BioGears: Integrators

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THANK YOU INTEGRATORS

Outline

Work with Advanced Modular Manikin (AMM)

- Validation
- Sepsis

Work with U.S. Army Institute of Surgical Research (USISR)

- Burn modeling
- Validation

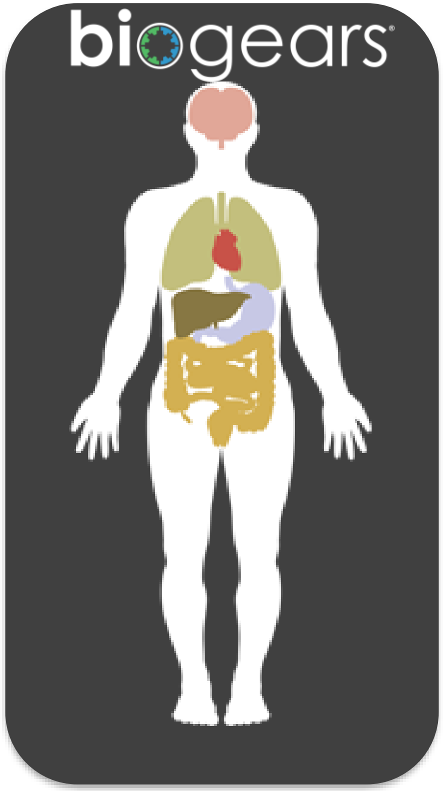
Other Applications

WORK WITH AMM

Work With Advanced Modular Manikin

Working with AMM to provide the physiology models for scenario development

- Includes updating/creating new models
- Provide all possible output data and update our CDM
- Work with team to validate engine for 5 key scenarios at UMN's anesthesiology department
- Work on publications and use cases with fellows at UW
- Proposed teaming on future efforts
  - Prolonged field care subcontractor



UW - CREST
The Center for Research in Education and Simulation Technologies
University of Washington

Two way street to support core application

Scenario Description

Pneumothorax (TPT) Validation:

Parameters:
HR, BP, MAP, PAP, CVP, CO,
RR, tidal volume, Sp02, PaC02, total lung volume, transpulmonary pressure

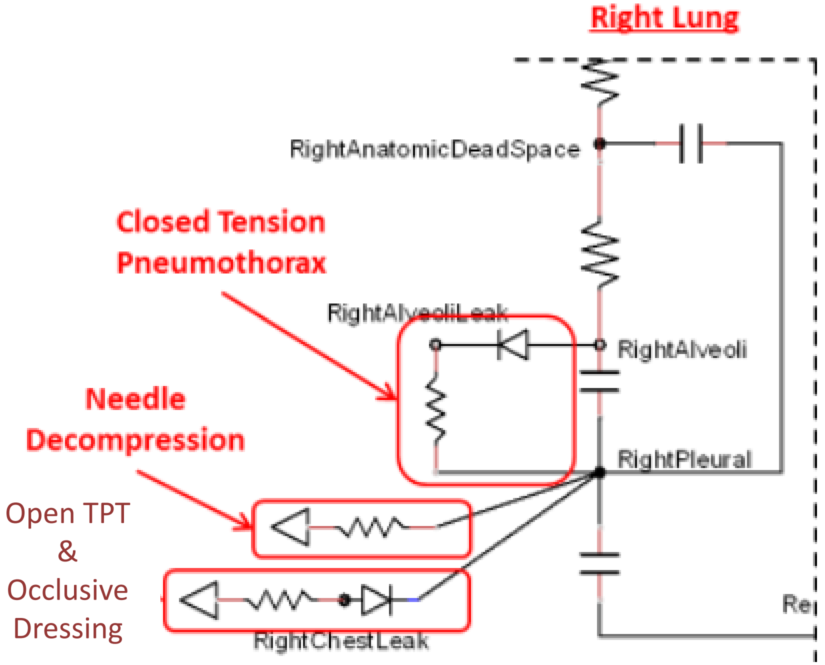
Protocol:

Four severities:

- Mild tension pneumothorax (TPT): +10 mmHg intrathoracic pressure (normal baseline is -4 mmHg)
- moderate TPT: +15 mmHg
- severe TPT: +20 mmHg
- open pneumothorax: 0 mmHg

Run each severity:

1. until parameters stable or endpoint reached
2. for 3 minutes, then off, then for 3 minutes
3. for 3 minutes, then "needle decompression" or "chest tube" intervention and run for 3 min



BioGears lumped parameter circuit model for Pneumothorax and the treatments involved

Work led to validation updates to respiratory driver v7.2

Results: Modifying a Scenario

Generic “code-agnostic” scenario xml file example, can be “pre-programmed” for your specific scenario and for ***repeatability***

