Integration of AI/ML into clinical workflows

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Disclaimer

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Overview of the Surgical Critical Care Initiative (SC2i)

FUNDING SOURCE  STRUCTURE  REPORTING

- Funded by DOD
- Launched in 2013 and designated as a USU Center in 2016
- A Federal / Non-Federal partnership
- Biannual Oversight Meetings

DUAL FOCUS

- Leveraging clinical and -omics data to develop 'precision' CDSTs in the acute care space
- Improving outcomes and lowering costs in both military and civilian systems

<table>
<thead>
<tr>
<th>CDSTs in development</th>
<th>Anticipated deployment</th>
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</thead>
<tbody>
<tr>
<td>AIDEx/AIDEx</td>
<td>FY23</td>
</tr>
<tr>
<td>WoundEx™</td>
<td>FY24</td>
</tr>
<tr>
<td>VTE Dx</td>
<td>FY24</td>
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<tr>
<td>Pneumonia Dx</td>
<td>FY24</td>
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<tr>
<td>ARI Dx</td>
<td>FY24</td>
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<tr>
<td>OA Dx</td>
<td>FY25</td>
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<tr>
<td>Bacteremia Dx</td>
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<tr>
<td>xMRI Dx</td>
<td>FY25</td>
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</tr>
<tr>
<td>ARDS Dx</td>
<td>FY26</td>
</tr>
<tr>
<td>SBO Dx</td>
<td>FY26</td>
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</tbody>
</table>

SC2i clinical research supported by:
- 2,400 + patients enrolled
- 86 million data elements
- 14.6 million molecular assay measurements
- 88,000 + biobank specimens

SC2i research products include at least 11 in-development and 3 deployed CDSTs, including AIDEx 1.0, MTP, and IFI.

To efficiently utilize all of this information, the data must be in a common format

- In the process of converting our databases into a relational data in OMOP format
  - Large flat files are an inefficient way of storing data
  - Observational Medical Outcomes Partnership (OMOP) Common Data Model is a standardized way to structure data
  - Will allow for more easy integration of new datasets
- Developing a data lake for assay results
  - Will allow for the integration of new assay results into our datasets

OMOP Structure

OMOP

Data Lake

SPECIMEN
specimen_id
person_id
other columns
specimen_source_id

REQUEST
specimen

<instrument>_lab_qc
Instrument output columns

<instrument>_curated
curated instrument output columns
specimen_id
WounDx™ Purpose and Process

- WounDx™ is a device intended to assist surgeons in making decisions related to the timing of closure for traumatic extremity wounds
  - Following consultations with the FDA, this device classified as class II (moderate risk)

- WounDx™ is a combination product
  - Biomarkers (Cytokine Panel: IL-5, IL-7, IL-15, IL-17A, IL12/IL23p40, GMSCF)
  - Clinical factors (Wound size measurements, wound location, wound type)
  - Predictive algorithm

- Initial wound effluent samples collected upon enrollment + 12~24 hours prior to each debridement

- WounDx™ provides clinicians with a binary recommendation of whether the wound should be closed in the next 24 to 72 hour prior to next debridement
### WoundDx Trial Study Design/Phases

- **Screening, enrollment:**
  - Randomization (blinding of CRT)

- **All wound surgeries:**
  - Samples, data and pictures (documentation and transfer)

- **Confirming wound closure:**
  - (30 days post closure)

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**Using multivariate data to predict sepsis occurrence**

**Proposed Schematic of Algorithm/Workflow**

- Multivariate time series
- DV Partitioning
- Network representation
- EMR features
- SVM Classifier
- Septic?

**Difference in network topology can be seen in control (blue) and pre-septic (red) patients**

Shashikumar et al., 2018 Physiol Meas.
AIDEx in the MHS

- Artificial Intelligence Decompensation Expert (AIDEx) is a clinical decision support tool that identifies patients with sepsis on average 4-8 hours prior to clinician suspicion
  - Received DNA funding for integration at ten level 5 MTFs

- AIDEx is composed of two key components:
  1. A location & EHR agnostic pipeline
     - Interfaces with a health system’s EHR to provide the algorithm with real-time patient data; Provides clinicians with a user interface for interpreting the algorithm’s predictions
  2. A machine-learning based sepsis prediction algorithm

Limitations with AI/ML Modeling of Real World Data to predict hospital complications

- Machine Learning and Artificial Intelligence are being used for prediction of various complications including sepsis and multiple organ failure yet there are challenges to these approaches
  - Improving the actual predictive performance
  - Future robustness of models
  - One way to improve performance is generating more data for the selected features to train these models but the actual amount of data is limiting
  - Synthetic datasets could be used to aid in training of the models
    - Has been done previously in image recognition/generation and text analysis/recognition
  - Propose the need to generate synthetic multiplexed mediator time series data coincides with the advent of the concept of medical digital twins
    - Specifically related to interpretations of medical digits twins that hew closely to the original description and use of industrial digit twins
    - Involves generating multiple digital twins from a common computation model specification
Plans to create a Post-Burn Sepsis Digital Twin to augment the development of ML-models to predict sepsis and MODS

Overview of Arrangement of Organ Configuration

Circuit Diagram designed that incorporates organ/tissue systems of interest

Labeled Points of Interest on Circuit Diagram

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
<th>Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Myocardium</td>
<td>9</td>
<td>Shunt</td>
</tr>
<tr>
<td>2</td>
<td>Pericardium</td>
<td>10</td>
<td>Pulmonary Circulation</td>
</tr>
<tr>
<td>3</td>
<td>Vena Cava</td>
<td>11</td>
<td>Arteries</td>
</tr>
<tr>
<td>4</td>
<td>Bleeding</td>
<td>12</td>
<td>Capillaries</td>
</tr>
<tr>
<td>5</td>
<td>IV</td>
<td>13</td>
<td>Veins</td>
</tr>
<tr>
<td>6</td>
<td>Right Heart</td>
<td>14</td>
<td>Liver</td>
</tr>
<tr>
<td>7</td>
<td>Left Heart</td>
<td>15</td>
<td>Kidney</td>
</tr>
<tr>
<td>8</td>
<td>Aorta</td>
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SC2i’s innovations allow for the consortium to address complex questions in critical care using novel methods and infrastructure
Acknowledgements

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