Towards Endoscopic EIT: Ex vivo Assessment of Human Prostates

Shadab Khan[1], Aditya Mahara[1] and Ryan Halter[2]

[1]Thayer School of Engineering at Dartmouth, Hanover, NH, USA, e-mail: Shadab.khan.th@dartmouth.edu

Abstract: Following robotic assisted laparoscopic prostatectomy (RALP), surgical margins are assessed for presence of cancerous tissues. An EIS/EIT based approach to identify benign and malignant tissues was evaluated. Excised prostates were probed using a micro-endoscopic EIT probe, and impedance measurements corresponding to benign and tumorous regions are compared.

1. Introduction

Prostate cancer is one of the most commonly occurring cancers in men. Following RALP, often used for treating organ-confined disease, surgical margins of the excised prostate are microscopically assessed for presence of cancerous tissues. Unfortunately, this assessment is a time-consuming process requiring hours to days to complete. By the time this evaluation is completed, the patient has left the operating room and the surgeon is no longer able to resect additional tissues suspected of harboring cancer.

To this end, we developed an EIT system and microendoscopic EIT probe that we intend to use to intraoperatively evaluate surgical margins.

2. Methods

Hardware setup: A newly developed EIT system was used to collect data [1]. A 9-electrode microendoscopic probe was fabricated to make measurements within a 10mm diameter region. Eight of the 9 electrodes were arranged on the periphery of the probe, and one electrode was placed at the probe center. Impedances were evaluated by driving currents through pairs of electrode in contact with sectioned prostate while induced voltages were recorded and logged from all other electrodes.

Clinical protocol: Experiments were performed at the Dartmouth Hitchcock Medical Center (DHMC), Lebanon, NH under an Institutional Review Board (IRB) approved protocol. Patient consent was obtained prior to undergoing a RALP procedure. Following prostate excision, it is sent in a sealed container to the Pathology lab, where the specimen dimensions are noted. At this point, we have access to the prostate for collecting the EIT data. The EIT system is positioned near to the pathology bench, to minimize probe cable lengths.

For each case, we probe the exterior surface of the prostate at the apex, base, and on the right and left lateral surfaces of the prostate (these represent locations with high incidences of positive surgical margins). The probed site is marked with green ink to allow localization of probing site afterwards. The prostate is then sectioned into ~3mm thick tissue specimens.

Multiple locations on the internal surfaces of the prostate specimens are probed. Specifically, the left and right surfaces of 3-4 sections are selected and probed, and inked pins are inserted through the slices to identify the position and orientation of the probe during the histological assessment of the slides.

3. Results and Conclusion

Measurements taken on the exterior surface of the prostate were grouped according to their location on the prostate, i.e., apex, base and lateral surface. Figure 1(c) shows the averaged magnitude and phase values across the frequency. It can be observed that the impedance measurements vary corresponding to the prostate anatomy ($Z_{lateral} > Z_{apex} > Z_{base}$). Additionally, impedance magnitude and phase spectra shown in Fig. 1(d) indicate that, in general, $Z_{tumor} > Z_{benign}$, which is consistent with the data reported previously [2].

These results obtained from a limited pilot study are very motivating, and we intend to collect more data to statistically evaluate differences in electrical properties between regions and tissues types of the prostate.

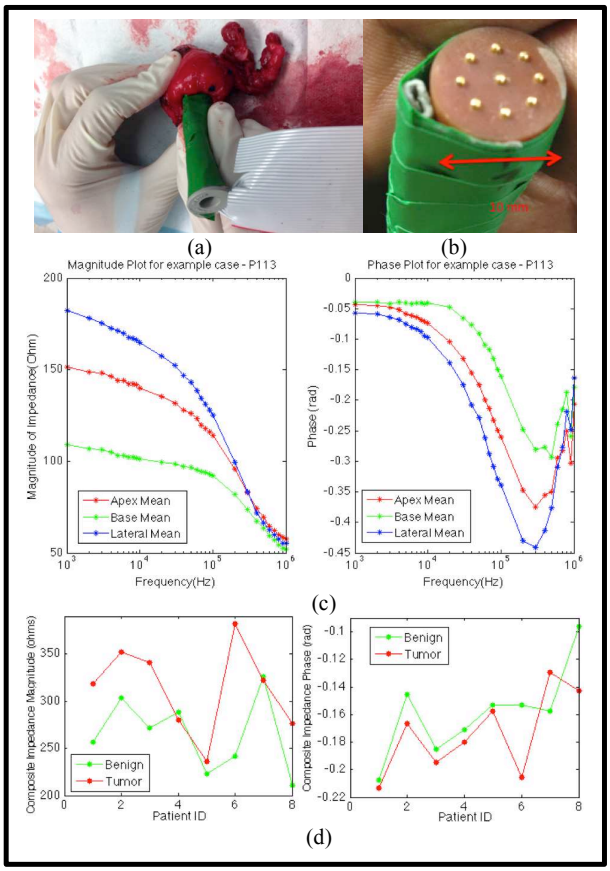

Figure 1: (a) Prostate being probed with a 9-electrode endoscopic probe, (b) Electrode arrangement on the probe head, (c) Magnitude and phase spectra for one of the prostate cases (exterior), (d) Impedance magnitude and phase spectra of internal surface measurements at 10 kHz for benign and tumorous regions.

References

1. S. Khan *et al.,* ICEBI, Germany, 2013.
2. R. Halter *et al., Journal of Urology*, **182**:1600-1607, 2009.