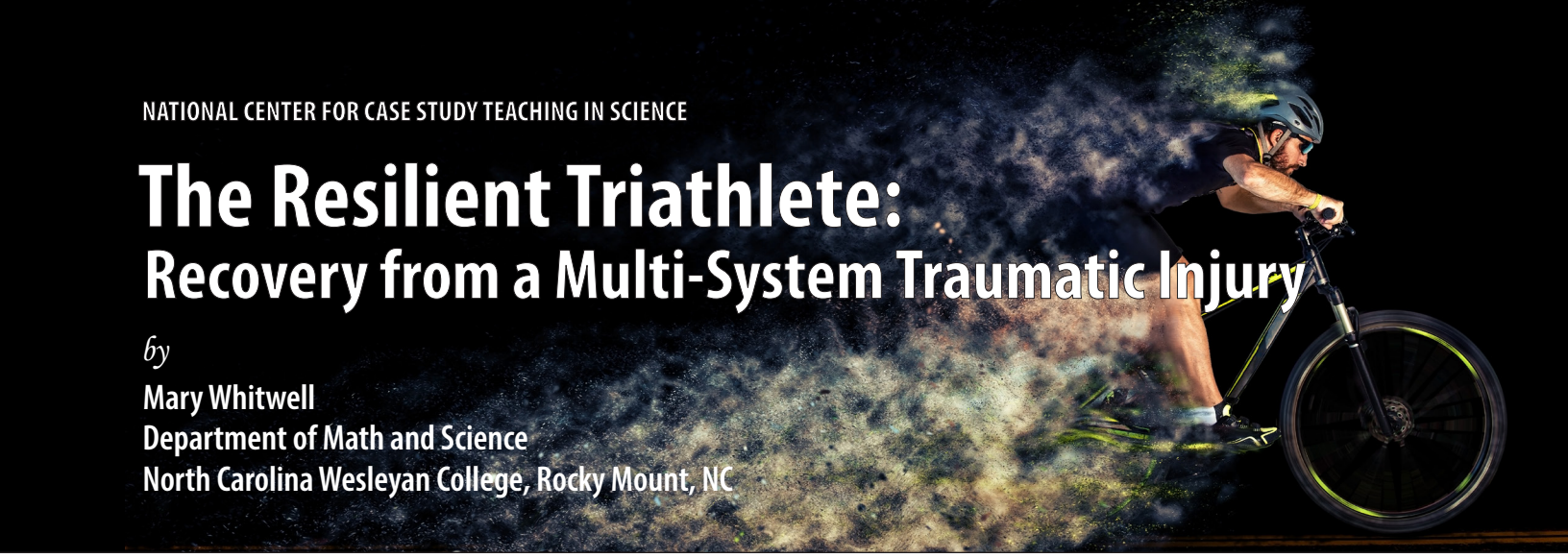
NATIONAL CENTER FOR CASE STUDY TEACHING IN SCIENCE

The Resilient Triathlete:
Recovery from a Multi-System Traumatic Injury



by
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Introduction

[This case study is based on the experiences of a real athlete. All information is as accurate as possible based on his recollections and medical materials in his possession.]

Butch is a 56-year-old triathlete who began racing in 2012. Through intensive training, he acquired the extreme level of conditioning required to compete successfully in races of all distances, including Ironman triathlons. The Ironman races are 2.4 miles of swimming, 112 biking miles, and 26.2 miles running, all done sequentially without stopping. Athletes also practice the "fourth sport" of transitioning between each segment in the least time possible. Consequently, Ironman competitors are among the most aerobically fit people in sport.

Butch raced the Lake Placid Ironman in 2017. While on the bike course traveling down a steep grade, he swerved to avoid another biker who inadvertently pulled out in front of him. He hit a traffic cone at 44 mph and crashed onto the roadway on his left side with his bike on top of him. His helmet is the reason he survived.

Your assignment in this case study is to explain the reasons for his clinical signs, analyze the care he was given, consider what other injuries could have happened, and predict his current physical status.