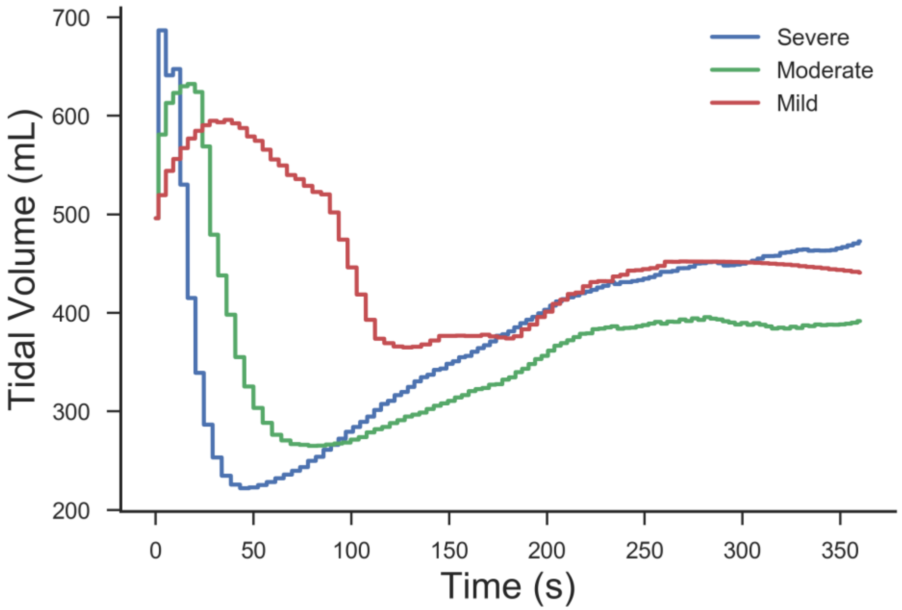
```xml
<Action xsi:type="TensionPneumothoraxData" Type="Closed" Side="Right">
    <Severity value="0.3"/>
</Action>
<Action xsi:type="AdvanceTimeData">
    <Time value="3.0" unit="min"/>
</Action>
<Action xsi:type="NeedleDecompressionData" State="On" Side="Right"/>
<Action xsi:type="AdvanceTimeData">
    <Time value="3.0" unit="min"/>
</Action>
```

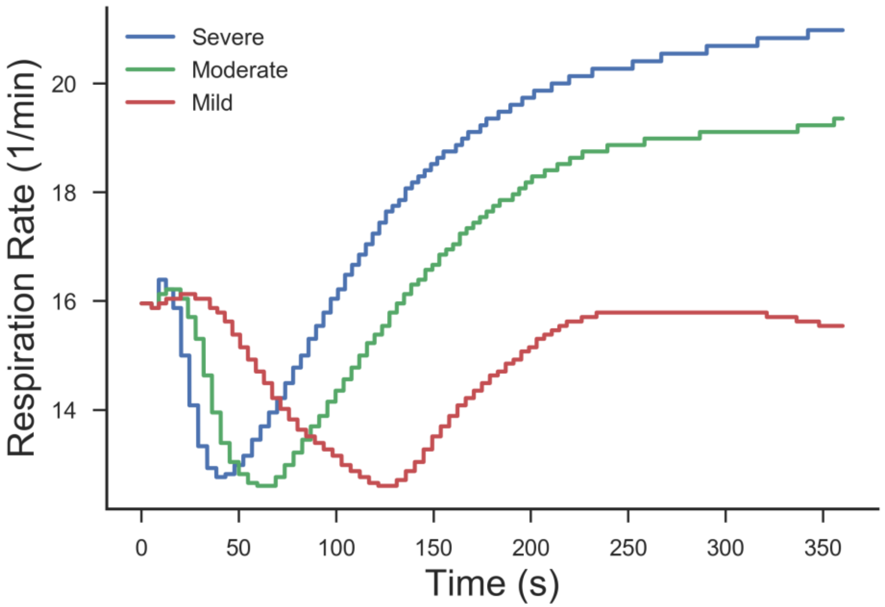
```xml
<Action xsi:type="TensionPneumothoraxData" Type="Closed" Side="Right">
    <Severity value="1.0"/>
</Action>
<Action xsi:type="AdvanceTimeData">
    <Time value="3.0" unit="min"/>
</Action>
<Action xsi:type="NeedleDecompressionData" State="On" Side="Right"/>
<Action xsi:type="AdvanceTimeData">
    <Time value="3.0" unit="min"/>
</Action>
```

```cpp
// Create a Tension Pnuemothorax
// Set the severity (a fraction between 0 and 1)
SETensionPneumothorax pneumo;

// You can have a Closed or Open Tension Pneumothorax
pneumo.SetType(CDM::enumPneumothoraxType::Closed);
//pneumo.SetType(CDM::enumPneumothoraxType::Open);
pneumo.GetSeverity().SetValue(0.75);

// It can be on the Left or right side
pneumo.SetSide(CDM::enumSide::Right);
//pneumo.SetSide(CDM::enumSide::Left);
pneumo.SetComment("ICD-9: 860.0");
//pneumo.SetComment('ICD-9: 860.0');
bg->ProcessAction(pneumo);
```

