many units of blood should be ordered. Some of these distractions may be omitted depending on the learner anesthesiologist's communication skill level, as well as time and/or personnel constraints.

If the learner anesthesiologist attempted to postpone the case because the patient was not able to consent, the surgeon would insist the surgery could not be postponed since the patient has a compound fracture with damage to the blood vessel. The surgeon would suggest the anesthesiologist call the family member to obtain phone consent.

After obtaining the phone consent, the anesthesiologist and the surgeon entered the OR. The patient actor donned the headset and switched their role to either resident surgeon or a circulator nurse, then entered the OR as well.

Once all participants were in the OR, the learner anesthesiologist was instructed to verbalize their train of thought so that the instructor could anticipate how the scenario may progress. Administration of medications was accomplished by verbalizing the action, but this could be accompanied by pushing the prop medications to the mannequin if it has the capability.

After the time-out protocol, general anesthesia was induced. The learner anesthesiologist should consider rapid sequence induction with in-line stabilization of the cervical spine given the patient's condition. Video laryngoscope could be utilized depending on the learner anesthesiologist's skill level.

Once the airway was secured and the drapes were up, the surgeon announced the start time and incision. As positive pressure ventilation continued, the patient's vital signs gradually deteriorated. Oxygen saturation dropped to the low 70′s, heart rate (HR) increased up to the 130 s, and systolic blood pressure (SBP) dropped to the 60′s. End-tidal carbon dioxide ($ETCO_2$) decreased to 28 mmHg, and peak airway pressure rose to 45 cmH_2O. The anesthesiologist should recognize the deterioration and immediately start communicating with the surgical team. They analyzed the abnormal vital signs and collected more information to eventually make the diagnosis of tension pneumothorax. The anesthesiologist should also notice that there are no lung sounds heard on the right side upon auscultation.

Once the diagnosis of tension pneumothorax was made, the learner anesthesiologist performed a needle decompression. The anesthesiologist could mimic this action, or they may insert an IV catheter into a specified chest port if the mannequin (e.g., Laerdal SimMan 3G) has this functionality. If the learner anesthesiologist is unsure where to place the needle on the mannequin, the instructor could offer guidance through the surgeon's headset using the surgeon actor as a proxy.

Once the needle decompression was accomplished, the vital signs improved. The surgeon offered to place a right chest tube and hook it up to the drain. An intraoperative chest X-ray (Appendix H) could be ordered to confirm the reinflation of the lung and the correct placement of the chest tube. The scenario ended when the anesthesiologist noticed the improvement of the patient's clinical condition and determined the post-operative disposition. The anesthesiologist decided if the patient was to be extubated or left intubated and transferred directly to the ICU. There was no absolute right or wrong answer so long as the learner anesthesiologist provided an appropriate rationale and justification.

2.5. Assessment

The facilitator reviewed the completion of the Critical Actions Checklist (Appendix B). Learners received formative feedback during the debriefing.

2.6. Debriefing

The debriefing was held immediately following the conclusion of the scenario. All the participants, including observers, moved to a nearby classroom. Alternatively, they could have remained in the simulated OR for the debriefing. The debriefing session began with an open-ended question to the learner who was in the "hot seat" about how they felt the scenario went. This is a strong tool to elicit spontaneous reflections from the learner as well as stimulate active discussions from the perspective of other participants. The following points are recommended to be discussed during the debriefing with the learners (Appendix C):

1. Evaluation of the patient in ED: This scenario involves multiple communication barriers during the assessment of the patient. The learner anesthesiologist should discuss how to stay focused in order to determine the best and the safest anesthesia plan in the middle of multiple distractors. Discuss if the anesthesiologist missed any information due to the distractions. Participants may share their real-life experiences in dealing with similar situations.

2. Communication with the surgical team: The learners should discuss the feasibility of obtaining anesthesia consent from a patient with questionable mental status. Where do you draw the line? What should you do if the family member or surrogate decision-maker is not available for consent? Additionally, discuss how to communicate with the surgeon in an assertive manner if you have any concerns about proceeding with the case.
3. Identification of tension pneumothorax: The learner anesthesiologist should discuss the differential diagnosis for the collective findings of desaturation, tachycardia, hypotension, and increased peak airway pressure. What are the differences between anaphylaxis, pulmonary thromboembolism, bronchospasm, and tension pneumothorax? Pros and cons of additional diagnostic measures such as chest auscultation, lung POCUS, and chest X-ray should be discussed.
4. Treatment of tension pneumothorax: The learners should discuss the pathophysiology and treatment of tension pneumothorax. Both the recommended needle size and the insertion site location for the needle decompression should be emphasized.
5. Postoperative airway management planning: The learners should discuss whether the tension pneumothorax patient who has already received definitive treatment with the chest tube could be extubated or would need to remain intubated after the surgery. It should be noted that many thoracic surgery patients can be safely extubated immediately after the procedure.

3. Results

The anesthesiology residency program at the Indiana University School of Medicine Department of Anesthesia has approximately 28 residents per class. We conduct simulation training for residents on a regular basis. Every Thursday, a group of 3 to 5 residents is assigned to a 3-h-long simulation training block. Each block consists of 3 to 4 anesthesia simulation scenarios that last 40 to 50 min each. The contents range from procedural workshops on perioperative anesthetic management to Objective Structured Clinical Exam (OSCE) training which puts more focus on interpersonal communication. This 50 min scenario was developed in 2013 and has been implemented yearly until the present year (2022) to train CA-1 anesthesia residents who are typically 8 to 9 weeks into their residency training. Two simulation faculty members have been involved in running this scenario, which has been carefully designed and updated annually to maintain an appropriate quality of education.

We have tried to keep our simulation experience as realistic as possible. Participants were asked to wear proper attire for each role. Supplies such as scrubs, masks, hats, gloves, patient gowns, and surgical gowns were available at the simulation center. Although the CA-1 residents are still in the very early stages of their training, they could relate very well to the distractors we have embedded in the scenario. They reported experiencing similar clinical situations as medical students and interns. Residents reported that they enjoyed playing the roles of the patient and the surgeon.

