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

1st Luke Liu[1], 2nd Harini Pennathur[1], 3rd Amy Cohn[1]
[1]Industrial & Operations Engineering, University of Michigan, Ann Arbor, MI

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].

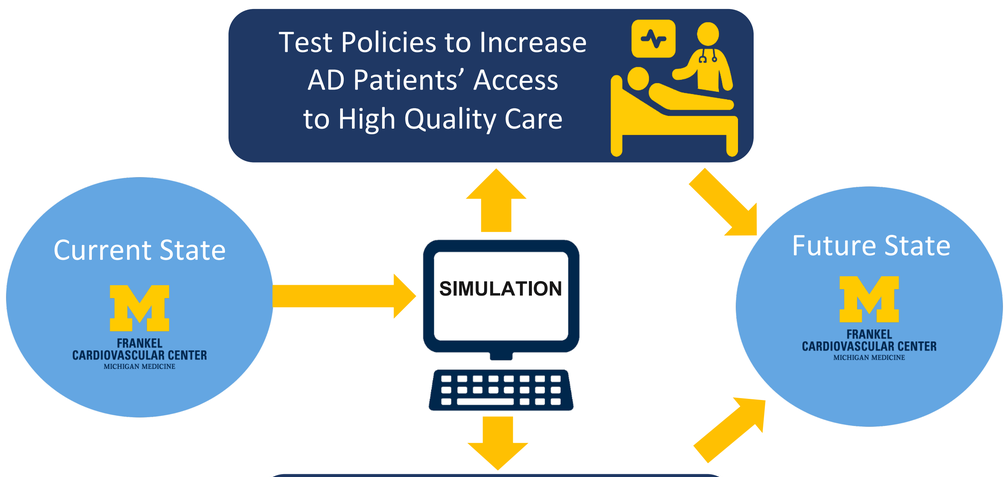
Cardiovascular disease is the leading cause of death in the US [3]. By 2030, approximately 40.5% of the US population is projected to have some type of cardiovascular disease [4].

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



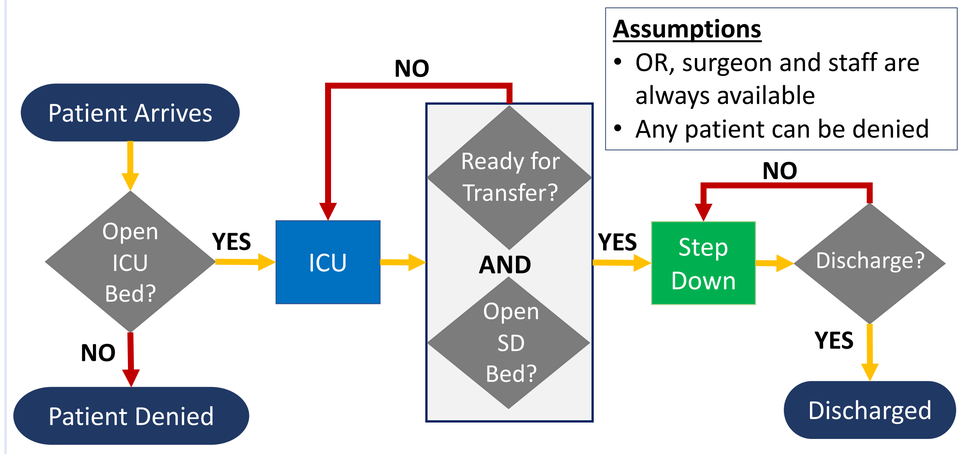
Results and Discussion

Patient arrival patterns greatly impact the utilization of scarce resources such as a cardic ICU, and variability in both patient arrivals and patient lengths-of-stay can make managing these resources challenging. Understanding the system-wide impact of policies and procedures (e.g. number of ICU vs stepdown beds; scheduling policies for elective procedures) can lead to better decision making.

Analysis:

1. **SDn Variation**
   - Change number of shared SDn beds
2. **Arrival Rate**
   - Change the hourly patient admission rate

Simulation Logic



Percentage of Shared Beds Available: 25% | 50% | 75% | 100%

Allocated Stepdown Beds	25	34	43	52
Patient Arrival	2718	2715	2717	2716
Outside Transfer Declined	**3%**	**2%**	**2%**	**2%**
Internal Transfer Bottleneck	**12%**	**9%**	**9%**	**9%**
ICU Average LOS Outside Transfer	4.93 days	4.93 days	4.93 days	4.95 days
ICU Avg LOS Internal Transfer	3.63 days	3.62 days	3.62 days	3.62 days
ICU Average LOS SDn status	**0.27 days**	**0.01 days**	**0 days**	**0 days**
SDn Average LOS	3.56 days	3.81 days	3.83 days	3.83 days

- Time Horizon = 1 Year
- Replications = 1,000
- 32 ICU Beds
- 16 Dedicated SDn Beds

Outside Transfer Arrival Rate Increased by 30%

Outside Transfer Arrival Rate	0.0602	0.0783	0.1017	0.1323	0.1719
Patient Arrival	2716	2875	3076	3345	3695
Outside Transfer Declined	**2%**	**4%**	**6%**	**9%**	**14%**
Internal Transfer Bottleneck	**9%**	**12%**	**15%**	**17%**	**20%**
ICU Average LOS Outside Transfer	4.95 days	4.95 days	4.98 days	4.98 days	5.02 days
ICU Avg LOS Internal Transfer	3.62 days	3.64 days	3.66 days	3.68 days	3.71 days
ICU Average LOS SDn status	**0 days**	**0 days**	**0 days**	**0 days**	**0 days**
SDn Average LOS	3.83 days	3.83 days	3.84 days	3.83 days	3.83 days

- Time Horizon = 1 Year
- Replications = 1,000
- 32 ICU Beds
- 52 SDn Beds
- Internal Transfer Arrival Rate = 0.25 patient/hr

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.

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