SDK “HowTo-TensionPneumothorax.cpp file example, dynamic execution

Results





- Scenarios show a 6 minute sustained closed tension pneumothorax
- Respiration rate initial decrease as the circuit stabilizes to the initial action
- Tachypnea happens after initial decrease and stabilizes at this higher rate
- Decreased tidal volume is consistent with collapse of the lung under pressure
- Can be used as a training tool for needle decompression or chest tube insertion
- Can be used as a research tool to investigate different patient responses to injury
    - Recovery rate for a diabetic?
    - Other treatments needed for combined respiratory insults?

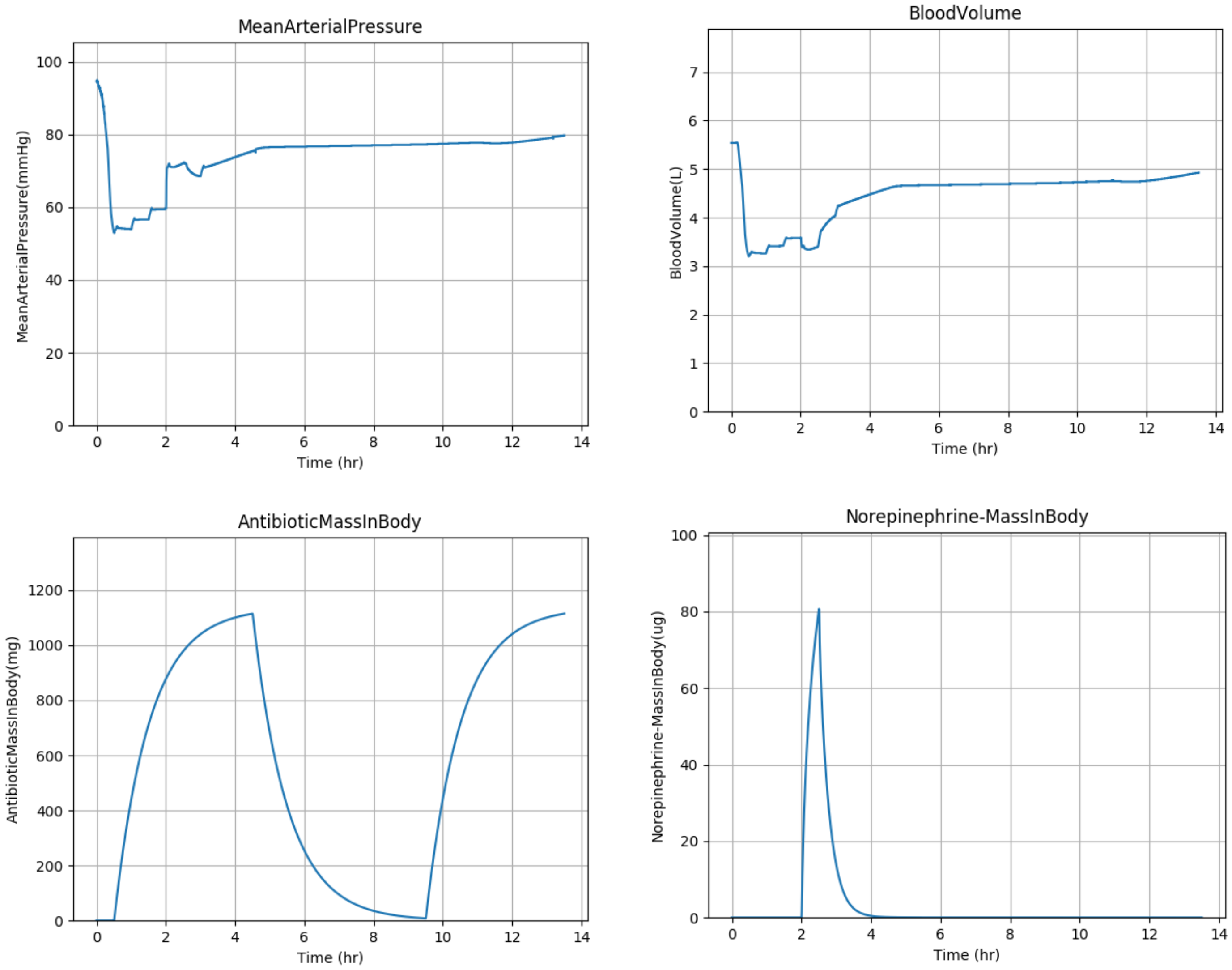
Sepsis Collaboration

1. ***Fast Progression***
   - Compartment = Gut
   - Severity = 1.0
2. ***Fast Progression w/ Treatment***
   - Treatment designed to mimic early-goal directed therapy (Rivers et all[12]) and that proposed by Keller/Barnes/Kiberenge/Konia
   - Scenario Actions (time, min)
   - Sepsis (t = 0 min)