We usually do not grade our residents' performance during the simulation training. We try to provide carefully selected perioperative incident topics relevant to the practice of anesthesia. Simulation faculty members ensure the learners are allowed to make mistakes without feeling psychological and emotional stress. Residents can learn from the mistakes committed during the simulations and be prepared to react to similar real-life incidents in the future.

Most of our residents met the majority of the educational objectives by performing very well in communicating with the patient, surgeon, and the family member of the patient. Most of them performed the induction sequence smoothly by paying adequate caution to a potentially full stomach and a difficult airway from wearing a neck collar. Some residents initially did not reach the diagnosis of tension pneumothorax and reported thinking it was either mainstem intubation, bronchospasm, pulmonary thromboembolism,

or anaphylaxis. Instructors were able to redirect the learner anesthesiologist by giving suggestions through the surgeon actor.

Residents were asked to provide feedback after the completion of each simulation. A total of 25 residents completed the electronic post-simulation questionnaire, representing a response rate of 31%. Each item of the survey was rated on a 5-point Likert scale (e.g., 1 = strongly agree, 2 = somewhat agree, 3 = neither agree nor disagree, 4 = somewhat disagree, 5 = strongly disagree). The two lowest (e.g., 1 = strongly agree, 2 = somewhat agree) and two highest (e.g., 4 = somewhat disagree, 5 = strongly disagree) categories were combined for data reporting (Table 1). The mean and standard deviation values were calculated using the raw Likert scores described above.

Table 1. Distribution of Survey Responses, Item Mean Scores, and Standard Deviations (N = 25).

Item [1]	Percent % (Raw Count)				
	Agree [2]	Neutral [3]	Disagree [4]	M [5]	SD
1. Before this simulation session, I could confidently IDENTIFY intraoperative Tension Pneumothorax.	56% (14)	28% (7)	16% (4)	2.44	0.94
2. Before this simulation session, I could confidently perform NEEDLE DECOMPRESSION for intraoperative Tension Pneumothorax.	32% (8)	20% (5)	48% (12)	3.20	1.26
3. My confidence in how to IDENTIFY intraoperative Tension Pneumothorax has improved as a result of this simulation session.	92% (23)	8% (2)	0% (0)	1.44	0.64
4. My confidence in how to perform NEEDLE DECOMPRESSION for intraoperative Tension Pneumothorax has improved as a result of this simulation session.	88% (22)	12% (3)	0% (0)	1.44	0.70
5. The debriefing faculty created a psychologically safe learning environment throughout the debriefing session.	96% (24)	4% (1)	0% (0)	1.12	0.43
6. I had the opportunity to ask questions during the debriefing session.	100% (25)	0% (0)	0% (0)	1.08	0.27
7. I received useful feedback and the most important issues were summarized during the debriefing sessions.[6]	100% (25) [7]	0% (0) [8]	0% (0) [9]	1.20	0.40

Abbreviations: M, Mean; SD, Standard Deviation. [1] Rated on a 5-point Likert scale (1 = *strongly agree*, 2 = *somewhat agree*, 3 = *neither agree nor disagree*, 4 = *somewhat disagree*, 5 = *strongly disagree*). [2] Strongly agree, somewhat agree. [3] Neither agree nor disagree. [4] Somewhat disagree, strongly disagree. [5] Mean values were calculated using raw Likert point scores. [6] Rated on a 5-point Likert scale (1 = *extremely useful*, 2 = *very useful*, 3 = *moderately useful*, 4 = *slightly useful*, 5 = *not at all useful*). [7] Extremely useful, very useful. [8] Moderately useful. [9] Slightly useful, not at all useful.

Items 1 and 2 assessed the residents' baseline confidence in their ability to identify intraoperative tension pneumothorax and perform needle decompression, respectively, prior to engaging in the simulation activity. Some learners did not feel confident in their ability to perform these tasks, as items 1 and 2 had "disagree" response rates of 16% and 48%, respectively. However, regardless of the learners' baseline skills, most residents indicated that the simulation improved their confidence in performing these tasks, as indicated by the "agree" response rates of 92% and 88% for items 3 and 4, respectively. Items 5, 6, and 7 assessed the faculty debriefing session and were scored highly by the residents, with no negative scores recorded. All participants indicated that the feedback and debriefings were "extremely useful" or "very useful."

Qualitative data were collected from open-response items. Participants were asked to offer any constructive criticism or suggestions for improvement. Two of 25 residents responded with free-text: (a) "Thought it was great. Sim is very useful," and (b) "Good session with adequate debriefing. It was an engaging session and I found it beneficial."

4. Discussion

Simulation education is vital in training anesthesia residents to manage perioperative crises—arguably the most important part of their jobs as future anesthesiologists. However,

simulation in healthcare tends to focus only on the acquisition of cognitive and procedural skills. The main purpose of the development of this simulation was to help residents develop crisis management skills for potential perioperative incidents in a safe environment. A secondary purpose was to foster excellent communication skills with patients and the perioperative team as mature anesthesiologists.

We also emphasized communication skills because it augments realism and enhances learning. The surgeon-anesthesiologist relationship is frequently viewed as hierarchical, which lends to debriefing residents on advocacy and assertive strategies to invoke when a team member's (anesthesiologist) viewpoint does not align with that of decisionmaker [5]. TeamSTEPPS® recommends stating the concern, problem, and solution in a firm and respectful manner [5]. If the initial statements are ignored, the next recommendation use the Two-Challenge Rule—voice the concern a second time and ensure the person being challenged acknowledges hearing the concern [5]. If the issue remains yet unresolved, then making stronger assertive statements using CUS (I am concerned; I am uncomfortable; This is a safety issue; Stop the line!), utilizing the chain of command, or calling a supervisor/leader may necessary [5].