Part I – Thoracic Trauma with Respiratory System Involvement

Butch broke left ribs 1–10. Ribs 1–6 were broken in multiple places, producing flail chest. Rib 2 broke angularly inward (see Figure 2, next page), slightly penetrating his lung. Butch was airlifted by helicopter to Vermont University, which has a specialized trauma center. Before he was transported, X-rays were taken using a portable unit. Based on these films, he was diagnosed with left side lung contusion and partial collapse, hemothorax and slight pneumothorax (see Figure 1). A chest tube was placed and then the 14-minute airlift took place.

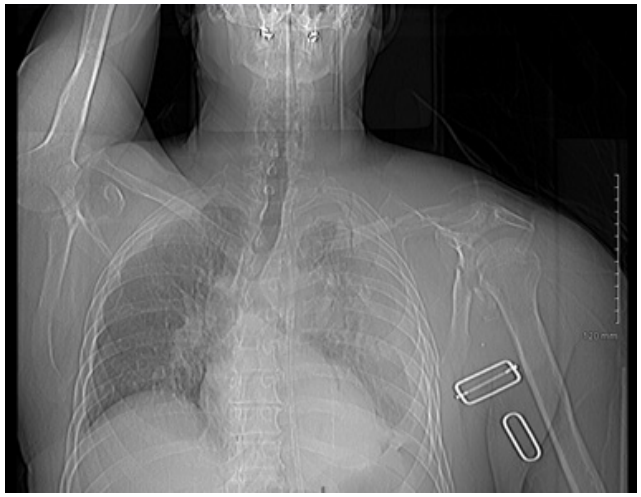

Figure 1. Initial chest X-ray.

Questions

1. Define the following terms: *flail chest, hemothorax,* and *pneumothorax.*

2. Clearly, trauma caused the hemothorax and pneumothorax. Provide a more specific anatomical source for each.

3. Explain why the left lung collapsed, referencing intrapleural pressure

4. Explain why the right lung was not simultaneously affected

5. Note in the CT scan the clearly evident multiple fractures of Rib 1 (see Figure 2), which does not commonly break. In terms of the cardiovascular system, what life threatening injury did Butch escape that could have occurred with his comminuted fracture of Rib 1? (*Hint:* there was no large hematoma at this site.)