     - Compartment = Gut
     - Severity = 1.0
   - Administer antibiotic (t = 30 min) [Barnes/Kiberenge/Konia]
     - 4.5 g over 4 hrs
     - Monitor for 4 hrs
   - Administer saline (t = 30 + 30n, n = 0:5)[12]
     - 500 mL bolus every 30 min
     - Each bolus infused over 5 min
   - Start norepinephrine infusion (t = 120 min)
     - 14 ug/min (0.19 ug/kg/min) = Highest dose explored by Ensinger[17]
     - Cited study in healthy volunteers with consideration of septic shock implications
     - From previous runs, t = 120 is about the time MAP < 65 mmHg
   - End norepinephrine infusion (t = 150 min)
   - Administer antibiotic (t = 510 min)
     - 4.5 g over 4 hrs

Scenario: Severe Progression with Treatment

Note: Our sepsis model has been updated, as well as our antibiotic administration (new oral options!)

Shows our iterative approach to validation

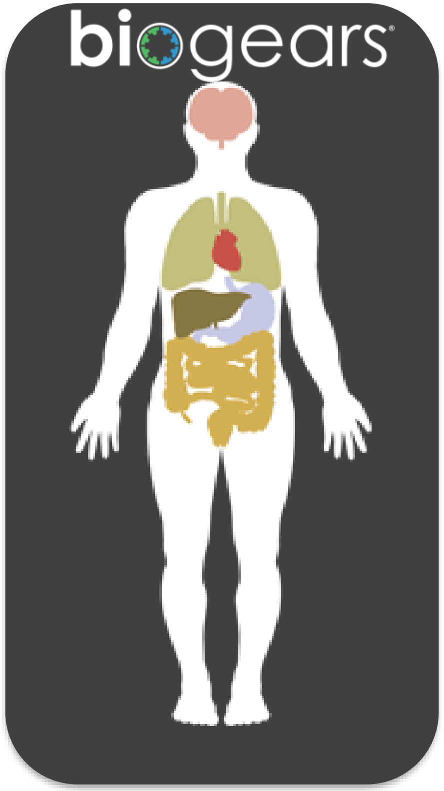


WORK WITH USISR

Work With USISR

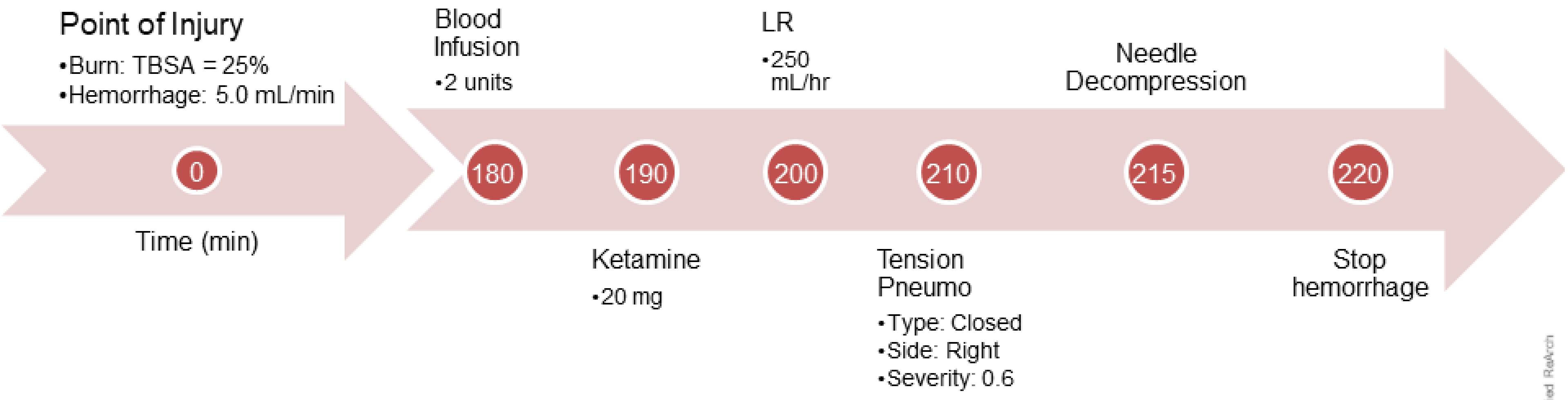
Working with USISR to develop a burn inflammation model