Due to time constraints, one of the limitations of this simulation is that only one or a pair of residents from a group of 3 to 5 can be placed in the anesthesiologist's "hot seat" at most, and the rest of the residents from that group must participate as non-anesthesiologist roles. Although feedback from the residents playing non-anesthesiologist roles indicated that they also learned much from the simulation, it remains to be seen if there is a difference in the effectiveness of training between the residents who are in the anesthesiologist "hot seat" and those who are not. Of note, the post-survey showed most residents agreed that their confidence level and knowledge increased, and all residents agreed that the debriefing was useful. To follow up longitudinally, we plan to survey the residents as to their experiences and the frequency of encountering pneumothorax cases in a variety of clinical settings, including perioperative, OR, ICU, and emergency room. This may serve as validity evidence to support continued simulation sessions, inform realism improvements, and promote self-reflection.

Imaging studies such as a chest X-ray, CT, or point-of-care ultrasound (POCUS) can confirm the diagnosis of pneumothorax. However, given the life-threatening nature of tension pneumothorax, it has been recommended that needle decompression be performed emergently rather than waiting on diagnostic imaging studies [6,7], basing the diagnosis primarily on clinical manifestations such as hemodynamic compromise, hypoxia, absent unilateral breath sounds on auscultation, and mediastinal shift [1,6]. The IngMar ASL 5000 Lung Solution connected to the Laerdal SimMan 3G simulation model can mimic spontaneous respiratory air movements, but it cannot simulate the ventilation dynamics of pneumothorax. Although SimMan 3G is capable of reproducing the unilateral lung ventilation sound required for this scenario, the sound from the speaker in one lung reverberates within the thoracic cavity of the mannequin and can be heard on the contralateral side. This was another limitation of this simulation, as it caused some residents to fail to diagnose pneumothorax by auscultation.

To address these issues, we plan to improve the scenario by adding an ultrasound machine to the available equipment list and providing digital medical images/videos of an E-FAST exam (Extended—Focused Assessment with Sonography for Trauma) since the residents cannot perform the exam on the mannequin. The FAST provides four basic views (the four "Ps": pericardial, perihepatic, perisplenic, and pelvic); the extended provides two views of the thorax to assess for pneumothorax and hemothorax [8–10]. As the use of POCUS increases in the perioperative environment, it is important to learn from other disciplines that pneumothoraces are common in trauma patients, and that an estimated 50% are missed on routine chest X-ray [11]. Thus, the importance of teaching anesthesiology residents to perform and interpret an E-FAST exam should be recognized by both simulationists and clinical educators.

Althoughother simulation exercises revolving around chest tube placement have been described [12,13], they weredesigned with the primary goal of developing this specific procedural competency within the learners—usually emergency medicine or surgery residents. Our simulation exercise was directed toward anesthesiology residents and placed greater emphasis on communication dexterity within the perioperative setting (with the distractors built into Scene 1) as well as the synthesis of data gathered by intraoperative monitoring methods to diagnose tension pneumothorax (with the OR in Scene 2).

Our anesthesia department also has an Anesthesiologist Assistant (AA) training program. We believe their training will be enhanced further when we are able to offer similar training to student AAs (SAAs) in the future. Since one of the themes of this simulation scenario is communication with patients and the perioperative team, it would make the simulation experience more realistic and effective if participants from different specialties, such as nursing and surgery, and standardized patient actors can join on a regular basis.

Author Contributions: Conceptualization, D.R.O.; methodology, D.R.O., J.F.C., C.M.; software, J.F.C., C.M.; validation, D.R.O., A.W.C., S.A.M., J.F.C., C.M. and T.J.B.; investigation, D.R.O.; resources, J.F.C. and C.M.; data curation, D.R.O., A.W.C.; formal analysis, A.W.C.; writing—original draft preparation, D.R.O.; writing—review and editing, D.R.O., A.W.C., S.A.M.; visualization, D.R.O., A.W.C.; supervision, T.J.B., S.A.M.; project administration, D.R.O., T.J.B. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board of Indiana University (Protocol Code 15587 and date of approval 24 June 2022) for studies involving humans. This research is exempt under the following category: Category 2 (ii).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The evaluation forms electronically filled in by the participating residents are stored on Indiana University Qualtrics website. The website is not open to the public. Please contact the corresponding author for access to survey data.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. Simulation Case

Table A1. Simulation Case Overview.

SIMULATION CASE TITLE: Intraoperative Tension Pneumothorax in a Trauma Patient: An Adult Simulation Case for Anesthesia Residents	
Brief narrative description of case	The patient is in the ED holding area after a motorcycle crash. He has a right femoral compound fracture. He is in minimal distress but appears nervous and restless. The anesthesiologist is asked to evaluate and consent the patient for an emergency surgery. This scenario was developed to train the anesthesia residents to learn how to collect the relevant information quickly without being distracted by distractions, and efficiently plan the best and the safest anesthesia for the planned emergency surgery. The residents will also learn how to recognize the clinical manifestation of tension pneumothorax, make the diagnosis, and properly treat this life-threatening complication in a timely manner.
Primary Learning Objectives	1. Evaluate and collect pertinent medical history from trauma patients who are not always optimized for the proposed surgery in the ED with a distracting environment. 2. Demonstrate effective communications with surgeons who are trying to rush the patient to the operating room (OR). 3. Communicate with family members if the patient is considered not eligible to consent. 4. Diagnose the intraoperative tension pneumothorax by identifying the signs and symptoms and discuss the differential diagnosis of tension pneumothorax. 5. Perform a needle decompression to treat the critical cardiopulmonary decompensation caused by tension pneumothorax.

