

Scenario Overview			
The Soldier Multi-Trauma Showcase Scenario simulates the injuries that a Combat Medic or other caregiver may encounter on the battlefield. This scenario highlights the ability of the Pulse physiology engine to simulate multiple insults occurring simultaneously. We have incorporated a tension pneumothorax with a massive hemorrhage. The tension pneumothorax is itself a combinatory insult, affecting both the respiratory and cardiovascular systems. Combining the tension pneumothorax with the blood loss from the hemorrhage pushes and eventually exceeds the limits of the homeostatic control mechanisms.			
Base Physiology	Insults and injuries	Assessments	Interventions
A 22 year old physically fit male soldier. No known complicating factors.	Trauma which causes massive hemorrhage and tension pneumothorax.	Heart Rate	Tourniquet
		Bleeding Rate	Needle Decompression
		Blood Pressure	Narcotics
		Distal Pulse	Fluid Resuscitation
		Respiration Rate	Transfusion
		Oxygen Saturation	
Scenario Narrative			
Segment 0	Engine initialization period.		
Segment 1	A team of soldiers is conducting a presence patrol through a small village in a troubled country. As they pass a mud wall, an improvised explosive device detonates injuring one of the soldiers. The squad medic was with the other team in another part of the village, and she reaches the casualty one minute after the onset of injury.		
Segment 2	The medic goes to work immediately, attempting to stop the hemorrhage with direct pressure while she assesses the casualty for other injuries. After one minute of assessment, the medic suspects a tension pneumothorax. She instructs a combat life saver to continue direct pressure on the hemorrhage while she prepares to treat the tension pneumothorax.		
Segment 3	The medic treats the tension pneumothorax by performing a needle decompression. The three inch needle is inserted immediately, and the medic spends the next four minutes finishing and assessing the effectiveness of the procedure.		
Segment 4	The medic notices that the combat life saver is unable to effectively control the bleeding with direct pressure. She applies a tourniquet stop the hemorrhage. The medic spends 30 seconds inspecting the tourniquet application and preparing an intravenous infusion.		
Segment 5	The medic initiates a bolus intravenous infusion of isotonic saline.		
Segment 6	The medic also administers five milligrams of morphine intravenously to control the casualty’s pain. She advises the ranking military person on the scene to call a CASEVAC and continues supportive care.		
References			
Publications:			
1	Bond, Casey, et al., eds. 68W Advanced Field Craft: Combat Medic Skills. Jones & Bartlett Publishers, 2009. P42.		
2	Bond, Casey, et al., eds. 68W Advanced Field Craft: Combat Medic Skills. Jones & Bartlett Publishers, 2009. P86.		
3	BRANDFONBRENER, MARTIN, MILTON LANDOWNE, and NATHAN W. SHOCK. "Changes in cardiac output with age." Circulation 12.4 (1955): 557-566.		
4	CHRISP, DELILA R. "Action Stat: Tension pneumothorax." Nursing2013 30.5 (2000): 33.		
5	Drummond, G. B., and B. Lafferty. "Oxygen saturation decreases acutely when opioids are given during anaesthesia." British journal of anaesthesia 104.5 (2010): 661-663.		
6	Echt, Martin, et al. "Effective compliance of the total vascular bed and the intrathoracic compartment derived from changes in central venous pressure induced by volume changes in man." Circulation research 34.1 (1974): 61-68.		
7	Feldschuh, Joseph, and Yale Enson. "Prediction of the normal blood volume. Relation of blood volume to body habitus." Circulation 56.4 (1977): 605-612.		
8	Grmec, Stefek, Mirjam Golub, and Alina Jelatancev. "Relationship between mean arterial pressure and end-tidal partial pressure of carbon dioxide during hemorrhagic shock and volume resuscitation." Signa Vitae 4.1 (2009): 24-26.		
9	Gutierrez, Guillermo, H. David Reines, and Marian E. Wulf-Gutierrez. "Clinical review: hemorrhagic shock." CRITICAL CARE- LONDON- 8 (2004): 373-381.		
10	Hall, John Edward, and Arthur C. Guyton. Textbook of medical physiology. Saunders, 2011. P229.		
11	Hall, John Edward, and Arthur C. Guyton. Textbook of medical physiology. Saunders, 2011. P469.		
12	Khorasani, Zadeh, et al. "Assessment of Moderate to Severe Abdominal Blood Loss Using Peripheral to Central Blood Oxygen Saturation." Advances in medical sciences 53.1 (2008): 87-93.		