- Includes updating/creating new scenarios
    - And how-tos
- Provide all possible output data and update our CDM
- Work with team to validate core burn model
- Work on publications and use cases with fellows at USISR
- Proposed teaming on future efforts



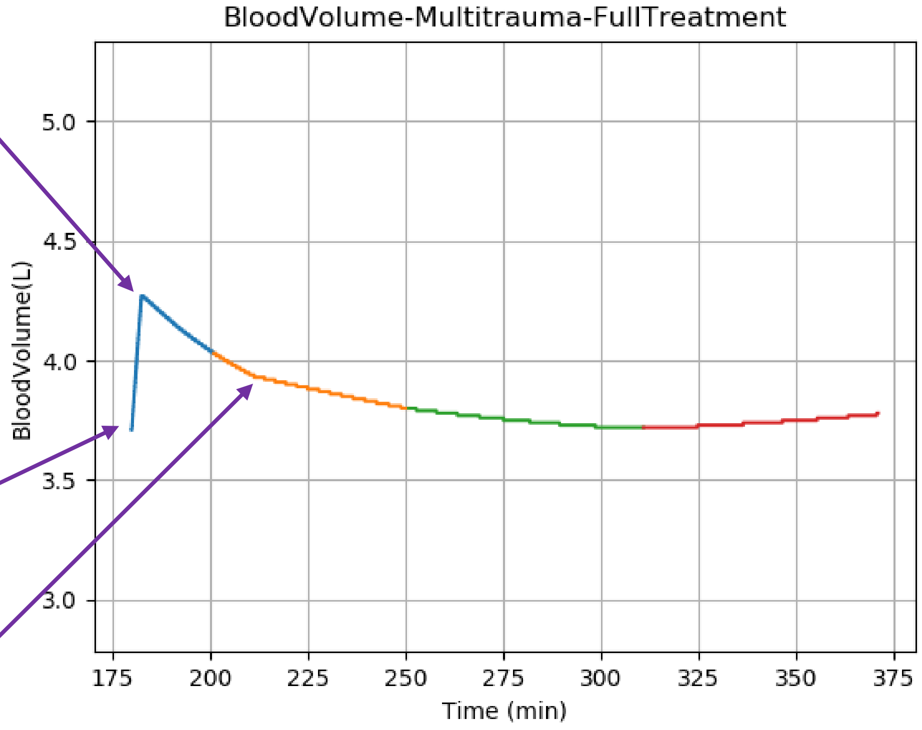
Two way street to support core application

