Collagen-Glycosaminoglycans
Heart Valve:
A Breaking Bio-Material Application
On Organ Transplantation

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Increasing Demand Of Heart Valves

- Reasons:  
  * rise in older population
  
  * increasing incidence of heart valve diseases

- Prediction:  
  * approximately 850,000 patients by 2050, triple from 2003
How Do Human Heart Valves Work?

2 major components of the human heart valve:
* leaflets
* chordae tendinae
Types Of Heart Valve Substitutes

**Mechanical Heart Valve**
- cage valves
- tilted disk valves
- bileaflet valves

**Biological Heart Valve**
- homografts: tissues from matched human donors
- xenografts: tissues from other animal species.
Drawbacks Of Mechanical Heart Valves

* experiences high stresses at the walls that can damage cells
* have flow separation that can easily cause thrombosis
* requires lifetime blood thinning medication
Drawbacks Of Biological Heart Valves

* limit on lifespan, requires re-open heart surgeries.
* unknown infectious potential from animal heart valves
* lack of human donors.
* have conflict with some religion beliefs.
A New Material for Artificial Heart Valves

Tensile testing and compressive testing shows fibrin gels reinforced with a 0.75% collagen, 0.044% GAG scaffolds can resist VSMC induced contraction significantly more than fibrin-only gels, while allowing cell proliferation and maintaining excellent cell viability.

A sample of the heart valve shaped CG material
Utilizing CG Material

Cell-seeding Technique

- In a human heart valve, the leaflets and chordae tendinae experience different stress and strain.
- Under different stress and pressure, the valvular cells seeded on collagen gel synthesize different types of GAGs.
Three-dimensional constrained collagen gel (5 days old) in a cross-shaped silicon mold. (A) mesh, (B) uniaxial, and (C) biaxial region

Three-dimensional unconstrained collagen gel (5 days old) in a cross-shaped silicon mold
Utilizing CG Material

Minimally-invasive Implantation of Stem Cells

- Integration of autologous cells, or stem cells, with CG material to create artificial heart valves will minimize rejection reaction.
- Stem cells are unspecialized cells that can rapidly divide and develop into any kind of tissue cell.
Benefits Comparing to Existing Artificial Heart Valves

Comparing to Mechanical Valves

- Biologically more similar to human body.
- Won’t lyse blood cells or cause thrombus
- Save money on life-long anticoagulants therapy

Comparing to Biological Valves

- Significantly shorter waiting time
- Free of blood transmitted diseases
- Smaller rejection reaction
- Doesn’t conflict with religious belief
Sustainability

- A sustainable medical device should be safe, effective, affordable and will promote the well-being of all patients.

- CG artificial heart valves are:
  - Clean and reliable
  - Cost-effective
  - Improve quality of life of patients
Potential Problems

Bioprosthetic Heart Valve Degeneration

- High-stress environment cause type-I collagen molecules on the cusps to be distorted.
- GAGs stored in the cusp constantly removed, flexibility of heart valves decrease
- Potential solution: artificial heart valves that regenerates
Potential Problems

Balancing Cost and Utility

- Engineering vs. Marketing
- Will patients choose a more expensive and more reliable product, or a cheaper but less advanced one?
- Utilitarian theory and the rights of person
- Possible solution: more research need to be done to lower the cost
Conclusion

- Increasing demand of heart valves
- Current artificial heart valves
  - Mechanical valves
  - Biological valves
- Collagen-Glycosaminoglycan
- Utilizing CG material
  - Cell-seeding technique
  - Minimally-invasive implantation of stem cells
- Advantages of CG heart valves
- Sustainability
- Potential problems
THANKS

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