Table A1. *Cont.*

SIMULATION CASE TITLE: Intraoperative Tension Pneumothorax in a Trauma Patient: An Adult Simulation Case for Anesthesia Residents	
Critical Actions	1. Respond in person to evaluate and consent the patient in the ED for the planned emergency surgery. 2. Conduct a focused history and physical examination of the patient. 3. Obtain a preoperative chest X-ray report. 4. Communicate with the surgeon and clarify the need for the emergency surgery. 5. Once the patient is deemed not able to consent, contact his family member to obtain the anesthesia consent over the phone. 6. Perform rapid sequence induction with in-line stabilization of the patient's cervical spine. 7. Turn on the ventilator and Sevoflurane. 8. Recognize the development of hypotension, hypoxia, tachycardia, and increased peak airway pressure. 9. Turn the inspiratory oxygen to 100%. 10. Check the anesthesia machine and circuit to rule out equipment errors. 11. Notify the surgeon of the situation and ask to hold the procedure. 12. Start administering medications to treat the hypotension. 13. Develop a differential diagnosis based on acquired information. 14. Auscultate the patient's respiratory sound to gather further information. 15. Make a clinical diagnosis of tension pneumothorax. 16. Perform a needle decompression. 17. Ask the surgeon to place a chest tube. 18. Order a chest X-ray to confirm the expansion of the lung. 19. Tell the surgeon to resume the procedure. 20. Make the decision whether the patient can or cannot be extubated immediately after the surgery and develop a disposition plan.
Learner Preparation or Prework	This is a 50 min small group simulation scenario designed for CA-1 anesthesia residents who are typically 8 to 9 weeks into their residency training. They are expected to be competent in endotracheal intubations of easy to moderately difficult airways, with additional knowledge of rapid sequence induction and in-line stabilization of the cervical spine on possible cervical spine injury patients. Two minutes prior to the patient encounter, the learners are given a stem with a brief description of the patient.

Table A2. Initial Presentation.

PATIENT NAME: Randy Danger **PATIENT AGE: 49** **CHIEF COMPLAINT: Right Femoral Compound Fracture after a Motorcycle Crash** **PHYSICAL SETTING: ED HOLDING AREA (SCENE 1), THEN OPERATING ROOM (SCENE 2)**	
Initial vital signs	BP 156/97 mmHg, HR 102, RR 20, SpO_2 97% on 8L O_2 face mask, T 36.8 °C, Sinus rhythm
Overall Setting and Appearance	**Scene 1: ED Holding** The learner will find the patient sitting up on the gurney in a room that is designed to appear as an ED holding room. The patient is awake and alert, and complains of some pain in the head, neck, and the open wound of the right thigh but not is in apparent distress. The patient appears nervous and restless. He is connected to a monitor EKG, pulse oximeter, and non-invasive blood pressure cuff. Bandages are applied around the patient's head, and right thigh. He is also wearing a neck collar. **Scene 2: Operating Room** The learner will find the mannequin wearing a neck collar, laying supine on the OR table, hooked up to IVs, monitors, and already prepped and draped. The OR is a room that is designed to appear as an OR. The mannequin patient is still awake and talking. A surgeon fully scrubbed in, and a circulator nurse are waiting for the anesthesiologist to get the case started in the OR. There are standard general anesthesia induction medicines drawn up in syringes and laid out on the anesthesia machine. A fully equipped anesthesia cart including a video laryngoscope, a stethoscope, and other medicines required for anesthesia is placed right next to the anesthesia machine. A code cart is available in the hallway right outside the OR.

Table A2. *Cont.*

PATIENT NAME: Randy Danger **PATIENT AGE: 49** **CHIEF COMPLAINT: Right Femoral Compound Fracture after a Motorcycle Crash** **PHYSICAL SETTING: ED HOLDING AREA (SCENE 1), THEN OPERATING ROOM (SCENE 2)**			
Standardized Participants (and their roles in the room at case start)	The instructor will observe the progress of the scenario from outside the room in both scenes via half-mirror or audiovisual feed. **Scene 1: ED Holding** **Patient:** Played by another anesthesia resident in the small group. The patient is likely under the influence of alcohol and/or illicit drug(s) at the time of presentation. When the anesthesiologist tries to engage in conversation with the patient, the patient gives ambiguous answers to the anesthesiologist's questions, and keeps asking "Where's my Buddy?", "I need to go!", and "Give me pain meds!"; see "HPI" below as well as Appendix B. **Surgeon:** Played by the other anesthesia resident in the small group. The surgeon will be waiting outside the ED holding, and 30 s after the anesthesiologist starts talking to the patient, walks into the room and interrupts their conversation. They will introduce themself to the patient, start explaining the surgical plan, and try to obtain surgical consent. See Appendix C. The other roles (the distractors) participate later in the scene but do not appear at the beginning. These can all be played by the instructor; see the "INSTRUCTOR NOTES" table below. **Scene 2: Operating Room** **Patient:** Now played by the mannequin. **Surgeon:** Played by the other anesthesia resident in the small group. This is the same surgeon from the ED holding. The surgeon is fully scrubbed in and standing by the OR table. Says "Let us start the procedure immediately" as soon as the anesthesiologist enters the OR. **Another surgeon:** Played by the anesthesia resident who was playing the role of the patient in Scene 1. Fully scrubbed in and standing by the OR table. **Circulator nurse:** Played by another anesthesia resident in the small group. Waiting in the OR and initiates the "Time Out" as soon as the anesthesiologist enters the room. "Time Out! This is Mr. Randy Danger, date of birth 11/03/19**, here for emergency right femoral ORIF and vascular reconstruction of the right deep femoral vein. He is allergic to morphine, codeine, meperidine, and hydrocodone. Does everyone agree?"		
HPI	The patient is a 49-year-old male transferred to ED after a motorcycle accident. He was the driver, and his "Buddy" was riding on the back seat. They were both not wearing helmets. The patient is awake and alert and complains of some pain in the head, neck, and the open wound of the right thigh but is not in apparent distress. The patient is restless and appears to be more concerned about his "buddy." The patient is a very poor historian and cannot give a detailed past medical history, often incoherent in regard to the situation and showing erratic behavior in the ED but admits to habitual use of illicit drugs. Smokes 3 packs of cigarettes per day, drinks 8–12 cans of beer daily, daily marijuana use, and cocaine last week. The anesthesiologist is asked to evaluate and obtain anesthesia consent for the planned emergency surgery of the compound fracture of the right femur.		
Past Medical/Surgical History	**Medications**	**Allergies**	**Family History**
Patient uncooperative and unable to obtain	Patient uncooperative and unable to obtain	morphine (hives) codeine (sick to the stomach) meperidine (sick to the stomach) hydrocodone (sick to the stomach)	Patient uncooperative and unable to obtain