Work With Advanced Modular Manikin



Work With USISR

End of blood infusion



Vascular volume loss reversed

Start of blood infusion

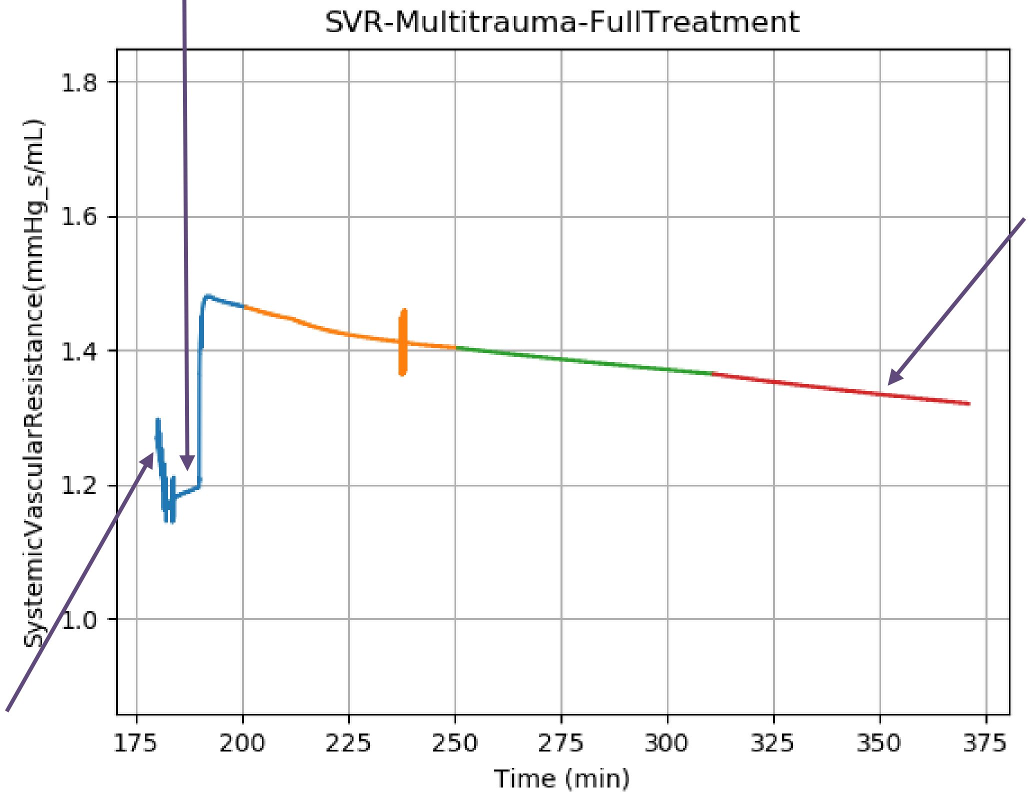
Stop hemorrhage

Legend

- Blue: Blood infusion
- Orange: LR @ 250 mL/hr
- Green: LR @ 312.5 mL/hr
- Red: LR @ 391 mL/hr

Work With USISR

Ketamine: Is increase in SVR how it accomplishes cardiac changes?



Decreasing as vascular volume restored

Blood infusion

Legend

- Blue: Blood infusion
- Orange: LR @ 250 mL/hr
- Green: LR @ 312.5 mL/hr
- Red: LR @ 391 mL/hr

Work With USISR

Action, start (min)	Sampled Time (min)	Heart Rate (1/min)	Respiration Rate (1/min)	Hematocrit
Burn: TBSA = 0.25 (0)	180	Increase (to ≈125)[GP]	Increase (to ≈ 22)[GP]	Increase[SME]
Hemorrhage: 5 mL/min (0)	180	Increase (to ≈125)[GP]	Increase (to ≈ 22)[GP]	--
Infusion: Blood (180)	185	Decrease[BG]	No change[BG]	Decrease[BG]
Ketamine Bolus: 20 mg (190)	200	Increase[22]	Decrease secondary to pain level decrease (to ≈ 15)[GP]	--
Infusion: LR, 250 mL/min (200)	260, 320, 380	Decrease, remain tachycardic[GP]	No change[BG]	Decrease[BG]
Tension Pneumothorax (210)	215	Increase[GP]	Increase[BG]	--
Needle Decompression (215)	220	Decrease[GP]	Decrease[BG]	--

Work With USISR

Action (Start Time, min)	Sampled Times (min)	Urine Output (mL/min)	SVR (mmHg-s/mL)	Blood Pressure (mmHg)
Burn: TBSA = 0.25 (0)	180	< 30 mL/hr[GP]	Increase[SME,]	Constant initially, then drop (to ≈ 95/60)[GP]
Hemorrhage: 5 mL/min (0)	180	Decrease[BG]	Increase[BG]	Constant initially, then drop (to ≈ 95/60)[GP]
Infusion: Blood (180)	185	Increase[BG]	Decrease[BG]	Increase[BG]
Ketamine Bolus: 20 mg (190)	200	--	Unclear[22]	Increase[22]
Infusion: LR, 250 mL/min initially (200)	260, 320, 380	Increase[BG]	Decrease[BG]	Increase[BG]
Tension Pneumothorax (210)	215	--	--	Decrease[GP]
Needle Decompression (215)	220	--	--	Increase[GP]

