

Design of Shape-memory Polymeric Strings for Minimally Invasive Prenatal Repair of Sacrococcygeal Teratoma

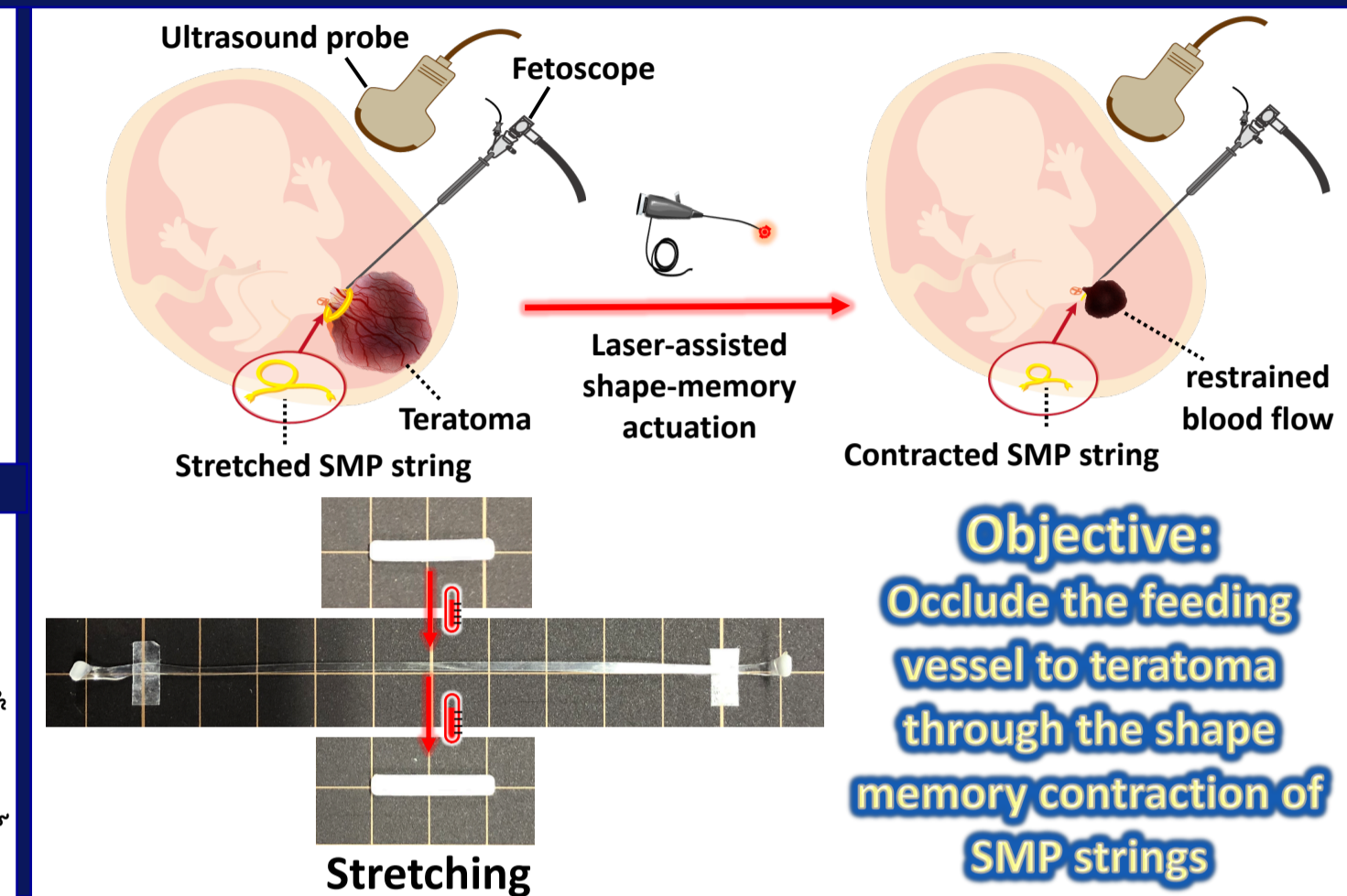
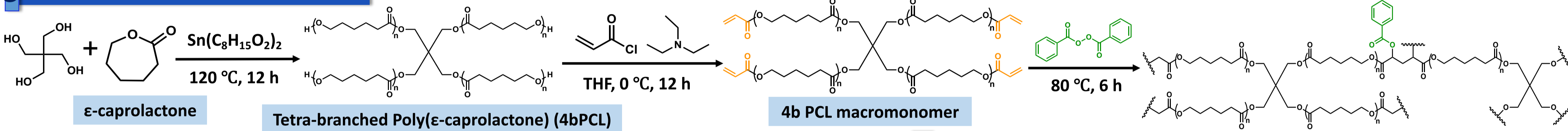
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Introduction

