Cardiovascular Applications of Biomedical Materials

Lecture 5

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- Every day, a healthy human heart pumps 2,000 gallons of blood through 60,000 miles of blood vessels
- Challenges of Navigating the Cardiovascular System
- Cardiovascular therapies need to be robust and durable, yet delicate, due to the complex vasculature of the heart .
- The intricate network of vessels and the sensitive nature of endothelial surfaces in the cardiovascular system require simplified navigation and manipulation inside the body

When foreign materials are implanted into the body there is always a risk of bacterial and fungal infections, particularly catheter-related infections, which significantly contribute to the increasing problem of nosocomial infections. To reduce the incidence of intravascular catheter -related bloodstream infections, it is important that biocompatible material technology continues to advance so that its potential contribution to these com -plications can be reduced or eliminated .

Medical devices designed for minimally invasive surgery MIS

- make procedures easier and less time -consuming for clinicians
- reducing the risk of tissue damage
- it can mean reduced postoperative pain, hospitalization, and scarring
- faster return to a normal life
- reduce the possibility of error

There are four major platforms of biomedical materials that are changing the way cardiovascular device manufacturers develop novel products

- polyurethanes
- coatings
- fibers
- drug delivery technologies

Polyurethanes

Polyurethanes, having extensive property and structural diversity, are one of the most biocompatible materials known today

Biostable polyurethanes are a crucial component in cardiovascular medical devices and have a proven track record in human implantations. Polyurethanes can be processed by extrusion and injection molding techniques to become part of devices that feel and behave like natural tissue, giving them an important role in next- generation devicesThese materials have played a major role in the development of a wide variety of cardiovascular medical devices ranging from central venous catheters to the total artificial heart.

1. Flexible
2. strong,
3. lightweight ‘
4. Durable
5. interact safely with the human body making them ideal materials for long-term implantation.
6. having extensive property and structural diversity, are one of the most biocompatible materials known today
7. fatigue resistance
8. compliance,
9. acceptance or tolerance in the body during healing

Thermoplastic polycarbonateurethane (PCU)

is well known as a medical grade polymer due to its long-term durability in implants. has many clinical applications because of

1. its biostability
2. biocompatibility
3. oxidative stability.

When compared to conventional silicone elastomers, its abrasion resistance makes it ideal for

1. use in pacemaker leads,
2. heart pump mem -branes,
3. stent coatings.
4. also has the potential to replace porcine tissue in next-generation heart valves, which has the potential to reduce the risk of foreign material rejection .

Coatings

Medical-grade coatings have become an important feature in many catheter and guidewire tools used to deliver implants, such as stents, stent grafts, and heart valves. Catheters and guidewires used to deliver these devices require low -friction, flexible, and durable delivery systems. Catheter delivery systems may require insertion through narrow path -ways and the delivery system itself must not damage the surrounding vasculature, making it crucial that the coatings on guidewires and catheters drastically reduce friction .

Customizable coatings allow for specialized features such as

1. hydrophilic coatings
2. silver-based antimicrobial coatings
3. Hemo compatible antimicrobial coatings.

Hydrophilic coatings are designed to for various devices such as guidewires, guiding catheters, balloon catheters, stent, and stent graft delivery systems

Antimicrobial coatings retain lubricious, hydrophilic coating performance and are designed to delay the onset of biofilm formation on devices such as

1. Foley catheters,
2. central venous dialysis catheters,
3. peripheral intravenous catheters
4. peripherally inserted central catheters

Ultra-high-molecular-weight polyethylene (UHMWPE) fibers

1. have the highest impact strength of any thermoplastic currently produced .
2. have the potential to aid in therapeutic repairs that last longer
3. increase comfort
4. exhibit stronger mechanical performance
5. extremely strong
6. soft and highly pliable

allowing the fibers to be processed into many two- and three -dimensional constructions for the development of devices such as

1. high-pressure balloon catheters
2. stent grafts
3. heart valves

UHMWPE fiber is ideal for transcatheter cardiovascular applications because of

1. Its proven biocompatibility and hemocompatibility.
2. Its extremely low friction coefficient facilitates sliding against other materials inside a catheter
3. Its softness and smaller size
4. lowering tissue inflammation and irritation .

Drug Delivery Technology

- Resorbable biomaterials that also provide biocompatibility play an important role in implantable and injectable drug delivery platforms, which are designed to add a controlled drug release feature to medical devices. In cardiovascular applications, biocompatible drug delivery technology enables controlled sustained release of a drug without evoking immune responses and reduces unwanted side effects like scar tissue formation in blood vessels, which can occur when using non-biocompatible compounds .

- Bioresorbable polymers can be designed to provide zero-order release ‹the ability to release equal quantities of therapeutic agents gradually over time. In cardiovascular vasculature, endothelial cells of vessel walls are sensitive, so ensuring even dosing of a drug over the entire release timeframe is important .