WORK WITH OTHERS

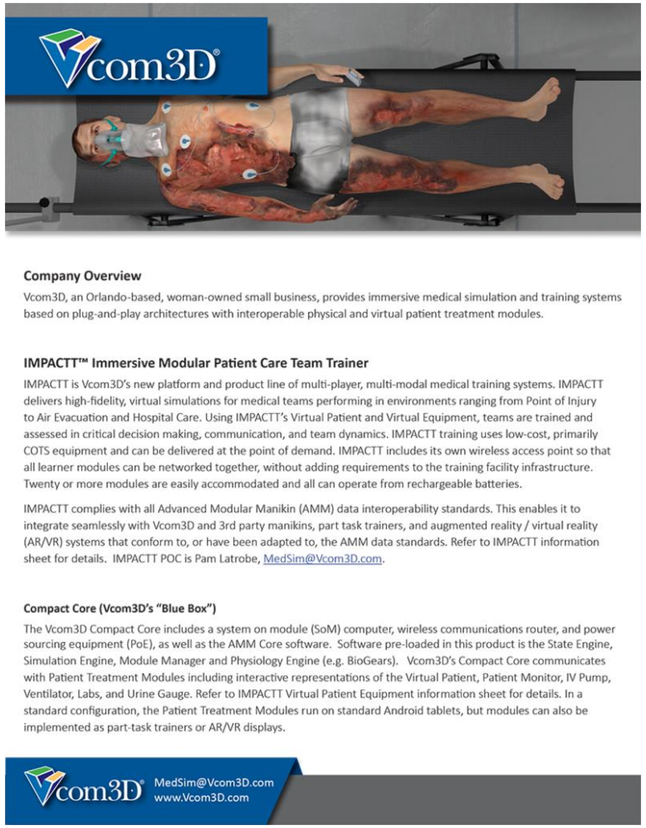
VCom3D

Helped them with integrating BioGears into the AMM project

They helped us with validation for saline infusion

They helped us with validation for respiratory scenarios

Have leveraged our burn and other trauma models for current work



Vcom3D®

Company Overview

Vcom3D, an Orlando-based, woman-owned small business, provides immersive medical simulation and training systems based on plug-and-play architectures with interoperable physical and virtual patient treatment modules.

IMPACTT™ Immersive Modular Patient Care Team Trainer

IMPACTT is Vcom3D's new platform and product line of multi-player, multi-modal medical training systems. IMPACTT delivers high-fidelity, virtual simulations for medical teams performing in environments ranging from Point of Injury to Air Evacuation and Hospital Care. Using IMPACTT's Virtual Patient and Virtual Equipment, teams are trained and assessed in critical decision making, communication, and team dynamics. IMPACTT training uses low-cost, primarily COTS equipment and can be delivered at the point of demand. IMPACTT includes its own wireless access point so that all learner modules can be networked together, without adding requirements to the training facility infrastructure. Twenty or more modules are easily accommodated and all can operate from rechargeable batteries.

IMPACTT complies with all Advanced Modular Manikin (AMM) data interoperability standards. This enables it to integrate seamlessly with Vcom3D and 3rd party manikins, part task trainers, and augmented reality / virtual reality (AR/VR) systems that conform to, or have been adapted to, the AMM data standards. Refer to IMPACTT information sheet for details. IMPACTT POC is Pam Latrobe, MedSim@Vcom3D.com.

Compact Core (Vcom3D's "Blue Box")

The Vcom3D Compact Core includes a system on module (SoM) computer, wireless communications router, and power sourcing equipment (PoE), as well as the AMM Core software. Software pre-loaded in this product is the State Engine, Simulation Engine, Module Manager and Physiology Engine (e.g. BioGears). Vcom3D's Compact Core communicates with Patient Treatment Modules including interactive representations of the Virtual Patient, Patient Monitor, IV Pump, Ventilator, Labs, and Urine Gauge. Refer to IMPACTT Virtual Patient Equipment information sheet for details. In a standard configuration, the Patient Treatment Modules run on standard Android tablets, but modules can also be implemented as part-task trainers or AR/VR displays.

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IMPACTT™

Immersive Modular Patient Care Team Trainer

Shared Virtual Patient View

The **IMPACTT™ Team Trainer** is a *system of systems* that wirelessly integrates Vcom3D's implementation of the Advanced Modular Manikin (AMM) open source standard with various configurations of Vcom3D and third-party medical simulation and training modules. These modules can be configured to simulate multiple echelons of care. Team performance impacts patient's condition during real-time scenarios. Individual and Team Performance is captured in both team assessments and patient ourtcomes. IMPACTT leverages the platform and distributed medical simulation modules described below.

Compact Core

Vcom3D Compact Core includes computer hardware, a wireless router, power sourcing equipment (PoE), and embedded AMM core software. The pre-loaded software consists of the state engine, simulation engine, module manager, and physiology engine (e.g. BioGears).

Learner Tablets

For each scenario, a learner performs the role of Physician, Nurse, Technician, or Respiratory Tech. The learner tablets enable each practitioner to perform interventions that are displayed on both the learner tablets and the virtual patient shared view.

Instructor Tablet

Instructor Tablet includes tabs for Scenario Control and Learner Assessment. The module automatically records and displays each learner action while treating the patient. The instructor may also note the use of team communication and appropriateness of the actions.