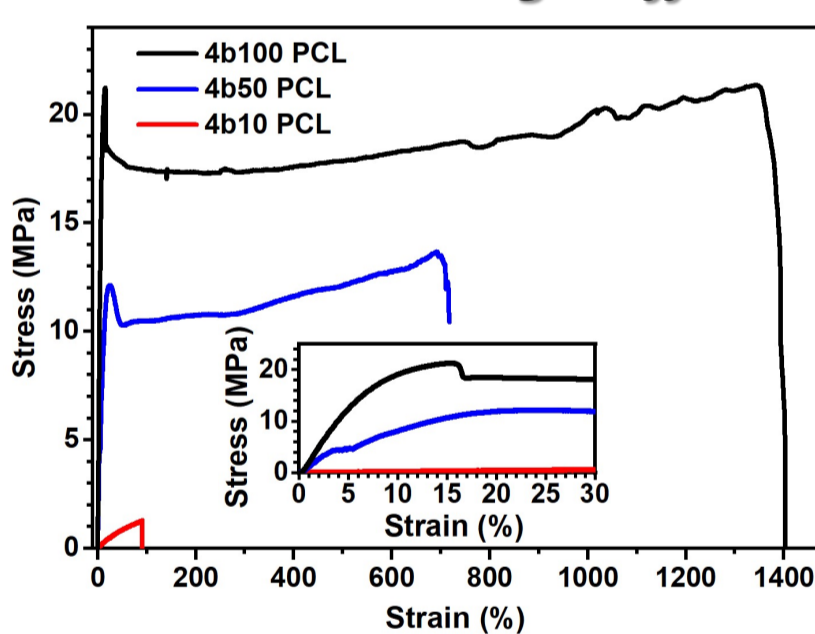
Numerous fetal diseases are one of the most significant causes of high fetal mortality rate nowadays. There are two common approaches to fix the fetal diseases before birth. **Fetoscopic surgery** is a nascent minimally invasive surgical approach for repairing fetal diseases. Nevertheless, due to its limited surgical vision, it's technically very difficult. Amongst all fetal diseases, **sacroccoccygeal teratoma (SCT)** as one of the most common fetal tumor, grows on the coccyx part of the fetus. Large, solid, highly vascular SCTs are associated with high mortality and morbidity due to a vascular-steal phenomenon, which may lead to high output fetal cardiac failure and fetal demise.^[1] On the other hand, shape-memory polymers (SMPs), as a representative of smart polymers, could change their shapes in response to external stimuli. Our lab have been developing novel SMPs for biomedical applications using crosslinked poly(ϵ -caprolactone) (PCL).^[2] **Therefore, in this research, we designed a novel shape-memory polymeric string (SMP string), of which the mechanical, shape-memory properties and contraction force could be adjusted simply by the manipulation of polymer molecular weight and crosslinking thickness. Assisted by fetoscopic surgery, the SMP string could be expected to compress the feeding vessel into SCT. In turn, decrease even obstruct the blood flow and help deliver the babies safely to term.**

