MNRLab
Medical Micro & Nano Robotics

GUC
German University in Cairo
الجامعة الألمانية بالقاهرة

Optimization of the Mechanical Grinding of Blood Clots *in Vitro*

Mechanical grinding of blood clots is influenced by several parameters, such as the strength of the magnetic field, magnetic field gradient, and rotation frequency of the rotating dipole fields. Here we will focus on optimizing the grinding parameters to minimize the clearing time of blood clots.

Objective

Magnetic field strength, magnetic field gradient, actuation frequency, and the geometry of the helical microrobots influence the grinding time of blood clots [1]. It is essential to minimize this time as ischemic tissue deprived of blood will not survive indefinitely.

Tasks

- Control of helical microrobot [2] and drilling of blood clots (Fig. 1);
- Modeling of the mechanical grinding using resistive-force theory;
- Investigating the influence of the magnetic field on the removal rate of clots;
- Investigating the influence of the magnetic field gradient.

Materials

- HeliMag is available in MNRLab;
- The blood clots have to be prepared [3] and microrobots have to be fabricated;
- Phosphate buffered saline and catheter segments [4].

PREREQUISITES

Students are expected to have a working knowledge of control theory, differential equations, linear systems, statics, kinematic and dynamics, dynamics at low Reynolds numbers. Familiarity with programming, especially with Matlab, LabVIEW, and C++.

OTHER NOTES

This project will involve a weekly meeting with the instructors and progress reports have to be prepared. All reports should be written in academic paper format.

1. References

[1] I. S. M. Khalil, A. F. Tabak, K. Sadek, D. Mahdy, N. Hamdi, and M. Sitti, "Rubbing against blood clots using helical robots: modeling and in vitro experimental validation," *IEEE Robotics & Automation Letters*, vol. 2, no. 2, pp. 927-934, April 2017.

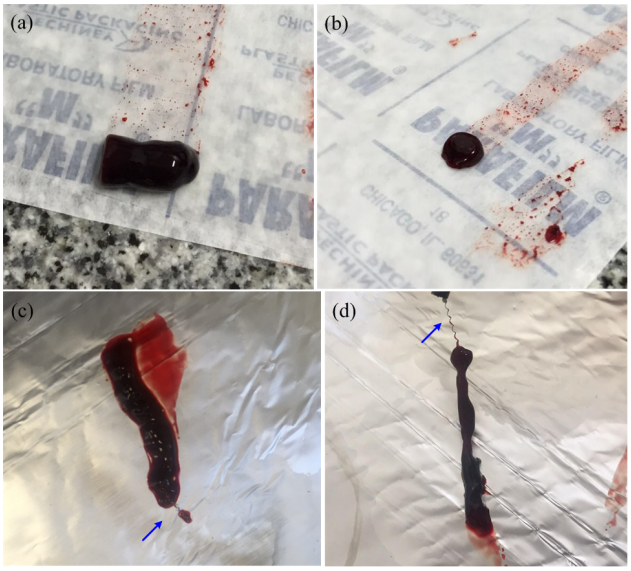

Figure 1. Pre- and Post-conditions of the blood clots following 20 minutes of drilling using a helical microrobot (blue arrow). (a) The mother clot with a long columnar shape is prepared to provide daughter clots. (b) Daughter clot is cut with length of 3 mm. (c) and (d) Dissolved blood clots after drilling using the microrobot for approximately 20 minutes.

[2] A. Hosney, A. Klingner, S. Misra, and I. S. M. Khalil, "Propulsion and steering of helical magnetic microrobots using two synchronized rotating dipole fields in three-dimensional space," in *Proceedings of the IEEE/RSJ International Conference of Robotics and Systems (IROS)*, Hamburg, Germany, pp. 1988-1993, November 2015.

[3] A. Hoffmann and H. Gill, "Diastolic timed vibro-percussion at 50Hz delivered across a chest wall sized meat barrier enhances clot dissolution and remotely administered streptokinase effectiveness in an in-vitro model of acute coronary thrombosis", *Thrombosis Journal*, vol. 10, no. 23, pp. 1–16, November 2012.

[4] A. Hosney, J. Abdalla, I. S. Amin, N. Hamdi, and I. S. M. Khalil, "*In vitro* validation of clearing clogged vessels using microrobots," in *Proceedings of the IEEE RAS/EMBS International Conference on Biomedical Robotics and Biomechatronics (BioRob)*, pp. 272-277, Singapore, June 2016.