



ESSS Conference - eoSurgical Essay Competition Winner

Title: How will the “internet of things” impact delivery and training of surgery? Are we heading for a global surgical reticulum?

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Introduction

From self-driving cars to smart cities, the internet of things (IOT) promises to revolutionize every aspect of our lives. IOT refers to any device that is able to collect and transmit data via the internet. The excitement surrounding this field is spurred by the marriage of IOT and artificial intelligence (AI), which will lead to “smarter” and more personalized devices. IOT technology has already begun to infiltrate several industries and healthcare is no exception. In this essay I will outline existing and potential impacts of IOT technology in the delivery and training of surgery.

Use of IOT in perioperative delivery of surgery

Preoperative

The aim of preoperative surgical care is to maximize the success of an operation. At the most fundamental level, patients are told to avoid eating and drinking for many hours prior to the operation. However, sometimes weeks or even years of preparation is needed, as in the case of obese patients who are advised to lose weight in order to reduce the risk of postoperative complications. Often patients are

passive participants in regards to their health and are only aware of whether an intervention has worked at periodic hospital appointments. IOT technology in the form of wearable sensors tries to change this by promoting individual health tracking. By measuring parameters such as heart rate, blood pressure, and calories burned, patients become more active in the management of their conditions. This technology has paved the way for more advanced personalized health monitoring such as the bio-integrated sensors developed at Profusa, Inc. The company claims that their sensors are able to transmit medical-grade data about the body’s chemistry through fluorescent signals sent to an optical reader on the skin.¹ Similarly, Proteus Digital Health has developed an ingestible sensor that monitors patients’ compliance with medications by transmitting signals to a patch worn on the patient’s torso.² This in-body monitoring will have a huge impact on the future health ecosystem as it will allow for the prediction of surgical outcomes based on patient data, as well as personalize preventative medicine interventions, which will lead to greatly reduced healthcare costs.

Intraoperative

Intraoperative IOT devices are less commonplace; however, several companies are working on IOT devices that can streamline the surgical process. Chimaera, developed by Cambridge Consultants, is a handheld surgical device that uses preoperative computed tomography data and sensors to reveal an image of the operative field in real time, thus helping surgeons to easily target or avoid specific nerves or blood vessels.³ It is believed that this form of intraoperative feedback would create safer surgeries with better outcomes. However, it is

still in development so its effects on surgery have yet to be measured.

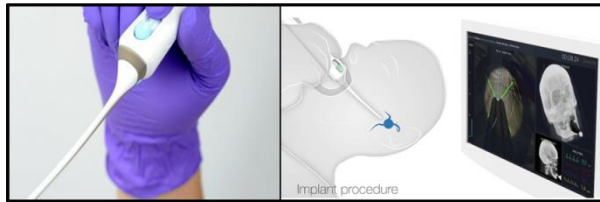


Figure 1. Left: Chimaera tool. Right: Chimaera used in surgery to identify structures on screen³

The ultimate goal for many of those involved in the IOT surgical field is to build an expert system, i.e. a computer program that uses AI, that can replace tasks traditionally done by humans. In this case the solution appears to lie in autonomous robotic surgery. The benefits of it would be that the robots would be unable to make human errors, never fatigue, and the results of surgery would be consistent and always optimal leading to a “surgical singularity”. Although this technology is still far away, efforts have been made towards this goal as demonstrated by the Smart Tissue Autonomous Robot (STAR), which was unveiled by surgeons and engineers from Johns Hopkins in 2016. STAR was able to perform pig bowel anastomoses with more even stitches than human surgeons. However, only 60% of the operations were done fully autonomously, proving the technology is still in its infancy.⁴ Furthermore, even if such technology does become available, the question of liability will still need to be addressed, thus the implementation of such technology in clinical practice may be a complicated endeavour and its potential impact remains unclear.

Postoperative

Like preoperative care, postoperative applications of IOT technology are centred on monitoring patient health in order to confirm the success of the operation and avoid complications. The three most common postoperative complications are infection, pain, and bleeding. A collaboration of researchers from Harvard, Purdue, and Tufts University hope to solve these problems by incorporating advances from microelectronics, sensors, biomaterials, and tissue engineering into a multifunctional “smart” bandage. The bandage will include a drug delivery system, “will be able to monitor all the vital signs of the healing process, such as oxygen levels and temperature, and will communicate the information to health professionals who are off-site”.⁵ This would greatly ameliorate postsurgical care as earlier discovery of surgical complications would lead to earlier interventions, thus resulting in better outcomes and overall reduced costs.

Use of IOT in surgical training

Five billion people lack access to safe, affordable surgical and anaesthesia care, thus the need to improve surgical training across the globe has never been greater.⁶ Solutions may have arrived in the form of virtual reality (VR) and augmented reality (AR). A key player in this field is Microsoft HoloLens, an AR technology that requires special glasses to allow one to see holographic anatomical images.⁷ Proximie, also an AR based platform, aims to democratize surgical training for those in developing countries by integrating live surgery with AR.⁸ The potential impact of these is huge, but it is important to note that lack of resources is as much if not more of a limiting factor than lack of training on surgical



education. Thus, without an increase in resources the impact will be minimal in developing countries. Unlike AR, VR immerses the user into a 360° virtual environment. This has been championed by surgeons like Dr Shafi Ahmed for surgical training. His pioneering use of Google Glass to record operations live, and his more recent branch into Snapchat Spectacles, also demonstrates how useful IOT can be in surgical education. He hopes to take it a step further by coupling VR with haptic gloves to make the experience tangible.⁹ This highlights the incredible boost that IOT technology could give surgical education.

Conclusion

From ingestible sensors to autonomous robots, it is clear that IOT technology in healthcare is no longer a distant promise. IOT has arrived. Like the technology that precedes it, IOT will undoubtedly have a resounding positive impact not only on surgical education and delivery but also on every aspect of our lives.

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