Synthesis of Shape-memory Polymers

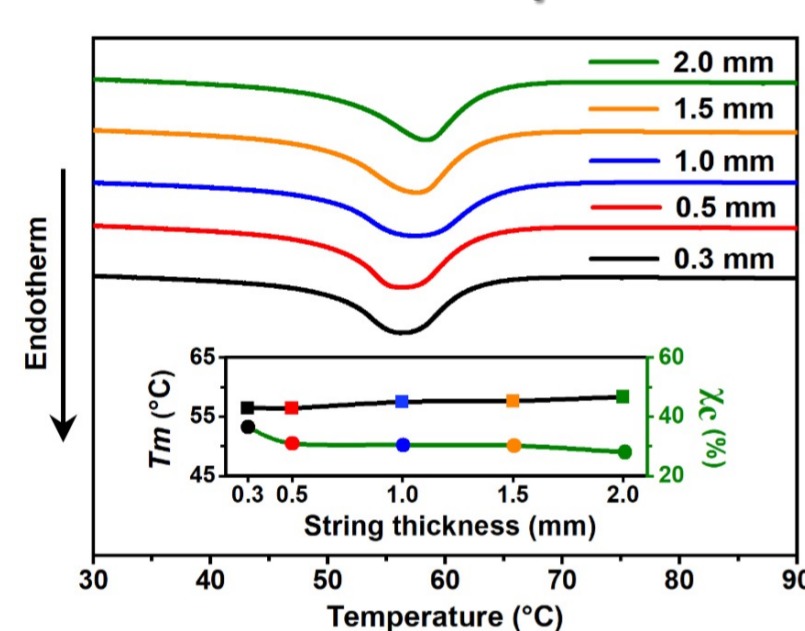


Physical Characterizations

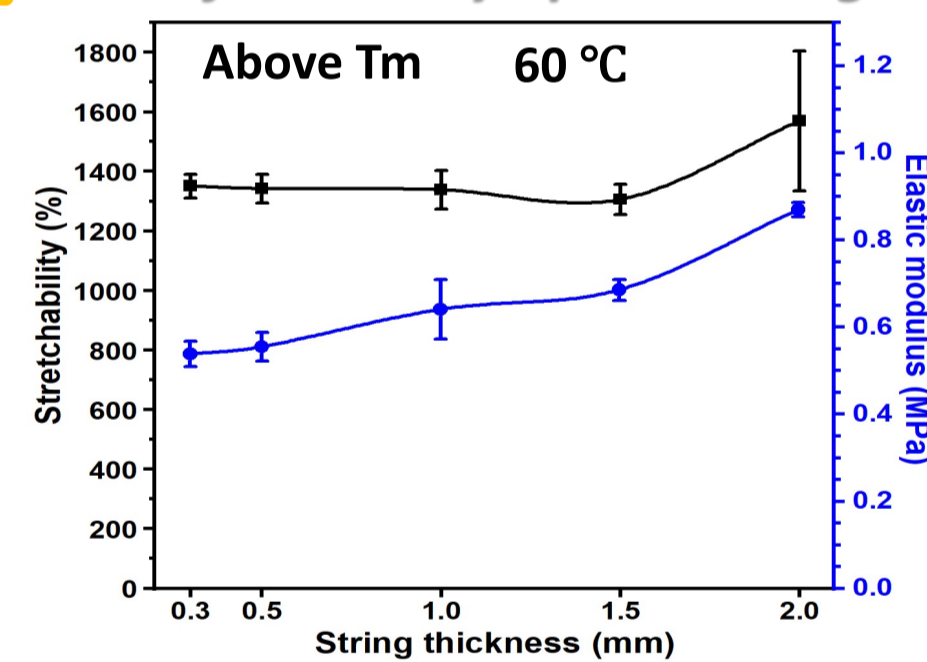
