An endoscope-catheter device for the detection of ovarian cancer

Xiaoyu Zhao, Axelle Lavigne, Haoxin Wu, Xueer Zhang, Maciej Zajaczkowski, Makinah Haq,
E. M. Drakakis

Dept. of Bioengineering, South Kensington Campus, Imperial College London, SW7 2AZ, London-UK

Abstract— **Tissue biopotential offers a method of identifying ovarian and breast cancer, which affects 1 in 78 women and 1 in 9 women respectively. Since cancerous cells differ from normal cells in their electrical properties, the construction of a biopotential sensing device shaped like a catheter can be used with endoscopes for various minimally-invasive procedures.**

Clinical Relevance— **This device allows surgeons to easily detect cancerous tissue from healthy tissues and helps surgeons determine tumour margins in real time.**

I. INTRODUCTION

As the leading cause of death amongst gynaecological cancer, with an increasing incidence rate of more than 300,000 cases every year, the low detection rate of ovarian cancer presents as a long-standing issue. Current methods of detection are very limited and often insufficient as most diagnoses are identified when patients are already at Stage 3 and above[1].

Existing literature shows that breast and epithelial ovarian cancer cells present lower transmembrane potential compared with healthy cells due to the difference in cell surface receptors[2]. Devices that take advantage of this property would help surgeons to identify cancerous tissues more easily, thus improving surgical outcomes and detection rates.

For this reason, the development of a device capable of detecting early stages of ovarian cancer could play an important role in early management and would be linked to significantly improved outcomes in patients.

II. METHODS

We aimed to produce a prototype device with the following design requirements: a catheter-shaped sensor with a tip of a diameter of max 3.5 mm so that it can fit in endoscopes to develop a minimally-invasive method of detection. The catheter tip contains the electrodes and one small PCB. The length of the device contains electrical wires, and the second PCB is placed outside of the catheter part itself.

The first PCB contains only essential and minimized components to achieve the goal size, including an instrumentation amplifier and corresponding resistors to regulate the gain. The second PCB has less restriction on size, which allows for larger parts like the battery and wireless module XBee3 to be housed. It also contains capacitors and an operational amplifier to form a low pass filter, used to remove noise. PCBs were ordered and tested.

The sensor part contains three electrodes: two tungsten electrode (ground and working) and one silver/silver chloride reference electrode. The latter had a large dimension, therefore a customised reference electrode was made to fulfill the requirements for size. This was then tested with different solutions to ensure their function.

III. RESULTS

Breadboard test results have confirmed the operation of the electronics.

For biosensing, the measurements were taken using healthy and cancerous tissue simulation media (TSM). The measurements are consistent and the healthy tissue TSM was always measured to have a greater biopotential than the cancerous tissue TSM, which is consistent with the theory. Additionally, consistency has been seen from the difference between the measured biopotentials of cancerous TSM and healthy tissue TSM. Comparing the custom reference electrode against the factory-made reference electrode shows that both have clear positive correlations with d a t a points exhibiting only small deviations. In addition, the data points can be successfully fitted with trendlines, even though the exact gradients and intercepts are different due to Cl- ion concentration difference in each electrode. This shows that the custom electrode has a very similar, and thus reliable, function as the factory-made electrode.

IV. DISCUSSION & CONCLUSION

The device has the theoretical ability to distinguish between normal and cancerous tissue based on biopotential measurements, which will increase the efficiency of ovarian cancer diagnosis. Repeated experiments are needed to get more data on biopotential measuring. Furthermore, the set-up should be used on ex-vivo samples of cancerous and healthy tissues to check the clinical testing outcome. There are limitations due to the early stage of the device. The electronic and electrode parts need to be combined and tested further.

REFERENCES

1. Lheureux S, Gourley C, Vergote I, Oza AM. Epithelial ovarian cancer. Lancet. 2019 Mar 23;393(10177):1240-1253. doi: 10.1016/S0140-6736(18)32552-2. PMID: 30910306.
2. Binggeli R, Weinstein RC. Membrane potentials and sodium channels: hypotheses for growth regulation and cancer formation based on changes in sodium channels and gap junctions. J Theor Biol. 1986;123(4):377–401.