13	Van Leeuwen, Anne M., and Mickey Lynn Bladh. Comprehensive Handbook of Laboratory & Diagnostic Tests with Nursing Implications. FA Davis, 2015. P93		
14	Van Leeuwen, Anne M., and Mickey Lynn Bladh. Comprehensive Handbook of Laboratory & Diagnostic Tests with Nursing Implications. FA Davis, 2015. P295		
15	Van Leeuwen, Anne M., and Mickey Lynn Bladh. Comprehensive Handbook of Laboratory & Diagnostic Tests with Nursing Implications. FA Davis, 2015. P471		
16	Leigh-Smith, S., and T. Harris. "Tension pneumothorax—time for a re-think?." Emergency medicine journal: EMJ 22.1 (2005): 8.		
17	Mattox, KENNETH L., et al. "Prehospital hypertonic saline/dextran infusion for post-traumatic hypotension. The USA Multicenter Trial." Annals of surgery 213.5 (1991): 482.		
18	Morgan, G. E., and M. S. Mikail. "Clinical Anesthesiology." (2006). P200.		
19	Price, James W. "Novel Electrocardiographic changes associated with iatrogenic pneumothorax." American Journal of Critical Care 15.4 (2006): 415-419.		
20	Rim, Taegeun, Joo Suck Bae, and Yong Soo Yuk. "Life-threatening simultaneous bilateral spontaneous tension pneumothorax-a case report." The Korean journal of thoracic and cardiovascular surgery 44.3 (2011): 253-256.		
21	Satsumae, Tsuyoshi, et al. "Magnesium sulfate attenuates tourniquet pain in healthy volunteers." Journal of anesthesia 27.2 (2013): 231-235.		
22	Waisman, Dan, et al. "Transient decrease in PaCO2 and asymmetric chest wall dynamics in early progressing pneumothorax." Intensive care medicine 39.1 (2013): 137-145.		
SMEs:			
S1	Rodney Metoyer - Former Army Combat Medic		
S2	Bryan Bergeron, M.D. -President, Archetype Technologies, Inc.		
Key			
	Good Agreement with data/trends		
	Agreement with most trends, some deviations from validation data/trends		
	Some major disagreements with validation data/trends		

Segment Number	Start Time (s)	Segment Duration (s)	Event (to begin segment)	Notes (End Segment Expected Physiology to right)	HeartRate (BPM)	Engine HeartRate (BPM)	HeartStrokeVolume (mL/Beat)	Engine HeartStrokeVolume (mL/Beat)	BloodVolume (mL)	Engine BloodVolume (mL)	MeanArterialPressure (mmHg)	Engine MeanArterialPressure (mmHg)	SystolicArterialPressure (mmHg)	Engine SystolicArterialPressure (mmHg)	DiastolicArterialPressure (mmHg)	Engine DiastolicArterialPressure (mmHg)	CardiacOutput (mL/min)	Engine CardiacOutput (mL/min)	HemoglobinContent (g)	Engine HemoglobinContent (g)	MeanCentralVenousPressure (mmHg)	Engine MeanCentralVenousPressure (mmHg)	RespirationRate (Breaths/min)	Engine RespirationRate (Breaths/min)	OxygenSaturation (Baseline)	Engine OxygenSaturation (Baseline)	TidalVolume (mL)	Engine TidalVolume (mL)	Total Lung Volume (mL)	Total Lung Volume (mL) [Measured as peak over 10 seconds]
0	0	60	Initialization (Advance time 1 minute)	An initial period to facilitate observation of changes	60 - 100 [51]	86	55.3 to 89.1 [3]	77	5500 [7]	5591	70 - 105 [13]	95	100 - 140 [13]	114	60 - 90 [13]	73	5000 (at rest) [16] Elevated due to increased HR [51]	6628	13.2 - 17.5 g/dL Blood [5]	851	3-4 [6]	4.3	12 - 20 [12]	16	0.95 - 0.99 [14]	0.97	500 [11]	598	2800 [11]	2655
1	60	60	Begin Tension Pneumothorax (Left side, closed, severity 0.75) Begin Massive hemorrhage (Right leg, rate 350 mL/min)	Massive hemorrhage from the right leg, 350 mL/min based on common femoral artery volumetric flow rate. See @cite:Holand2019bLower: 700 mL of blood loss at the end of this segment (Class I hemorrhage). Tension pneumothorax has progressed untreated for 3 minutes.	~25% increase [9] Tachycardia [16]	94	Decrease [51]	67	5150	5250	NC or decrease [16] Compensatory Mechanisms Keep it at Baseline Values [52]	93	Moderate Decrease Acutely [52] Decrease, but not completely collapse [52]	110	No Change [52]	74	Decrease [51]	6243	799	798	Increase [6]	4.00	40 [4] 14-30 [9] Tachypnea [22] [2] [16]	14	Decrease [4] [2] [16] [12]	0.96	~25% Decrease [22]	321	~70% of Baseline [52]	1950
