Mrs. M’s Story
She is 91 years old

- Independent in caring for herself, lives alone
- Teaches Sunday school and sings in the choir, “spry”
  recently uses wheelchair for long distances
- Has 3 daughters, 1 son

“Mama is still large and in charge.”

Past medical history:

_Vascular_: Type II diabetes, hypertension, hyperlipidemia, obesity, remote stroke (mild L arm weakness)

_Non-vascular_: Arthritis, H/o Breast cancer in 1996

Went to see her primary doctor for rectal bleeding ->
Diagnosed with colorectal cancer
A hard decision: Surgery or no surgery?
Course

Underwent proctocolectomy with end colostomy

Day 1: Blood pressure dropped (78/50); Bleeding from surgical site
- Transfused 2 units of blood and received medicines to keep blood pressure normal

Day 2: Massive Heart Attack. Emergent cardiac catheterization shows many blockages. New heart failure. Could not immediately open the clots in her heart, in setting of surgical site bleeding. 1:1 balloon pump, intubated
Patient remained lucid; passed “Vigilance A” test; giving “thumbs up” sign
“A Week of Hellish Uncertainty”
Questions I asked myself all week

• How much stress can this complex dynamic system take and still regain homeostasis?
• What reduced state will the system be in, when or if it regains stability?
• Is the system showing signs of critical failure? Are we past a point of no return?
• Are there tests we could do NOW (or should have done BEFORE) that would help answer the first questions?
Course

**Day 9:** Undergoes cardiac revascularization w/ bare metal stents. Balloon pump removed.
- Remains lucid: smiling, nodding appropriately
- Slow weaning from ventilator (a good sign)

**Day 11:** Ventilator requirements increase; diagnosed with **vent-associated pneumonia.** Self-extubates in early a.m., but had to be re-intubated within hours. First sign of confusion.

**Day 12:** **Cardiac Arrest, resuscitated;** Fluid on lungs; Team had to restart IV medications to maintain blood pressure
- Holiday weekend – family wants to wait to make decisions until full team can assess her and weigh in.
Course

Day 14: Kidney function worsens.

Day 16: Patient is confused again (alert, trying to communicate, unable to use alphabet board)

Status Changed: Do Not Attempt Resuscitation

Day 17-20: Some signs of improvement – a little more lucid; kidneys are improving; blood pressure more stable; slow weaning from the ventilator

Day 21: Frank bleeding in endotracheal tube

Asystolic arrest
Mrs. M’s course didn’t really look like any of these...
The “real world” course was maybe more like this

- Surgery
- Heart Attack
- Pneumonia
- Cardiac Arrest
- Pulmonary Hemorrhage

**Functional Status**

- Whole person
- Cardiovascular
- Immune/Thrombotic
- Central nervous system

**Time**
Applying the Emerging Construct of “Physical Resilience” to Clinical Care
Working Definitions

**Physical Resilience** = ability to avoid or recover from functional decline following acute or chronic health stressors

Resiliencies = resilience within discrete organ systems to a particular stressor

Reserve = potential capacity of a cell, tissue, or organ system to function beyond its basal level in response to demands (stressors)
Phenotyping Resilient Outcomes after a Stressor
Working Conceptual Model

Physical Resilience

Pillars of Aging

- Reserve
- Psychology
- Social
- Environment

Stressor

Outcomes/
Resiliency
Phenotypes
Approach for Clinical Research on Physical Resilience

- **Stressor Characteristics**: Intensity, Duration, Features
- **Status before Stress**: Cell, tissue, organ level, Whole-person health indicators, Social/environmental
- **Resiliency Outcome Measures**: Repeated measures of health
- **Tests and Assays**: Do they predict trajectory phenotypes?
- **Interventions**: Do they alter trajectory phenotypes?
- **More resilient responses**
- **Less resilient responses**

Time -> Function
Clinical Tests that may indicate level of resilience to some future stressor
Predicting Resilience – Provocative Tests

• **Stimulus-Response**

• **Examples in use:**
  – Response to vaccine
  – Glucose tolerance test
  – Gait lab challenge
  – Dual tasking tests
Predicting Resilience – Dynamic output

Multiple, interconnected inputs = complex output

Force Platform

Zhou et al. Sci Reports 2017
Ongoing Study in Elective Surgery Cohort

EEG Density (n=25)

Pre-op Average Complexity

Change in Average Complexity
Points for Discussion

• Conceptualizing resilience in discrete organ systems versus one complex dynamical system
  • Helpful or overly simplistic?
  • Role of psychological, social, and spiritual domains

• What tests or markers BEFORE surgery, or along the way, may have predicted course?
  • Stimulus-response (stress) tests? Biomarkers?

• What interventions may enhance resilience?

• Elective procedures as an opportunity to address knowledge gaps about human physical resilience
RESERVE SLIDES
Quantifying Phenotypes of Resilience

Stressor

Initial (I)  Post-Recovery (P)

Point of No Return (D)  Nadir (N)

Resilience Parameters
1. $P - I$ at a given $t$
2. $P - N$
3. $(P - N)\Delta t$ (rate of recovery)

Reserve = $(I - D)$

More Resilient  Less Resilient

$P = I$; Quick  $P = I$  $P < I$  $P << I$  Dead

Is resilience related to distance between the initial state and point of no return?
Is resilience related to the distance between nadir and the point of no return?
What degree of recovery is sufficient to be considered resilient?

Courtesy of Dr. Stephen Kritchevsky, Wake Forest University
Geroscience Initiative – The Pillars of Aging

7 intertwined and potentially modifiable pathways affected by age

**Hypothesis:** Favorable biology in these pathways may cut across organ systems to support resilience at the whole-person level.

From Kennedy et al. *Cell* 159; 2014
Resilience is About What Happens After the Stressor

The spectrum from robust to frail may reflect an individual’s degree of physical reserve (potential capacity).

Resilience reflects the actualization of that potential.