Molecular Weight Effect



Thermal Properties

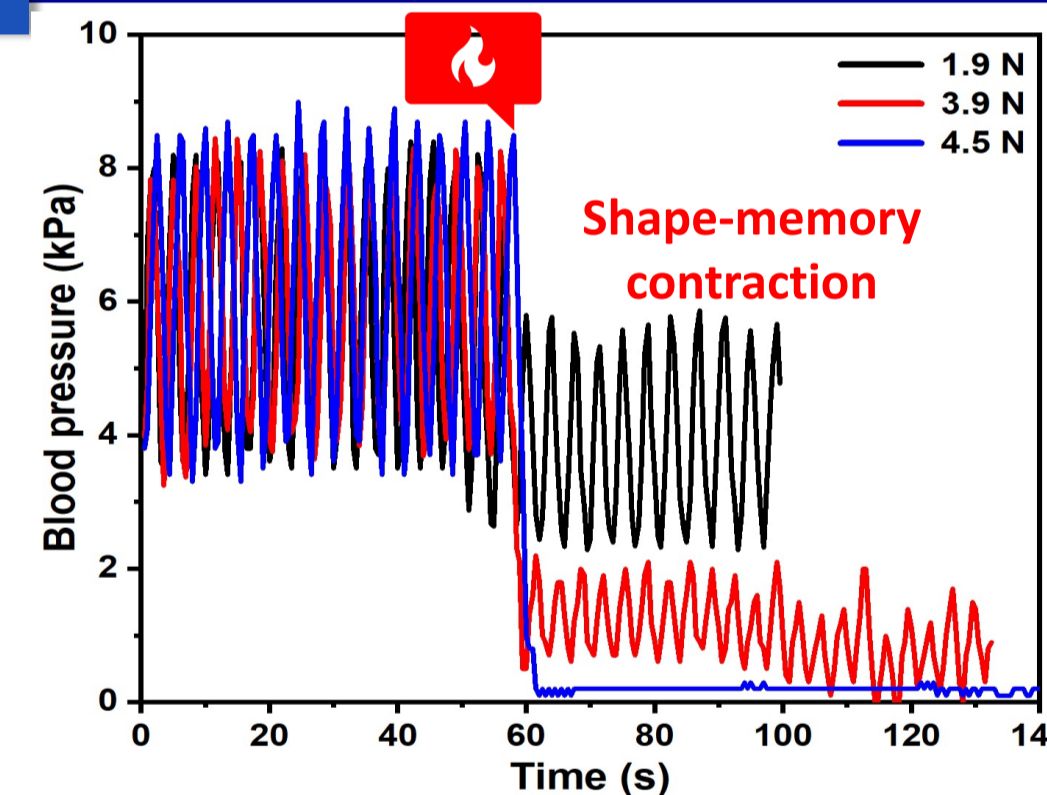
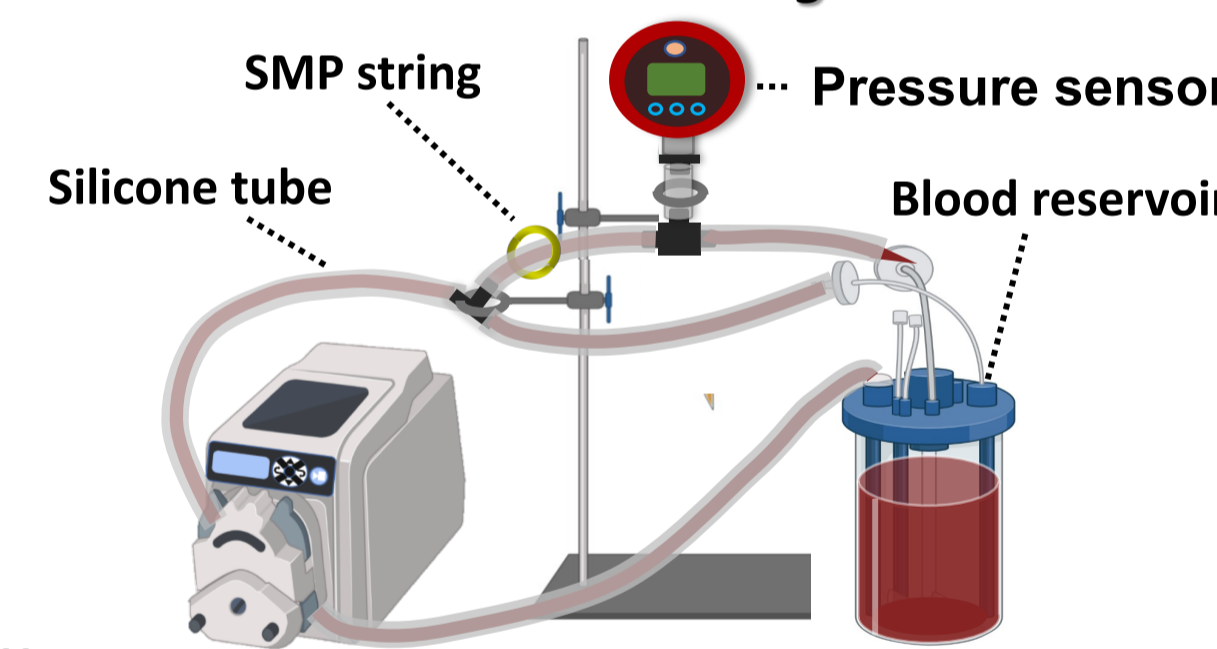