2	120	60	Non-tourniquet bleeding control (Manual pressure reduces hemorrhage to 50 mL/min)	A pressure dressing or manual pressure is applied to attempt to control the bleeding. 750 mL of blood loss at the end of this segment (Transitioning from Class I to Class II hemorrhage). Tension pneumothorax has progressed untreated for 3 minutes.	~25% increase [9] Tachycardia [16]	103	No Change [52]	57	5100	5250	NC or decrease [16] Compensatory Mechanisms Keep it at Baseline Values [52]	95	No Change [52]	110	No Change [52]	75	Stress-induced slight elevation [52]	6600	799	790	Increase [6]	4.00	40 [4] 14-30 [9] Tachypnea [22] [2] [16]	17	Decrease [4] [12] Plateaus [22]	0.94	~25% Decrease [22]	395	~70% of Baseline [52]	1982
3	180	240	Needle Decompression	A needle decompression procedure is applied on the affected side.	90 - 110 [51]	102	Increases [52]	65	4900	5028	Compensatory Mechanisms Keep it at Baseline Values [52]	94	NC or Slight Increase [52]	111	No Change [52]	75	Stress-induced slight elevation [52] Increase with the Needle Decompression [51]	6250	765	759	Decreasing, but not to baseline [51] NC or Slight Decrease [52]	4.00	Back to Baseline [52]	17	Increase > 0.95 [26]	0.97	Back to Baseline [52]	450	~90% of Baseline [52]	1960
4	420	30	Tourniquet Application (Hemorrhage completely controlled, rate 0 mL/min)	A tourniquet is applied to the hemorrhaging leg. Note: this action only stops bleeding. There is not currently a tourniquet model in the Engine! application please see @cite:deloughy2020b and @cite:ham2002a for more. 950 mL of blood loss at the end of this segment (Class II hemorrhage). At this point bleeding has stopped.	Possibly no significant change [19]	103	No change	65	4900	5200	No Change or increase [21]	94	No Change or increase [21]	112	No Change or increase [21]	75	No Change	6250	751	759	Decreasing, but not to baseline [51] NC or Slight Decrease [52]	4.20	Back to Baseline [52]	17	Back to Baseline [52]	0.97	Back to Baseline [52]	420	~90% of Baseline [52]	1960
5	450	120	Intravenous Fluid Resuscitation (Saline, 500 mL at rate of 100 mL/min)	Saline is administered over 5 minutes at a rate of 100 mL/min.	Slight decrease because of partial correction of the hypotension. [51] Stress-induced Moderate Tachycardia [52]	94	increase with the increase in blood volume [51] Toward Baseline as pre-dose returns to normal [52]	66	5100	5280	Increase [8]	95	Increase [11] [57] Back toward baseline [51]	113	Increase [52]	75	Increase [52]	6500	791	759	Move toward Baseline [52]	4.50	Back to Baseline [52]	14	Back to Baseline [52]	0.96	Back to Baseline [52]	400	~90% of Baseline [52]	1928
6	570	160	Narcotics (Morphine) Administration (5 mL of morphine IV at concentration of 1 mg/mL)	A bolus of 5 mg of morphine is administered intravenously. The rest of the time in this segment is to allow the saline to finish and to observe.	Decrease [51] Decrease [18]	115	Toward Baseline [52]	80	5600	5700	Mild Decrease [18]	90	Mild Decrease [18]	110.	Mild Decrease [18]	70	Mild Decrease [52]	7000	791	759	Mild Decrease [52]	4.50	15-20% Decrease [18]	12	NC [51] Decrease [5]	0.94	Moderate Decrease [52]	450	~90% of Baseline [52]	2000
730			End Scenario																											

Note: Blood Volume is a direct calculation

Note: Direct calculation based on blood loss and assumed homogeneity