Table A2. *Cont.*

PATIENT NAME: Randy Danger **PATIENT AGE: 49** **CHIEF COMPLAINT: Right Femoral Compound Fracture after a Motorcycle Crash** **PHYSICAL SETTING: ED HOLDING AREA (SCENE 1), THEN OPERATING ROOM (SCENE 2)**	
Physical Examination	
General	Well-developed, non-obese male, sitting up on a gurney in no apparent distress but behaving nervous and restless
HEENT	Minor abrasions on the head and face. Has bandages on his head.
Neck	No deformities, no open wounds. Wears a neck collar.
Lungs	Clear to auscultation bilaterally. Sharp pains on right ribs with arm movements.
Cardiovascular	Regular rate and rhythm. No murmurs, rubs, or gallops.
Abdomen	Soft and nontender. Normal bowel sounds.
Neurological	Awake, alert, and mostly oriented to person, place, and time. Often incoherent in regard to the situation and showing erratic behavior in the ED. CN II-XII are grossly intact and there are no focal deficits.
Skin	Multiple minor abrasions on the right side of the body including head, face, upper and lower extremities, and chest wall.
GU	Normal
Psychiatric	Nervous, indifferent to own current situation, and easily agitated.

Table A3. Instructor Notes—Changes and Case Branch Points.

Intervention/Time Point	Change in Case	Additional Information
Initiation of Scene 1	Anesthesiologist tries to engage in conversation with the patient.	Patient gives ambiguous answers to anesthesiologist's questions and keeps asking "Where's my Buddy? I need to go" "Give me pain meds!"
Distractor 1: 30 s into scenario	Surgeon walks into the holding area and starts talking to the patient, interrupting the conversation. The anesthesiologist tries to re-engage with the patient.	Surgeon: "Hello, I am Dr. Bone taking care of your leg surgery today" Patient: "Who are you? I need to go" Incoherent conversation continues
Distractor 2: 1 min after the surgeon entered the room (from Distractor 1)	Meal service aid (played by the instructor) brings the meal tray into the room. The anesthesiologist stops the patient from reaching for the food (in the interest of being NPO) and tries to re-engage with the patient.	Aid: "Mr. Randy Danger? Your dinner's here!" Patient: "Oh that is great!"
Distractor 3: 1 min after the Meal service aid left the room (from Distractor 2)	Patient is convinced the overhead Code Blue (voice only, played by the instructor) is about his "buddy" and tries to get off the gurney. The anesthesiologist stops the patient and tries to re-engage with the patient.	Overhead voice: "Code Blue, shock room 5. Code Blue, shock room 5" Patient: "That is my Buddy! I gotta go! Is he okay?"
Distractor 4: 2 min after the Code Blue (from Distractor 3)	OR circulator nurse (voice only, played by the instructor) rings the anesthesiologist's cell phone and asks how many units of pRBC should be ordered.	Circulator: "Hello anesthesia? How many units of blood do you want in the room?" "Can you order type and cross then?"
Anesthesiologist requests for the chest X-ray	Chest X-ray shows multiple rib fractures with no apparent pneumothorax or hemothorax.	
Anesthesiologist feels the patient is not optimized for the surgery and asks surgeon if this case can be postponed	Surgeon does not want to postpone the surgery.	Surgeon: "This is not just an open fracture. A branch of the femoral vein is damaged, and it really needs to be fixed emergently"
Anesthesiologist decides to call the patient's family member to obtain anesthesia consent	The family member on the phone (voice only, played by the instructor) agrees to proceed with the surgery after brief conversation with the anesthesiologist.	

Table A3. *Cont.*

Intervention/Time Point	Change in Case	Additional Information
Initiation of Scene 2 Anesthesiologist prepares for rapid sequence induction	Patient still awake and talking	Anesthesiologist should ask the circulator to bring the video laryngoscope as a back-up
Anesthesiologist starts the rapid sequence induction of anesthesia	Patient stops talking and closes the eyes.	Anesthesiologist should ask the circulator to apply cricoid pressure as well as in-line stabilization of the cervical spine.
Endotracheal intubation accomplished successfully	BP 186/101, HR 109, SpO2 99, ETCO2 42, Peak airway pressure (PAP) 21	Anesthesiologist can use a video laryngoscope if needed.
2 min after the intubation	Surgeon makes the incision. BP 135/84, HR 101, SpO2 92, ETCO2 43, PAP 34	Anesthesiologist should recognize the increase in PAP.
4 min after the intubation	Patient becomes noticeably hypotensive and hypoxic. BP 72/34, HR 118, SpO2 71, ETCO2 24, PAP 48	
Anesthesiologist alerts the surgeon and other surgical team members	Surgeon halts the surgery. Code cart is brought into the OR.	
Anesthesiologist turns up the FiO2 to 100% and initiates the investigation to find the reason for decompensation	Patient continues to decompensate. BP 58/26, HR 124, SpO2 63, ETCO2 21, PAP 53	Anesthesiologist should rule out the mechanical failure of the anesthesia machine and circuit.
Anesthesiologist administers pressors	Vital signs do not improve with pressors	
Anesthesiologist performs the auscultation of the chest	Severely diminished right breath sound and moderately diminished left breath sound	Anesthesiologist should make the clinical diagnosis of right tension pneumothorax.
Anesthesiologist performs the needle decompression with a large bore needle at the right second intercostal space, midclavicular line	An audible release of trapped air occurs, and the patient vitals start to improve.	If the anesthesiologist hesitates to place the needle in SimMan 3G, surgeon can indicate there is a dedicated needle decompression port on the mannequin's chest.
1 min after needle decompression	BP 117/76, HR 109, SpO2 96, ETCO2 48, PAP 19	
Anesthesiologist asks the surgeon to place the chest tube	Surgeon places the right chest tube.	A chest X-ray was ordered to confirm the lung expansion and correct chest tube placement.
Surgeon finishes the surgery and asks if the patient is going to be extubated postoperatively	Anesthesiologist should give rational reasoning whether the patient can be extubated or should remain intubated	This will end the scenario.