Deformability upon heating

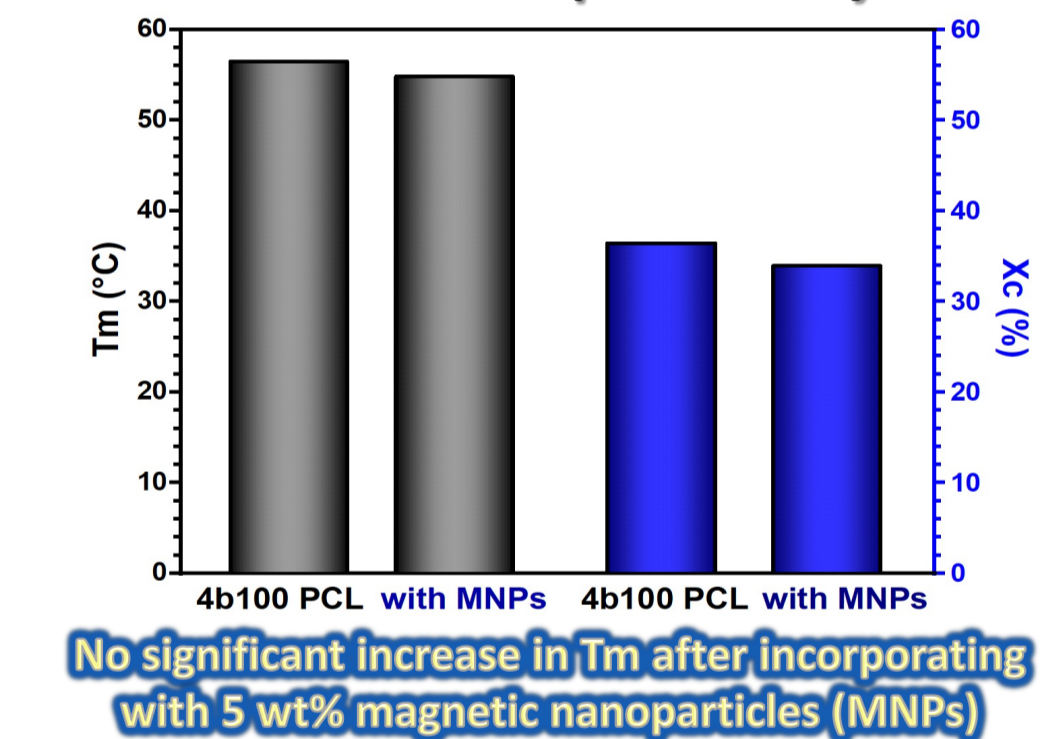


Shape-memory Contraction Effect Evaluations

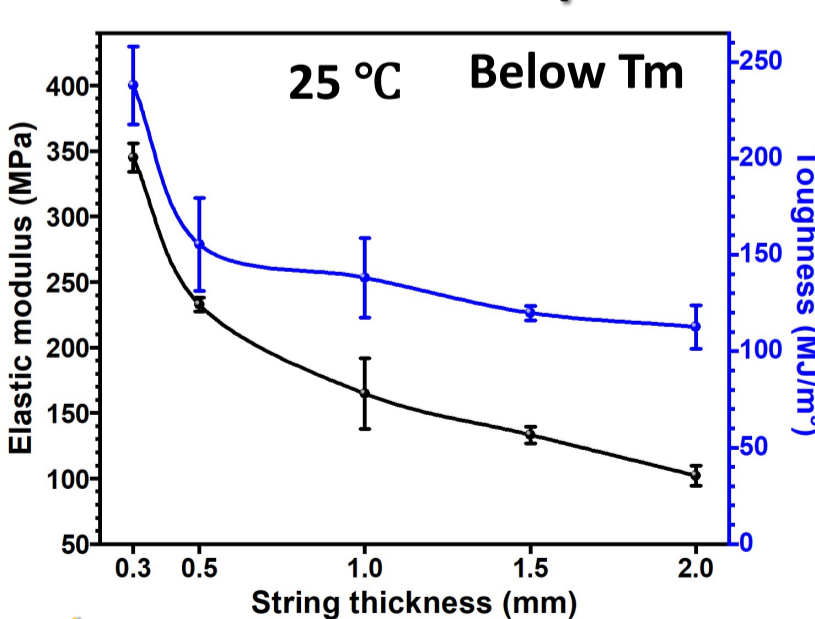
Fetal Heartbeat Mimicking Pressure Test



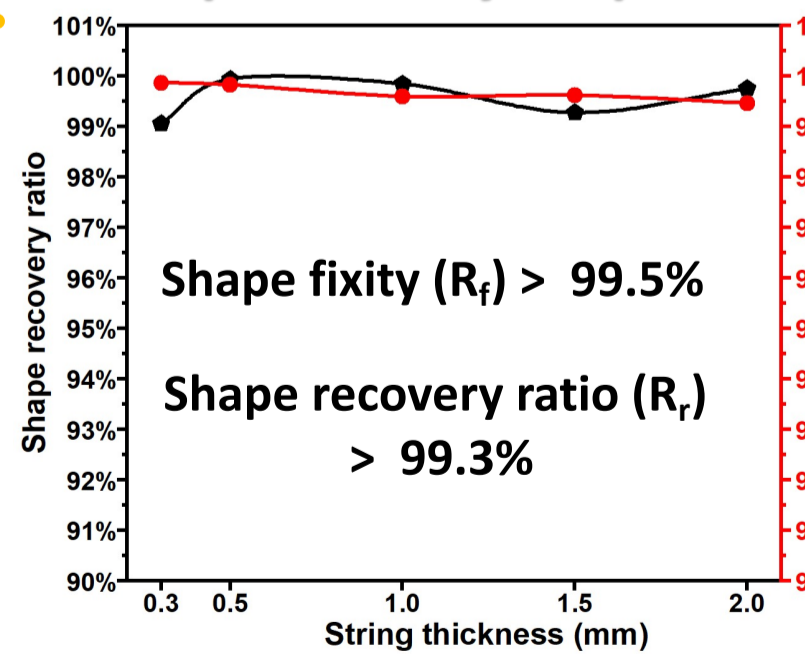
Laser-actuated Shape-memory Test



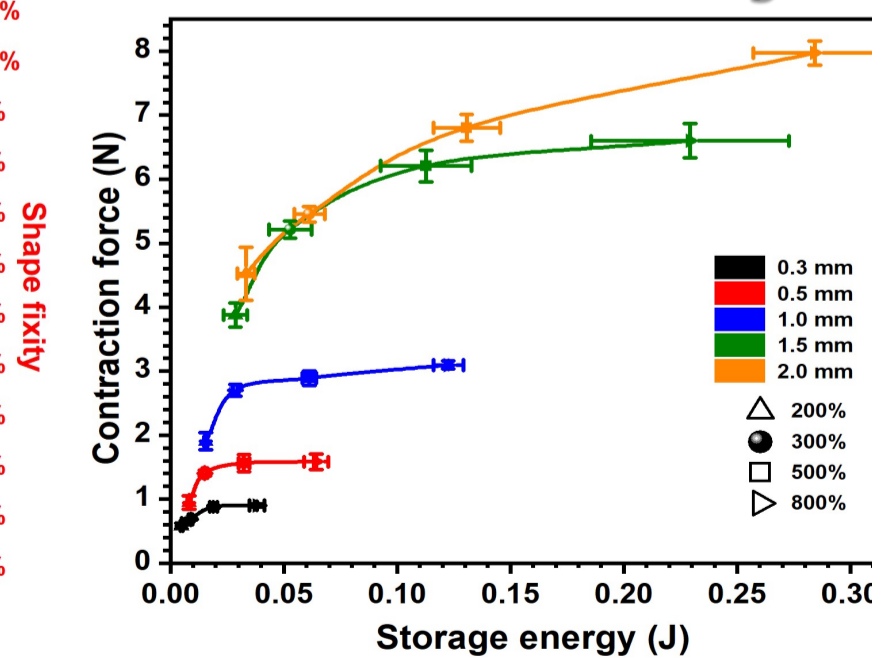
Mechanical Properties



