MNR Lab
Medical Micro & Nano Robotics

GUC
German University in Cairo
الجامعة الألمانية بالقاهرة

A Comparative Study between Clearing Blood Clots using Helical Microrobots and Chemical Lysis *in Vitro*

We will achieve mechanical penetration of blood clots using helical microrobots with average diameter of 300 μm inside catheter segments without chemical lysis. The helical microrobot is steered and propelled under the influence of rotating magnetic fields (20 mT). The mechanical grinding of blood clots will be compared to chemical lysis to optimize the integration of the mentioned two technqieues in clearing blood clots.

Objective

In this work, we will achieve mechanical penetration of blood clots using helical microrobots [1] inside catheter segments. First, we will prepare clots based on the protocol provided by Hoffmann and Gill [2]. Second, we will grind the blood clots using the microrobot and measure the removal rate [3]. Third, we will compare the mechanical grinding to chemical lysis using a fibrinolytic agent (Streptokinase).

Tasks

- Modeling of the helical robot and the driving magnetic-based robotic system;
- Preparation of clots inside catheter segments [4];
- Control of helical microrobot and drilling of blood clots, as shown in Fig. 1;
- Development of a volume detection software to calculate the volume of the clots;
- Measuring the removal rate of mechanical rubbing and chemical lysis using visual feedback.

Materials

- Helical microrobots and blood clots;
- The blood clots have to be prepared;
- Blood clots and phosphate buffered saline;
- Fibrinolytic agent (Streptokinase).

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.

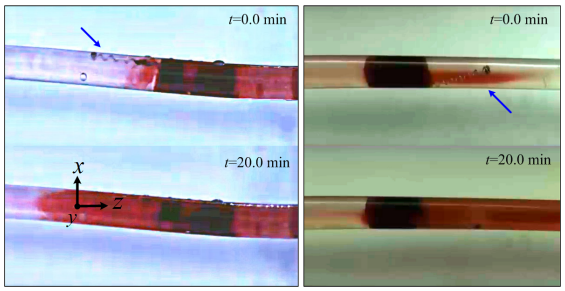

Figure 1. Representative pre- and post-drilling experimental results of blood clots using helical microrobots (blue arrows). The microrobot is propelled using rotating magnetic field. Left: A helical microrobot rotates counter clockwise and drills through the clot along z-axis. Right: A microrobot drills along negative z-axis.

1. References

[1] 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.

[2] 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.

[3] 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.

[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.