

1. Initial state model

- Start with Ankush's model
 - Geometry, CFA, material properties

Determine $\vec{\xi}_{FSM}$
for each leaflet

Determine $\vec{\xi}_{EM}$
for each leaflet

2. Quasi-static simulation in the current state

- Pressure waveform for 1 cycle at simulation time s_i can be physiological, AWT, or others to be specified

QS simulation

$\mathbf{F}_{RMS}(\vec{X}, s_i)$ for
each leaflet

3. Update $\vec{\xi}_{EM}(\vec{X}, s_i)$ and $\mathbf{F}_{PS}(\vec{X}, s_i)$

k

Compute $\vec{\xi}_{FSM}(L, s_i)^3$
Assume the same
for each leaflet L

Find $\mathbf{F}_{PS}(\vec{X}, s_i)$ by minimizing the FSM
with the parameters $\vec{\xi}_{FSM}(\vec{X}, s_i)$

Compute
 $\vec{\xi}_{EM}(L, s_i)$

4. Update unloaded leaflet geometry and collagen fiber architecture

Pseudo pressure field $\vec{p}(\vec{X})$
to be optimized
Not necessarily normal to
surface

QS simulation

$\mathbf{F}_p(\vec{X})$

Acceptable?

Yes

Update the
unloaded
geometry with
 $\mathbf{F}_p(\vec{X})$

Update the convected
CFA(\vec{X}) in the
unloaded state

Update

No

$$s_i = s_{i-1} + \Delta s$$

END of
cycling

¹ Calibrated with existing data and published behaviors

² Check results against extant data

³ The PS rate constant k may need to be updated

⁴ Using $\mathbf{F}_{RMS}(\vec{X}, s_i)$ to append the array keeping track of the strain history at every \vec{X} , $\mathbf{A}(\vec{X}, s_i)$,
where $\mathbf{A}(\vec{X}, s_i) = \mathbf{F}_{RMS}(\vec{X}, s_i) \mathbf{A}(\vec{X}, s_{i-1})$

Legend

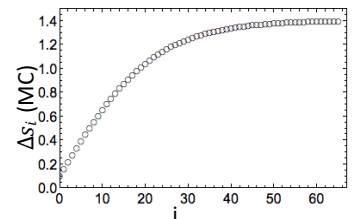
Properties/inputs

Tasks/operations

i = iteration
 s = simulation time

p = pressure
 $\mathbf{A}(s)$ = strain history
MC = million cycles
PS = permanent set
EM = effective model
FSM = full structural model

CFA = collagen fiber
architecture
TAVR = Transcatheter aortic
valve replacement



Time step size per iteration