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 BioGears® 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 Bleeding Rate Blood Pressure Distal Pulse Respiration Rate Oxygen Saturation	Tourniquet Needle Decompression Narcotics Fluid Resuscitation Transfusion

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.

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SMEs:

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Key

(green)	Good Agreement with data/trends
(yellow)	Agreement with most trends, some deviations from validation data/trends
(red)	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)
0	0	60	**Initialization** (Advance time 1 minute)	An initial period to facilitate observation of changes
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 holland1998lower. **700 mL of blood loss** at the end of this segment (**Class I hemorrhage**). Tension pneumothorax has progressed untreated for 2 minutes.
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.
3	180	240	**Needle Decompression**	A needle decompression procedure is applied on the affected side.
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 BioGears® engine. For the systemic effects of tourniquet application please see @cite deloughry2009arterial and @cite kam2001arterial. **950 mL of blood loss** at the end of this segment (**Class II hemorrhage**). At this point **Bleeding has stopped**.
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.
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.
	730		End Scenario	

Segment Number	HeartRate (BPM)	BioGears HeartRate (BPM)	HeartStrokeVolume (mL/Beat)	BioGears HeartStrokeVolume (mL/Beat)	BloodVolume (mL)	BioGears BloodVolume (mL)	MeanArterialPressure (mmHg)	BioGears MeanArterialPressure (mmHg)	SystolicArterialPressure (mmHg)	BioGears SystolicArterialPressure (mmHg)	DiastolicArterialPressure (mmHg)	BioGears DiastolicArterialPressure (mmHg)
0	60 - 100 [S1]	86	55.3 to93.1 [3]	77	5500 [7]	5591	70 - 105 [13]	95	100 - 140 [13]	114	60 - 90 [13]	73
1	~25% Increase [9] Tachycardia [16]	94	Decrease [S1]	67	5150	5250	NC or decrease [16] Compensatory Mechanisms Keep it at Baseline Values [S2]	93	Moderate Decrease Acutely [S2] Decrease, but not completely collapse [S1]	110	No Change [S2]	74
2	~25% Increase [9] Tachycardia [16]	103	No Change [S2]	57	5100	5250	NC or decrease [16] Compensatory Mechanisms Keep it at Baseline Values [S2]	95	No Change [S2]	110	No Change [S2]	75
3	90 - 110 [S1]	102	Increases [S2]	65	4900	5028	Compensatory Mechanisms Keep it at Baseline Values [S2]	94	NC or Slight Increase [S2]	111	No Change [S2]	75
4	117.9 [12] 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
5	Slight decrease because of partial correction of the hypovolemia. (S1) Stress-Induced Moderate Tachycardia (S2)	94	increase with the increase in blood volume [S1] Toward Baseline as preload returns to normal [S2]	66	5100	5280	Increase [8]	95	Increase [1] [17] Back toward baseline [S1]	113	Increase [S2]	75
6	Decrease [S1] Decrease [18]	115	Toward Baseline [S2]	80	5600	5700	Mild Decrease [18]	90	Mild Decrease [18]	110.	Mild Decrease [18]	70

Segment Number	CardiacOutput (mL/min)	BioGears CardiacOutput (mL/min)	HemoglobinContent (g)	BioGears HemoglobinContent (g)	MeanCentralVenousPressure (mmHg)	BioGears MeanCentralVenousPressure (mmHg)	RespirationRate (Breaths/min)	BioGears RespirationRate (Breaths/min)	OxygenSaturation (fraction)	BioGears OxygenSaturation (fraction)	TidalVolume (mL)	BioGears TidalVolume (mL)	TotalLungVolume (mL)	TotalLungVolume (mL) [Measured as peak over 10 seconds]
0	5600 (at rest) [10] Elevated due to increased HR [S1]	6628	13.2 - 17.3 g/dL Blood [15]	851	3.4 [6]	4.3	12 - 20 [1]	16	0.95 - 0.99 [14]	0.97	500 [11]	598	2800 [11]	2655
1	Decrease [S1]	6243	799	798	Increase [6]	4.00	40 [4] 14-20 [9] Tachypnea [22] [2] [16]	14	Decrease [4] [2] [16] [12]	0.96	~25% Decrease [22]	321	~70% of Baseline [S2]	1950
2	Stress-Induced slight elevation [S2]	6600	799	790	Increase [6]	4.00	40 [4] 14-20 [9] Tachypnea [22] [2] [16]	17	Decrease [4] [12] Plateaus [22]	0.94	~25% Decrease [22]	395	~70% of Baseline [S2]	1982
3	Stress-Induced slight elevation [S2] Increase with the Needle Decompression [S1]	6250	765	759	Decreasing, but not to baseline [S1] NC or Slight Decrease[S2]	4.00	Back to Baseline [S2]	17	Increase > 0.95 [20]	0.97	Back to Baseline [S2]	450	~90% of Baseline [S2]	1960
4	No Change	6250	791	759	Decreasing, but not to baseline [S1] NC or Slight Decrease[S2]	4.20	Back to Baseline [S2]	17	Back to Baseline [S2]	0.97	Back to Baseline [S2]	420	~90% of Baseline [S2]	1960
5	Increase [S2]	6500	791	759	Move toward Baseline [S2]	4.50	Back to Baseline [S2]	14	Back to Baseline [S2]	0.96	Back to Baseline [S2]	400	~90% of Baseline [S2]	1926
6	Mild Decrease [S2]	7000	791	759	Mild Decrease [S2]	4.50	15-20% Decrease [18]	12	NC [S1] Decrease [5]	0.94	Moderate Decrease [S2]	450	~90% of Baseline [S2]	2000

Note: Blood Volume is a direct calculation

Note: Direct calculation based on blood loss and assumed homogeneity