BM1030 BIOMEDICAL ENGINEERING

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Problem

About 30,000 people in the United States suffer a brain aneurysm rupture every year. In fact, a brain aneurysm ruptures every 18 minutes! Preventing blood flow into aneurysm is one way to keep it from rupturing. Different types of coils are used to treat the ruptured aneurysm or prevent the aneurysm from bursting. There are various metal occlusion devices used till date. Researchers found that embolization of the coils cause inflammation or can compact over time and cause subsequent rupture or lead to formation of another aneurysm near the original one.
In the recent past, flow divertor stents have been used as an important tool in treating aneurysm.

History of treatment

Treatment depends on the type of aneurysm i.e whether it is ruptured or unruptured intracranial aneurysm.

- For unruptured aneurysm we use periodic radiographic imaging like the conventional angiography or magnetic resonance angiography to keep track of the condition of the patients.
- Ruptured aneurysm is cures by surgical clipping or endovascular coiling.

History of Endovascular Occlusion devices

This technique dates back to 1970s with the introduction of proximal balloon occlusion by russian neurosurgeon Fjodor A. Serbinenko. This was associated with many complications and increased rupture rate. Later came the Guglielmi detachable coils (GDCs) which is the platinum detachable microcoils invented by American based neuroradiologist.

Shortcomings

The outcomes of this endovascular embolization are not so satisfying. The recurrence rate of completely embolized aneurysms could approach 41% within 3-5 years of initial therapy, with 26% of those requiring retreatment.

Biomedical Approaches

After 20 long years of research,Dr.Duncun Maitland at Texas A&M University came up with a device treating the aneurysm with shape memory polymers. He created a peripheral occlusion device, called polyurethane based shape memory polymer foams.

Shape-memory polymers (SMPs) can change their shape in a predefined way on demand when exposed to a suitable stimulus, which means they have the ability to undergo large elastic deformation, low weight, low cost, an easily controllable synthesis procedure,. Though the primitive SMPs were not meant to be used in biomedical devices, these properties prompted the researchers all over the globe to use these SMPs as biomaterials owing to their biocompatibility.

Recovery temperatures of most SMPs tend to be too high for biological systems, but more recently photothermally triggered cytocompatible SMPs that can be triggered at or near body temperature have been reported.

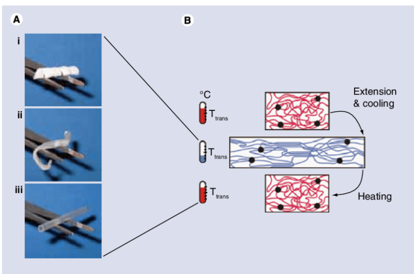

Figure 1: Shape-memory creation procedure and recovery process.
T_{trans}: Thermal transition temperature related to the switching phase

An open-cell porous polyurethane SMP material referred to as Cold-

Hibernated Elastic Memory (CHEM) foam is a suitable alternative for GDCs. After experimenting in animals, they came to a conclusion that the polymer acquired an expanded, porous configuration activated by the body heat. Also it was shown that the material has good compatibility with human fibroblasts despite having a low affinity.

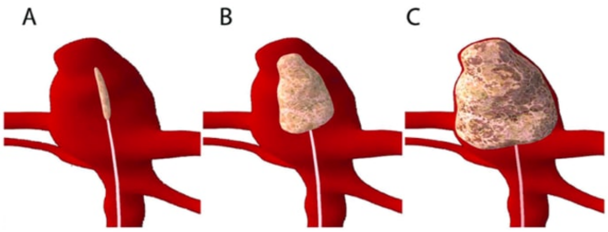

Figure 2: A crimped SMP foam device is delivered to an aneurysm via catheter and then expands to a permanent shape within the aneurysm where it stabilizes the aneurysm and promotes healing.

Simulations to observe the responses

A simulation of blood flow through a bifurcated artery with an aneurysm was created in an experimental model.
Two SMP coils are inserted into the aneurysm under simulated flow conditions. The first coil was inserted into the aneurysm cavity and the second coil was inserted around the first coil after it acquires the programmed shape.Eventually these coils reduce flow velocity inside the aneurysm.

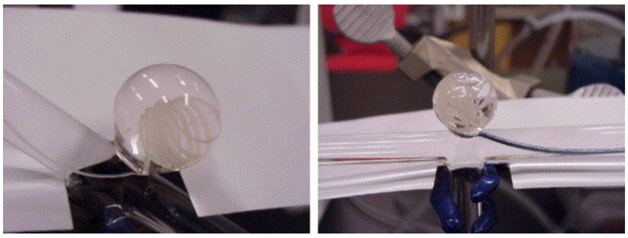

Figure 3: Deploying the two coils inside aneurysm

Advantages of using this material

It is shown to promote long term health of the person suffering from aneurysm in addition to producing a healing response. Once the foams are inserted into the aneurysm they show minimal inflammation.

Conclusion

The materials used for occlusion devices are being continuously reinvented to provide healthy lifestyle for aneurysm patients. Biomedical approaches like modelling and simulations of aneurysm and cerebral angiography have been instrumental in drawing suitable conclusions regarding the use of the smart material SMP. SMPs having the biocompatability are under extensive research for different biomedical applications.

Acknowledgements

1. https://www.aans.org/en/Patients/Neurosurgical-Conditions-and-Treatments/Cerebral-Aneurysm
2. https://www.sciencedirect.com/science/article/pii/S0928493105002122
3. https://res.mdpi.com/d_attachment/polymers/polymers-11-00631/article_deploy/polymers-11-00631-v2.pdf