BME Graduate Introduction
Cardiovascular Challenges and Opportunities for Biomedical Engineering in 2020
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Cardiovascular disease, mortality & burden 2015.

| Table 1: Summary Cardiovascular Diseases, Related Mortality, and Burden in 2015
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cause of Death</td>
<td>No. Deaths</td>
<td>Mortality Rate</td>
<td>Burden Score</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Cardiovascular disease</td>
<td>22,000,000</td>
<td>3,000,000</td>
<td>100</td>
</tr>
<tr>
<td>Other causes</td>
<td>7,500,000</td>
<td>1,500,000</td>
<td>50</td>
</tr>
</tbody>
</table>

Risk factors.

| Table 2: Prevalent Risk Factors for Myocardial Infarction and Stroke Based on the INTERHEART and FIBRISCAT Studies
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Risk Factor</td>
<td>Odds Ratio</td>
<td>CI</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Age</td>
<td>2.04</td>
<td>1.25 - 3.34</td>
</tr>
<tr>
<td>Gender (male)</td>
<td>1.30</td>
<td>1.10 - 1.54</td>
</tr>
<tr>
<td>Hypertension</td>
<td>2.09</td>
<td>1.80 - 2.47</td>
</tr>
<tr>
<td>Diabetes</td>
<td>2.10</td>
<td>1.86 - 2.37</td>
</tr>
<tr>
<td>Smoking</td>
<td>2.12</td>
<td>1.80 - 2.51</td>
</tr>
<tr>
<td>Obesity</td>
<td>1.50</td>
<td>1.30 - 1.72</td>
</tr>
<tr>
<td>Physical inactivity</td>
<td>1.40</td>
<td>1.20 - 1.63</td>
</tr>
<tr>
<td>Alcohol consumption</td>
<td>1.50</td>
<td>1.20 - 1.84</td>
</tr>
<tr>
<td>Family history</td>
<td>1.50</td>
<td>1.20 - 1.90</td>
</tr>
</tbody>
</table>

Troubling evidence between ~2012 to 2019.

Ischemic heart disease mortality with achievements and initiatives.

Cardiovascular mortality is no longer falling.

- CVD is the leading cause of death 17.3 million globally per year, projected to 23.6 million by 2030.
- Age adjusted mortality has remained flat in recent years.
- Decline in CHF in hospital patients is also leveling off.
- Declines in age-adjusted stroke mortality have similiarly plateaued.
Actually rising in rural areas.

Cardiovascular health disparities persist.

The value of cardiovascular care is declining.

- $318 billion spent in 2015 for all aspects of CVD.
These risk factors call for a shift toward more upstream prevention rather than the current emphasis on downstream treatment.

For example, a 10% increase in hypertension treatment could prevent 14,000 deaths each year, and a 10% increase in treating low-density lipoprotein cholesterol or in preventive aspirin could prevent 8000 deaths.
● Although spending on technological changes for cardiovascular care showed high value through the 1990s, with benefits in length and quality of life that far outweighed their costs.

● The currently stagnating (or worsening) trends in cardiovascular outcomes along-side higher spending suggest that this trend no longer holds.


Limited innovation in cardiovascular medical products.

![Limited innovation in cardiovascular medical products](image)


Development pipeline is flat with no clear path forward.

![Development pipeline is flat with no clear path forward](image)

### Conventional medical therapy...

- Administration of angiotensin-converting enzyme inhibitors, angiotensin receptor blockers, beta-blockers, and aldosterone antagonists.

<table>
<thead>
<tr>
<th>No.</th>
<th>Drug</th>
<th>Dose</th>
<th>Clinical usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ARB</td>
<td>25-50 mg/day</td>
<td>ACE inhibitors</td>
</tr>
<tr>
<td>2</td>
<td>Loop diuretics</td>
<td></td>
<td>Loop diuretics</td>
</tr>
<tr>
<td>3</td>
<td>Spironolactone</td>
<td></td>
<td>Spironolactone</td>
</tr>
<tr>
<td>4</td>
<td>Aldosterone</td>
<td></td>
<td>Aldosterone</td>
</tr>
<tr>
<td>5</td>
<td>Beta-blockers</td>
<td></td>
<td>Beta-blockers</td>
</tr>
<tr>
<td>6</td>
<td>ACE inhibitors</td>
<td></td>
<td>ACE inhibitors</td>
</tr>
<tr>
<td>7</td>
<td>ARB</td>
<td></td>
<td>ARB</td>
</tr>
<tr>
<td>8</td>
<td>Loop diuretics</td>
<td></td>
<td>Loop diuretics</td>
</tr>
</tbody>
</table>

Engineering opportunities in chronic heart failure.

1. Interventional
2. Mechanical
3. Surgical
4. Tissue
5. Rehabilitation

1. Interventional engineering...

- Percutaneous balloon mitral valvotomy (PBMV)
- Percutaneous coronary intervention (PCI)
- Pacing:
  - Left ventricular pacing (LVP)
  - Biventricular pacing (BiVP) or cardiac resynchronization therapy (CRT)
  - Implantable cardioverter defibrillator (ICD)
  - CRT-ICD (CRT-D) Catheter ablation (AF, VT)

2. Mechanical engineering...

- Left ventricular assistant device (LVAD)
- VA-ECM Olmpeila Recover 2.5 (IR2.5)
- Tandem Heart Venoarterial Shunt (VAS)
- Internal artery balloon counter-pulsation (IABP)
- Cardiopulmonary support (CPS)
- Cardiac support device (CSD)
- Total artificial heart (TAH)
- Pulmonary artery pressure sensor
- Interatrial shunt device (IASD) Intravenous inotropic therapy

3. Surgical engineering…
- Coronary artery bypass graft (CABG)
- Valve surgery (VS)
- Partial left ventriculectomy
- Dynamic cardiomyoplasty
- Myosplint implantation
- Heart transplantation (HT)

4. Tissue engineering…
- Gene therapy (GT)
- Stem cell transplantation
- Cellular cardiomyoplasty
- Myocardial tissue engineering

5. Rehabilitating…
- Cardiac rehabilitation (CR)
- External counter-pulsation (ECP)
- Enhanced ECP (EECP)
- Health education
- Psychological interventions
- Home-based hydrotherapeutic
- Thermal program
- Functional electrical stimulation
- Nursing
- Intravenous ferric carboxymaltose (FCM)
- Diet: Flavanol-rich chocolate
- Palliative care