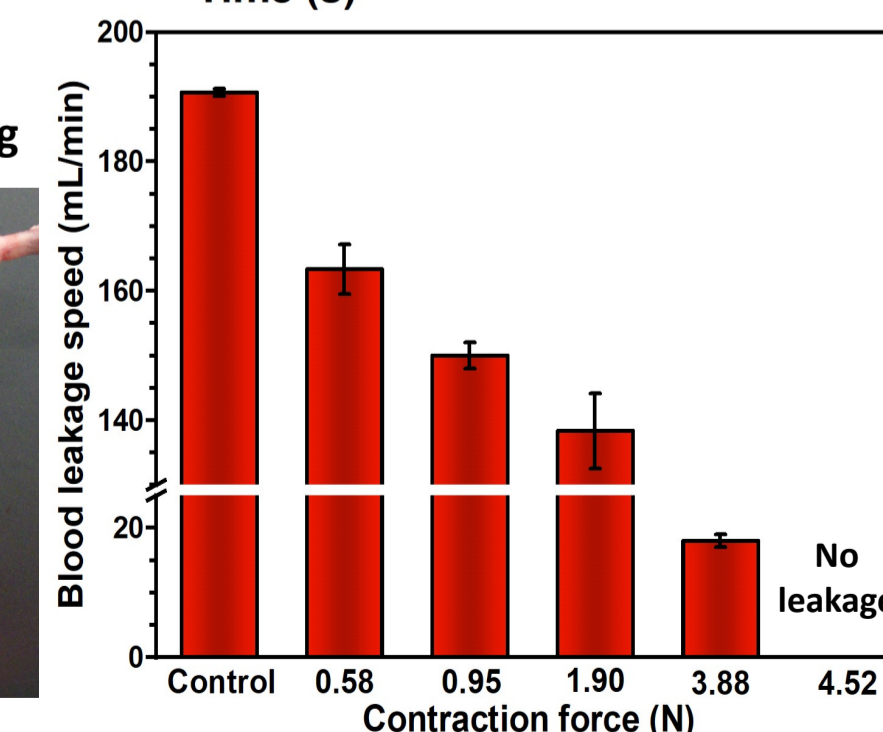
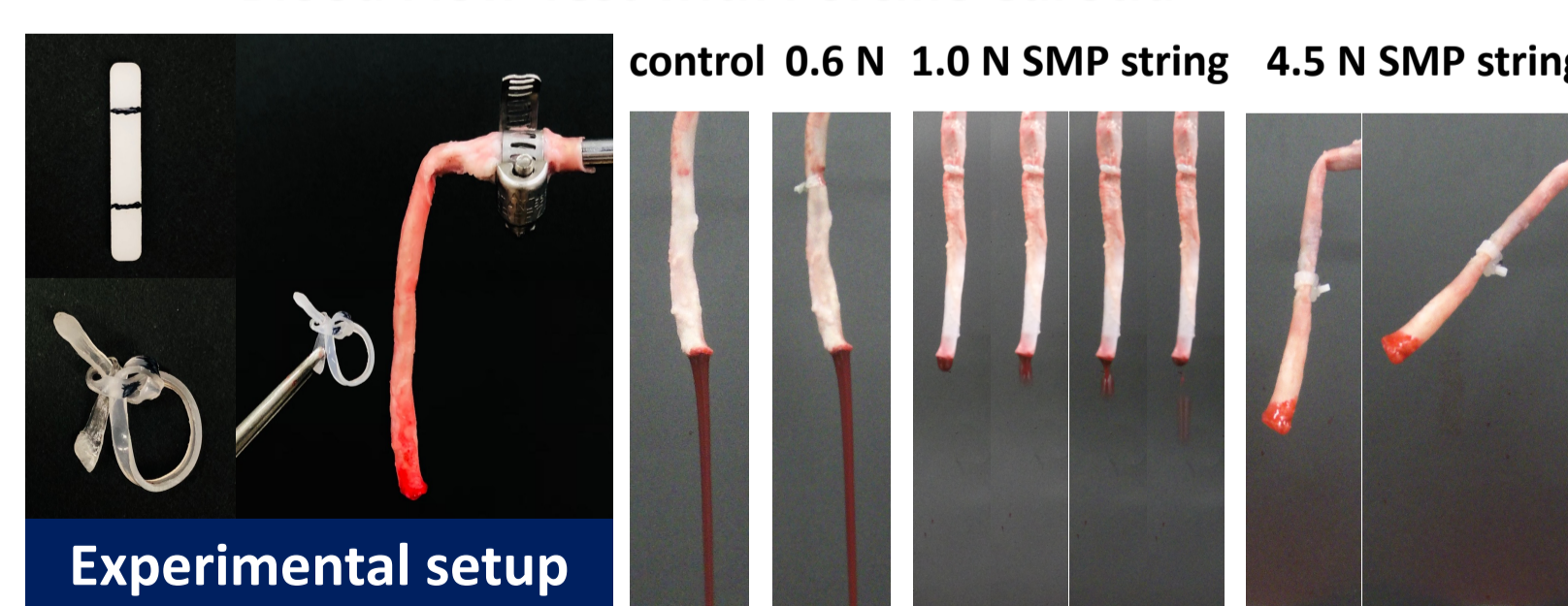
Shape-memory Properties



Contraction Force & Storage Energy



Blood Flow Test with Porcine Carotid



✓ Strong elastic modulus and toughness ✓ Designable stretchability and contraction force

✓ Strong and controllable shape-memory contraction effect

✓ Successful shape-memory actuation by the irradiation of YAG laser

Conclusion

- Optimal condition of the SMP string was achieved with an average stretchability over 1300%, and a high modulus and strong toughness.
- Contraction forces of the SMP strings correlates to their storage energies, which could be manipulated by the string thickness and stretched strain.
- Strong shape-memory contraction effect was proved, fetal blood pressure could be completely obstructed by the contraction of SMP strings.

Future Plan

- Further precise contraction force manipulation methods (polymer network design, crystallinity control etc.) under investigation.

Reference

- [1] S. Hirose et al., *Clin. Perinatol.*, 2003, 30, 493.
- [2] M. Ebara et al., *Adv. Mater.*, 2012, 24, 273.