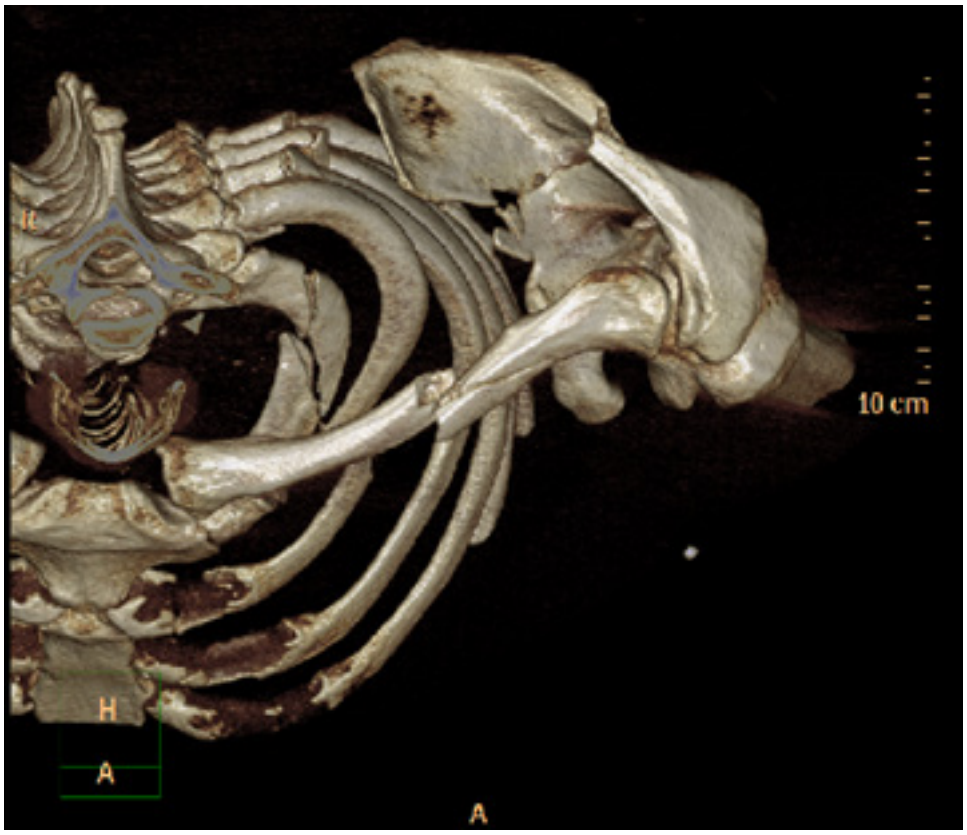

Figure 2. Left thorax and shoulder CT scan. Superior view.

Part II – Skeletal System Fractures in Addition to Rib Fractures

Along with multiple overriding rib fractures, Butch suffered fractures of the left transverse processes of T6 and T7 vertebrae, a comminuted midshaft clavicular fracture, and a complex comminuted left scapular fracture that included several breaks into the glenoid cavity with displacement (see Figures 3 and 4).

Figure 3. X-ray of left scapular and clavicular fractures (anterior view).

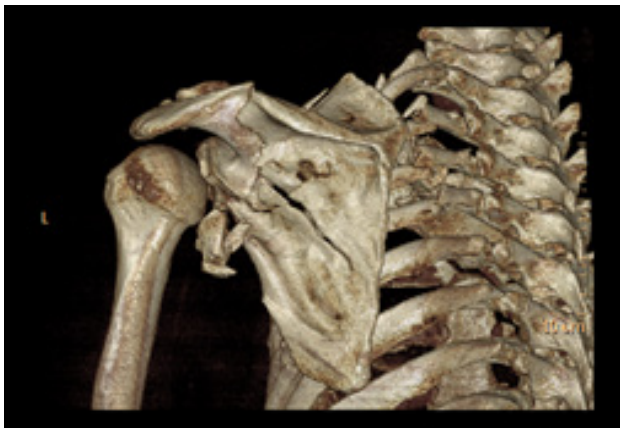

Figure 4. CT scan of scapular fractures (posterior view).

In addition, he experienced three incomplete non-displaced fractures of his pelvis, all on the left side: the anterior acetabular wall and the superior and inferior pubic rami (see Figure 5). The radiologist's comment stated that the rest of the bony pelvis was intact. Incredibly, there were no limb fractures.

The pelvic fractures were treated with rest and restricted use. The clavicle was stabilized with a full length plate. The scapula was repaired with a combination of plates and pins (see Figure 6).

Figure 5. Pelvic X-ray.

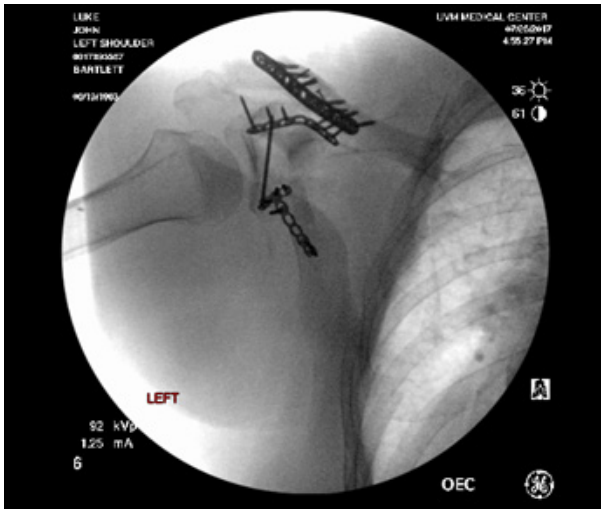

Figure 6. Post surgical X-ray. Clavicular plate; scapular plates and pin.

Questions

1. In general terms, describe the process of bone healing assuming there is adequate alignment of the fragments.

2. In Butch's case, what aspect of which bone required the most precise stabilization and why?

3. Why could his pelvis be successfully treated with rest and reduced use only?

4. Based on the fractures that did occur, and the fact that there were no limb fractures or dislocations, state the most likely positioning of his body as it impacted the ground (explain your answer).

