Simulating the Flow of Patients with Aortic Dissection through a Cardiac Intensive Care Unit

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Introduction

Aortic dissection (AD) is an emergency cardiovascular condition affecting the aorta. It is the result of a tear in the inner wall of the aorta causing severe internal bleeding and potential death.

Mortality rate for AD increases 1% per hour [1] and 20% of AD individuals die before reaching the hospital [2].

Aortic dissections are rare, but when they occur, they are medical emergencies.

AD patients receive care among other cardiovascular surgery patients, which represent the most common surgery in the United States [3].

Cardiovascular disease is the leading cause of death in the US [3]. By 2030, approximately 40.5% of the US population is projected to have some type of cardiovascular disease [4].

Preliminary analysis conducted by the CVC staff showed that the most common reason for patient deferral when requesting transfer to Michigan Medicine is attributed to unavailable ICU beds.

Objective

Our research was motivated by the desire to ensure adequate capacity in a major teaching hospital to accept aortic dissection patients for transfer. This led to a broader investigation of how to more effectively utilize the cardiovascular ICU, which is often the limiting resource.

Materials and Methods

Test Policies to Increase AD Patients’ Access to High Quality Care

Simulation Logic

Patient Arrives

- Open ICU Bed?

<table>
<thead>
<tr>
<th>Assumptions</th>
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<tbody>
<tr>
<td>- OR, surgeon and staff are always available</td>
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<tr>
<td>- Any patient can be denied</td>
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</tbody>
</table>

Patient Denied

- Step Down

Discharged

PREPARED FOR DISCHARGE

Simulation Arrival Rate Increased by 30%

<table>
<thead>
<tr>
<th>Outside Transfer Arrival Rate</th>
<th>0.0002</th>
<th>0.0783</th>
<th>0.1015</th>
<th>0.1232</th>
<th>0.1719</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside Transfer Declined</td>
<td>2718</td>
<td>2718</td>
<td>2718</td>
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<td>2718</td>
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<tr>
<td>Internal Transfer Bottleneck</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>ICU Average LOS Outside Transfer</td>
<td>4.93 days</td>
<td>4.93 days</td>
<td>4.93 days</td>
<td>4.93 days</td>
<td>4.93 days</td>
</tr>
<tr>
<td>ICU Average LOS Internal Transfer</td>
<td>3.63 days</td>
<td>3.63 days</td>
<td>3.63 days</td>
<td>3.63 days</td>
<td>3.63 days</td>
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<tr>
<td>ICU Average LOS SDN Status</td>
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<td>0 days</td>
<td>0 days</td>
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<tr>
<td>SDN Average LOS</td>
<td>3.63 days</td>
<td>3.63 days</td>
<td>3.63 days</td>
<td>3.63 days</td>
<td>3.63 days</td>
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</tbody>
</table>

- Time Horizon = 1 Year
- Replications = 1,000
- % ICU Beds
- % SDN Beds
- Internal Transfer Arrival Rate: 0.2% per hour

Conclusions

The use of flexible, domain-specific simulation tools can enable policymakers to better plan and operate complex clinical systems. In addition, through collaborative development and use of such tools, physicians and other clinical decision-makers can develop a deeper understanding of the effects of variability on system behavior, leading to better decision making.

Acknowledgement

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References