Virtual Equipment

Learners interact with virtual medical equipment, including a ventilator, patient monitor, triple IV pump, urine gauge, and lab reports. Each item of equipment is simulated on a standard touch screen tablet and includes a graphical user interface that functions like the actual medical device. Refer to IMPACTT Virtual Patient Equipment information sheet for details.

Part Task Trainers and Female Manikin

Female Trauma Manikin, Central Venous Access part-task trainer, and HHIO trainer have been integrated with IMPACTT and are each used during scenarios on which the learner performs selected procedures.

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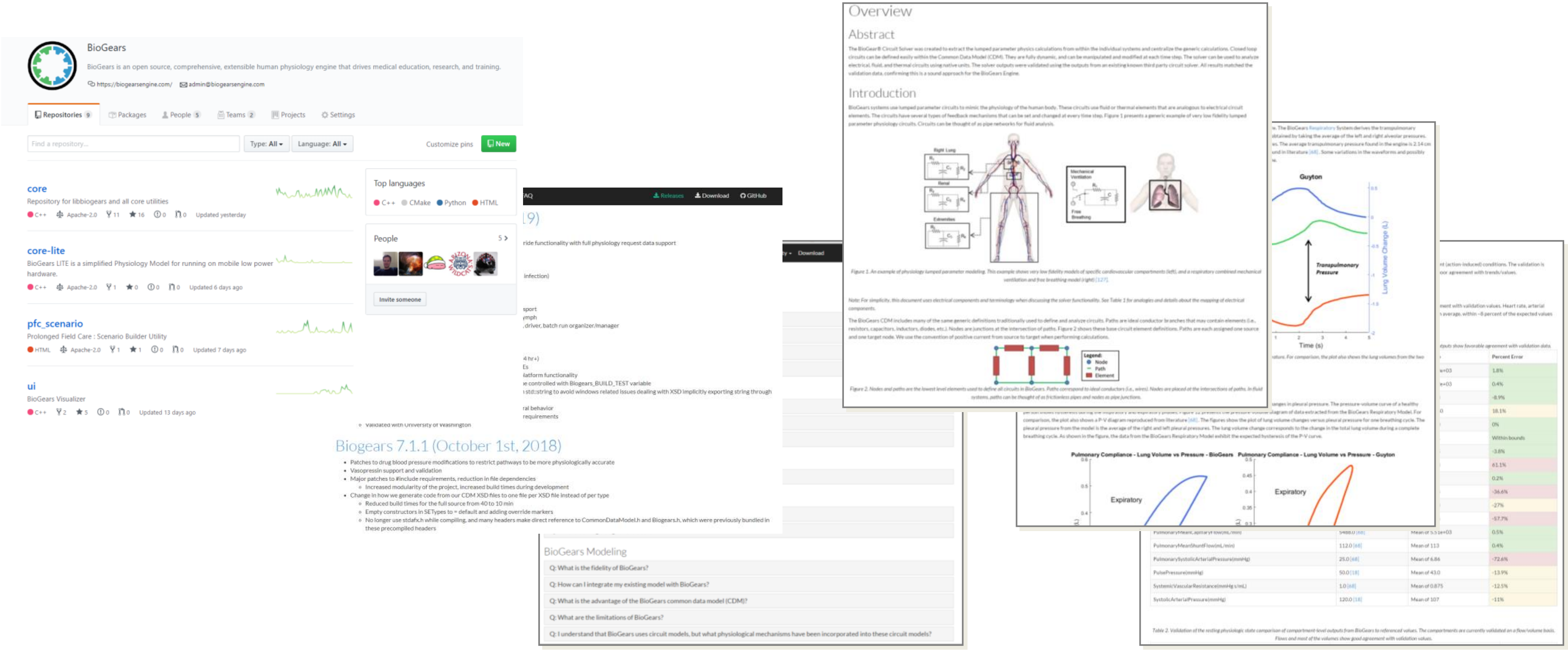
Documentation and Tutorials

- The website includes detailed documentation for each physiology system and software component (e.g., CDM, Toolkit, SDK, Source Code)
- This includes text and tables that explain: system background, model limitations, equations used, and validation data sources and matrices
- https://www.biogearsengine.com, https://www.biogearsengine.dev
- Github site for code, pushing changes, and logging errors/bugs (github)



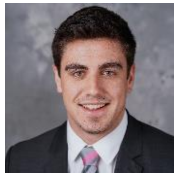
BioGears: Future

Thank you!

Team







Contracts

W81XWH-17-C-0172

Select Government Collaborators/Users

ARL

TATRC

PEO STRI

Select University Collaborators/Users

THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

Carnegie Mellon University

MGH 1811 MASSACHUSETTS GENERAL HOSPITAL

Select Commercial Collaborators/Users

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