5. Throughout his care, a combination of X-rays and CT scans were done. MRI is a widely used diagnostic procedure as well. Discuss when one diagnostic technique might be chosen over another and why (i.e., describe the advantages and disadvantages of each).

Part III – Concern for Renal Function

The presence of a urinary catheter is visible in the pelvic X-ray (see Figure 5). This was placed at the time of admission due to Butch's cognitive condition and also so urine content and output could be monitored. The catheter was removed after several days and urine monitoring was continued until normalcy was well established. Happily, there was no indication at any time of renal damage, nor were there urine abnormalities.

Questions

1. In terms of general anatomy, why are the kidneys subject to traumatic damage, especially from impact injuries or posterior blows?

2. It is possible for a renal artery to spasm or partially thrombose (clot) from blunt abdominal trauma. If the blood flow through a renal artery decreases slightly due to spasm, what do you anticipate might happen initially to glomerular filtration rate (GFR) in that kidney? Discuss the two intrinsic mechanisms that would occur within that kidney attempting to re-establish basal GFR.

3. More extensive thrombosis or direct renal parenchymal damage on rare occasion can produce systemic hypertension. Explain the extrinsic renal mechanism producing the hypertension.

Part IV – Cardiac Function and Athletic Alterations

Pain medication was administered before Butch was airlifted to Vermont University. During his initial examination there, the attending physician (also an endurance athlete) noted Butch's heart rate was 82 and immediately suspected he was still in severe pain. Then he asked Butch what his normal resting heart rate was and the answer was 54, so the doctor prescribed additional pain medication.

Questions

1. Why did the doctor suspect persistent pain when Butch's heart rate was only 82, even before knowing Butch's resting heart rate?

2. Explain the low resting heart rate in terms of cardiac output and the Frank-Starling law of the heart, based on Butch's level of physical conditioning.

3. With only one functional lung, it is especially important to avoid excess cardiac stress, as the heart is very oxygen dependent. Explain why a hard working heart relies on increased blood to it when its oxygen demands increase, in terms of resting state level of hemoglobin O_2 unloading. Also explain the role of cardiac myoglobin, referencing pulsatile blood flow.

Part V – Integumentary Damage

Along with the skeletal injuries, Butch suffered a concussion and extremely severe road rash burns, with areas of third degree damage surrounding the point of impact. Integument damage extended from his proximal left upper limb across his shoulder and over much of the left posterior thorax. He was treated as a thermal burn victim, including silver nitrate patches. Fluids were administered both to combat shock and as part of his general treatment for the skin damage. Fortunately, grafting was not required, nor were blood transfusions.

Questions

1. What constitutes a third degree burn? Explain in terms of skin structure and reference the tissue types of all layers.

2. What is the most immediate cause of death from very severe burns? If a patient survives the initial day, what is the second greatest concern, and the most common cause of death?

3. Why were silver nitrate patches applied?

4. Butch's blood type is O^+. If he had needed a transfusion of whole blood, what blood types could he safely receive? Include both ABO group and Rh factor and explain your answer.

Part VI – Alteration of the Vestibular Apparatus

Post-operatively during his PT sessions, Butch experienced severe vertigo as a result of alterations to his vestibular system. The otoliths of his linear equilibrium apparatus had been knocked out of position. Therapists positioned him on his back and sides and manipulated his head to return those otoliths to the correct location, although they had to wait several months before putting him on his left side.

Questions

1. State the names and anatomical location of the receptors for both linear and rotational equilibrium.

2. Define *otoconia/otolith* and explain how they function as part of the human linear system. Include how the effect on hair cell stereocilia influences action potential frequency in the vestibular nerve.

3. State the pathway of neural transmission from the inner ear to the vestibular nuclei, identifying the parts that belong to the peripheral nervous system vs. the central nervous system.

Conclusion – Butch's Prognosis for Survival and Future Quality of Life

Using your knowledge of the systems injured, the severity of the injuries, and the medical care Butch received, state the prognosis you would have given him at the time of the accident. Then state what you think Butch's quality of life was like three years later.