Table A4. Instructor Notes—Ideal Scenario Flow and Anticipated Management Mistakes.

Ideal Scenario Flow
This simulation scenario has two scenes. Scene 1 starts with an encounter with a trauma patient in the ED holding area. The patient was transferred to the ED following a motorcycle crash. The anesthesiologist was called to evaluate and consent the patient for an emergency surgery. The anesthesiologist will do their best to evaluate the patient to plan for the best and safest anesthesia despite the 4 distractors. First, the surgeon will interrupt the anesthesiologist's conversation with the patient. Second, the meal service delivers a meal tray by mistake. Third, an overhead Code Blue will make the patient agitated. Fourth, the OR circulator nurse calls the anesthesiologist's phone with a question about blood order. The anesthesiologist confirms the preoperative chest X-ray and acknowledges there are multiple rib fractures with no apparent pneumothorax. The anesthesiologist considers this patient not eligible to consent for anesthesia and obtains one from the family member over the phone. Scene 2 is in the OR. Utilizing a video laryngoscope, the anesthesiologist successfully performs a rapid sequence induction applying an in-line stabilization to the cervical spine, since the possibility of full-stomach and cervical spine injury has not been ruled out. The patient is put on the ventilator, when he starts to develop progressive tachycardia, hypoxia, hypotension, and increased peak airway pressure. The anesthesiologist alerts the surgeon and the OR surgical team member, then quickly increases the FiO2 to 100%, disconnects the anesthesia circuit from the patient, checks the machine, and determines the problem is on the patient side. Once the anesthesiologist recognizes the hypoxia and hypotension are not improving with the 100% FiO2 and pressors, they list the differential diagnosis of tension pneumothorax, anaphylaxis, pulmonary thromboembolism, or bronchospasm. The anesthesiologist auscultates the patient's chest and finds out there is no breath sound on the right side. No skin rashes were seen that may indicate anaphylaxis. Knowing that there is no time for confirmation with an imaging study, the anesthesiologist makes the clinical diagnosis of tension pneumothorax. A large-bore needle is inserted into the right second intercostal, mid-clavicular line, and audible release of the trapped air occurs. The patient's vital signs quickly start to improve. The anesthesiologist asks the surgeon to place a right chest tube for the definitive treatment of the pneumothorax. A chest X-ray was ordered to confirm the lung expansion and correct chest tube placement. The surgery was resumed and finished with the patient still in stable condition. The anesthesiologist decides to extubate the patient and transfer to PACU.
Anticipated Management Mistakes
1. Failure to collect necessary information from the patient: The anesthesiologist may be distracted and does not order a preoperative chest X-ray. The chest X-ray may not show apparent pneumothorax but will show multiple rib fractures suggestive of occult lung injuries which may potentially lead to intraop complications. The anesthesiologist may also rush to obtain anesthesia consent from the patient who is likely under the influence of drugs or alcohol. The instructor can use the surgeon as a proxy to suggest the anesthesiologist to obtain a chest X-ray or to contact the family member to obtain the anesthesia consent. 2. Failure to isolate the cause of the intraoperative complication: The anesthesiologist may have a normalcy bias and believe the abnormal vital signs may be caused by equipment failures. The anesthesiologist should always remember to see and feel the patient directly and confirm the patient is truly cyanotic and tachycardic. Disconnecting the anesthesia circuit from the patient at the Y-piece to confirm there is no gross leak or obstruction in the circuit takes only seconds, and it will indicate the problem is on the patient side, not the machine side. 3. Failure to perform immediate needle decompression of the tension pneumothorax: Given the life-threatening nature of tension pneumothorax, it has been recommended that emergent needle decompression should be performed without awaiting diagnostic confirmation via imaging studies. Ordering the chest X-ray may be too time-consuming and delay therapeutic intervention. 4. Failure to extubate the patient after the procedure: A chest tube has already been placed as the definitive treatment of the tension pneumothorax. Unless the patient had been exposed to a prolonged period of hypotension and hypoxia due to failure to treat the tension pneumothorax, the patient can be extubated upon completion of the procedure.

Appendix B. Critical Action Checklist: To Be Used during Sim to Check Off Critical Actions as Learners Participate. Can Be Used to Facilitate Debriefing of Items Completed Well or Items That Could Be Improved

	Critical Action	Definitely Completed	Maybe	Missed
1	Respond in person to evaluate and consent the patient in the ED for the planned emergency surgery			
2	Conduct a focused history and physical examination of the patient			
3	Obtain a preoperative chest X-ray report			
4	Communicate with the surgeon and clarify the need for the emergency surgery			
5	Once the patient is deemed not able to consent, contact his family member to obtain the anesthesia consent over the phone			
6	Perform rapid sequence induction with in-line stabilization of the patient's cervical spine			
7	Turn on the ventilator and Sevoflurane			
8	Recognize the development of hypotension, hypoxia, tachycardia, and increased peak airway pressure			
9	Turn the inspiratory oxygen to 100%			
10	Check the anesthesia machine and circuit to rule out equipment errors			
11	Notify the surgeon of the situation and ask to hold the procedure			
12	Start administering medications to treat the hypotension			
13	Develop a differential diagnosis based on the acquired information			
14	Auscultate the patient's respiratory sound to gather further information			
15	Make a clinical diagnosis of tension pneumothorax			
16	Perform a needle decompression			
17	Ask the surgeon to place a chest tube			
18	Order a chest X-ray to confirm the expansion of the lung			
19	Tell the surgeon to resume the procedure			
20	Make the decision whether the patient can or cannot be extubated immediately after the surgery and develop a disposition plan			

Appendix C. Debriefing Materials

The following points should be discussed during the debriefing with the learners:

1. Evaluation of the patient in ED: This scenario involves multiple communication barriers during the assessment of the patient. The learner anesthesiologist should discuss how to stay focused in order to determine the best and the safest anesthesia plan in the middle of multiple distractors. Discuss if the anesthesiologist missed any information due to the distractions. Participants may share their real-life experiences in dealing with similar situations.
2. Communication with the surgical team: The learners should discuss the feasibility of obtaining anesthesia consent from a patient with questionable mental status. Where do you draw the line? What should you do if the family member or surrogate decision-maker is not available for consent? Additionally, discuss how to communicate with the surgeon in an assertive manner if you have any concerns about proceeding with the case.
3. Identification of tension pneumothorax: The learner anesthesiologist should discuss the differential diagnosis for the collective findings of desaturation, tachycardia, hypotension, and increased peak airway pressure. What are the differences between anaphylaxis, pulmonary thromboembolism, bronchospasm, and tension pneumothorax? Pros and cons of additional diagnostic measures such as chest auscultation, lung POCUS, and chest X-ray should be discussed.
4. Treatment of tension pneumothorax: The learners should discuss the pathophysiology and the treatment of the tension pneumothorax. Both the recommended needle size and the insertion site location for the needle decompression should be emphasized.
5. Postoperative airway management planning: The learners should discuss whether the tension pneumothorax patient who has already received definitive treatment with the chest tube could be extubated or would need to remain intubated after the surgery. It should be noted that many thoracic surgery patients can be safely extubated immediately after the procedure.

Appendix D. Information for Patient

Your role: You are the patient. You were transferred to the ED after a motorcycle accident. You are under the influence of illicit drugs and are restless. You have multiple abrasions. The rib fractures on your right chest elicit sharp pain as you move your right arm. You keep asking for more pain meds. You are hungry and try to reach for food when the food tray is delivered. You are more worried about your "Buddy" who was riding on the back seat of the motorcycle. When you hear the overhead Code Blue, you become agitated, believing he could be in a serious condition. Your conversation is somewhat incoherent and may not be eligible for giving consent for the anesthesia.
Once the encounter in the ED finishes, your next role will be as an additional surgeon in the OR.
Mr. Randy Danger, a 49-year-old male, was transferred to the ED after a motorcycle accident. He was not wearing a helmet. The planned emergency surgery is
open reduction and internal fixation of the compound fracture of the right femur, and vascular reconstruction of the right deep femoral vein.

Allergies: morphine, codeine, meperidine, hydrocodone
Past Medical History: Unable to obtain
Past Surgical History: Unable to obtain
Current Medications: Unable to obtain
Social History:
Tobacco Use: 3 packs of cigarettes per day
Alcohol Use: 8–12 cans of beer daily
Drug Use: marijuana daily, cocaine last week.
Pertinent Physical Examination:
Height: 183 cm, Weight: 75 kg
Vital Signs: BP 156/97 mmHg, HR 102 Sinus, RR 20, SpO2 97% on 8L O2 face mask, T 36.8 °C
General: Well-developed, well-nourished adult. The patient is awake and alert.
Multiple abrasions in the head, face, chest, upper and lower extremities.
A cervical collar has been placed. Cervical spine injury has not been ruled out yet.
Airway: Poor dentition
Lungs: Normal breath sounds bilaterally
Heart: RRR
Abdomen: Soft, non-tender

CBC: **Basic Metabolic Panel**:

WBC	13,000	Sodium	141	Glucose	201
Hgb	28.2	Potassium	3.8	BUN	23
Hct	9.1	Chloride	101	Creatinine	1.4
Plt	210,000	Carbon Dioxide	23		

Appendix E. Information for Surgeon

Your role: You are the surgeon. You are waiting outside the ED holding. You enter the ED 30 s after the anesthesiologist and interrupt the anesthesiologist's conversation by introducing yourself and start explaining today's surgery plan. If the anesthesiologist questions the need for the emergency surgery, you will explain that this is a true emergency because it also requires vascular reconstruction. If the anesthesiologist tries to obtain consent from the patient, suggest the patient may be ineligible to consent and the family member should be available to give consent over the phone. You will be wearing a headset and the Simulation Instructor will tell you what you say or how to behave throughout the scenario. You will have to try and end the anesthesiologist's encounter as quickly as possible by saying that you have to bring the patient to the OR immediately.

Mr. Randy Danger, a
49-year-old male, was transferred to ED after a motorcycle accident. He was not wearing a helmet. The planned emergency surgery is **open reduction and internal fixation of the compound fracture of the right femur, and vascular reconstruction of the right deep femoral vein**.

Allergies: morphine, codeine, meperidine, hydrocodone
Past Medical History: Unable to obtain
Past Surgical History: Unable to obtain
Current Medications: Unable to obtain
Social History:
Tobacco Use: 3 packs of cigarettes per day
Alcohol Use: 8–12 cans of beer daily
Drug Use: marijuana daily, cocaine last week.
Pertinent Physical Examination:
Height: 183 cm, Weight: 75 kg
Vital Signs: BP 156/97 mmHg, HR 102 Sinus, RR 20, SpO2 97% on 8L O2 face mask, T 36.8 °C
General: Well-developed, well-nourished adult. The patient is awake and alert.
Multiple abrasions in the head, face, chest, upper and lower extremities.
A cervical collar has been placed. Cervical spine injury has not been ruled out yet.
Airway: Poor dentition
Lungs: Normal breath sounds bilaterally
Heart: RRR
Abdomen: Soft, non-tender

CBC:

WBC	13,000
Hgb	28.2
Hct	9.1
Plt	210,000

Basic Metabolic Panel:

Sodium	141	Glucose	201
Potassium	3.8	BUN	23
Chloride	101	Creatinine	1.4
Carbon Dioxide	23		

Appendix F. Information for Anesthesiologist

Your role: You are the anesthesiologist. You are asked to evaluate and consent the patient for anesthesia for the planned emergency surgery.

Mr. Randy Danger, a
49-year-old male, was transferred to ED after a motorcycle accident. He was not wearing a helmet. The planned emergency surgery is **open reduction and internal fixation of the compound fracture of the right femur, and vascular reconstruction of the right deep femoral vein**.

Allergies: morphine, codeine, meperidine, hydrocodone
Past Medical History: Unable to obtain
Past Surgical History: Unable to obtain
Current Medications: Unable to obtain
Social History:
Tobacco Use: 3 packs of cigarettes per day
Alcohol Use: 8–12 cans of beer daily
Drug Use: marijuana daily, cocaine last week.
Pertinent Physical Examination:
Height: 183 cm, Weight: 75 kg
Vital Signs: BP 156/97 mmHg, HR 102 Sinus, RR 20, SpO2 97% on 8L O2 face mask, T 36.8 °C
General: Well-developed, well-nourished adult. The patient is awake and alert.
Multiple abrasions in the head, face, chest, upper and lower extremities.
A cervical collar has been placed. Cervical spine injury has not been ruled out yet.
Airway: Poor dentition
Lungs: Normal breath sounds bilaterally
Heart: RRR
Abdomen: Soft, non-tender

CBC:		**Basic Metabolic Panel**:			
WBC	13,000	Sodium	141	Glucose	201
Hgb	28.2	Potassium	3.8	BUN	23
Hct	9.1	Chloride	101	Creatinine	1.4
Plt	210,000	Carbon Dioxide	23		

Appendix G. Preoperative Chest X-ray

FINDINGS:
A frontal and lateral study of the chest shows a midline trachea. The heart, aorta, and remaining visualized mediastinal structures appear unremarkable. Right-sided non-displaced right lateral third, fourth and fifth rib fractures are seen. No evidence of pneumothorax. No pleural effusion or parenchymal infiltration is seen.
IMPRESSION:

1. No active cardiopulmonary disease.
2. There are multiple right-sided rib fractures including the third, fourth and fifth ribs.

Appendix H. Intraoperative Chest X-ray

FINDINGS:
A frontal and lateral study of the chest shows a midline trachea. There is a new placement of an endotracheal tube, and the tip is 15 mm above the carina. There is a new right-sided chest tube placed with the tip at the third rib. New onset of minimal pneumothorax is seen in the right lung. No pleural effusion. Stable right-sided rib fractures including the third, fourth and fifth ribs.
IMPRESSION:

1. New placement of an endotracheal tube.
2. New placement of a right-sided chest tube.
3. Minimal right pneumothorax.
4. Stable multiple right-sided rib fractures including the third, fourth and fifth ribs.

References

1. Leigh-Smith, S.; Harris, T. Tension pneumothorax—time for a re-think? *Emerg. Med. J.* **2005**, *22*, 8–16. [CrossRef] [PubMed]
2. Mavarez-Martinez, A.; Soghomonyan, S.; Sandhu, G.; Rankin, D. Intraoperative Tension Pneumothorax in a Patient with Remote Trauma and Previous Tracheostomy. *J. Investig. Med. High Impact Case Rep.* **2016**, *4*, 2324709616636397. [CrossRef] [PubMed]
3. Chen, K.Y.; Jerng, J.S.; Liao, W.Y.; Ding, L.W.; Kuo, L.C.; Wang, J.Y.; Yang, P.C. Pneumothorax in the ICU: Patient outcomes and prognostic factors. *Chest* **2002**, *122*, 678–683. [CrossRef] [PubMed]
4. Hsu, C.W.; Sun, S.F.; Lee, D.L.; Chu, K.A.; Lin, H.S. Clinical characteristics, hospital outcome and prognostic factors of patients with ventilator-related pneumothorax. *Minerva Anestesiol.* **2014**, *80*, 29–38.
5. Pocket Guide: TeamSTEPPS. Content Last Reviewed January 2020. Agency for Healthcare Research and Quality, Rockville, MD. Available online: https://www.ahrq.gov/teamstepps/instructor/essentials/pocketguide.html (accessed on 6 August 2022).
6. Roberts, D.J.; Leigh-Smith, S.; Faris, P.D.; Ball, C.H.; Robertson, H.L.; Blackmore, C.; Dixon, E.; Kirkpatrick, A.W.; Kortbeek, J.B.; Stelfox, H.T. Clinical manifestations of tension pneumothorax: Protocol for a systematic review and meta-analysis. *Syst. Rev.* **2014**, *3*, 3. [CrossRef]
7. Rutherford, R.B.; Hurt, H.H., Jr.; Brickman, R.D.; Tubb, J.M. The pathophysiology of progressive, tension pneumothorax. *J. Trauma* **1968**, *8*, 212–227. [CrossRef]
8. Rozycki, G.S.; Newman, P.G. Surgeon-performed ultrasound for the assessment of abdominal injuries. *Adv. Surg.* **1999**, *33*, 243–259. [PubMed]
9. Studer, M.; Studer, P. Focused surgical bedside ultrasound: E-FAST (focused assessment with sonography in trauma)—Abdominal aortic aneurysm—Cholecystolithiasis—Acute appendicitis. *Praxis* **2014**, *103*, 697–703. [CrossRef] [PubMed]
10. Williams, S.R.; Perera, P.; Gharahbaghian, L. The FAST and E-FAST in 2013: Trauma ultrasonography: Overview, practical techniques, controversies, and new frontiers. *Crit. Care Clin.* **2014**, *30*, 119–150. [CrossRef]
11. Ball, C.G.; Kirkpatrick, A.W.; Laupland, K.B.; Fox, D.L.; Litvinchuk, S.; Dyer, D.M.M.; Anderson, I.B.; Hameed, M.; Kortbeek, J.B.; Mulloy, R. Factors related to the failure of radiographic recognition of occult posttraumatic pneumothoraces. *Am. J. Surg.* **2005**, *189*, 541–546. [CrossRef] [PubMed]
12. Berger, M.; Weber, L.; McNamara, S.; Shin-Kim, J.; Strauss, J.; Pathak, S. Simulation-Based Mastery Learning Course for Tube Thoracostomy. *Med. Ed. Portal* **2022**, *18*, 11266. [CrossRef] [PubMed]
13. Léger, A.; Ghazali, A.; Petitpas, F.; Guéchi, Y.; Boureau-Voultoury, A.; Oriot, D. Impact of simulation-based training in surgical chest tube insertion on a model of traumatic pneumothorax. *Adv. Simul.* **2016**, *1*, 1–7. [CrossRef]