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EDITORIAL

Machine learning to improve surgical performance: Research methodology session from the European Society of Coloproctology

Alaa El-Hussuna

OpenSourceResearch Collaboration, Aalborg, Denmark.

Correspondence: Alaa El-Hussuna, OpenSourceResearch Collaboration, Aalborg, Denmark. Email: contact@osrc.network

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Surgical research is associated with specific methodological and practical challenges related to the assessment of complex interventions and variation of clinical equipoise (1). Biases can, to some degree, be overcome by randomisation, blinding, and intervention standardisation, although randomised trials can be costly and time-consuming. This poses a unique opportunity for innovation in surgical research design and evaluation to improve both validity of surgical trials and their assessment (2). There are many examples of challenging topics in surgical research, and despite thousands of studies, robust evidence is still elusive. Many of those challenges might be addressed by implementing Machine Learning approach.

Machine Learning, which is a subtype of Artificial Intelligence, might be able to positively influence the nature of surgical research. Because in contrast to conventional statistical analyses, ML is not built on a pre-structured model; rather, the data shape the model by detecting underlying patterns. The more variables (input) used to train the model, the more accurate the ultimate model will be (3). These variables can be investigated through the iterations of the model while adjusting for different interactions. Machine Learning algorithms are therefore best suited to solve complex challenges as these models can analyse thousands of datasets to predict patterns that may not be detectable for human investigator.

To illustrate this, we examined three examples of projects that were presented during the European Society of Colo-Proctology annual meeting in Vilnius, Lithuania, on 29th September 2023 (Table 1).

Project 1: Analysis of surgical procedures videos in laparoscopic and robotic gastro-intestinal surgery

Surgical videos are commonly recorded during laparoscopic and robotic procedures. A project from University Hospital Waterford, Ireland is analysing laparoscopic low anterior resection videos in collaboration with Incision Academy (4). The analysis of those video films will be conducted manually. The team will identify different phases of the procedures under the supervision of expert colorectal surgeons form Europe and USA. Deviations from the expected procedure flow will be identified and surgeon's performance can then be assessed accordingly.

Automation of the process using ML would allow for surgical phase recognition (detection of different steps in surgical procedure) and automated performance measures (tracking surgical instruments, calculating different movements, and correlation with post-operative outcomes) (5). Such a project may decrease the time needed to train surgeons and represent a good investment, especially in low-and middle-income countries where the need for surgeons is lagging behind available resources.

Project 2: Predicting the impact of surgery on human physiology

The surgical stress response refers to the physiological and psychological changes that occur in the body due to the stress associated with surgery. When a person undergoes surgery, it is a significant stressor for the body, and various physiological systems can be activated in response. The stress response involves the activation

of the sympathetic nervous system and the release of stress hormones such as cortisol and adrenaline. An ongoing systematic review was presented that indicated that current methods of measuring surgical stress response are limited by cost, heterogeneity, and difficulty of inferring practical conclusions.

A machine learning model to assess intra-operative measurements to investigate the impact of surgical intervention on human physiology and post-operative outcomes was presented (Novodan Ltd, Denmark). Such models can include many objective measurements, including imaging, blood investigations, and intra-operative monitoring, although cannot consider all individual-related variation.

Project 3: Understanding anastomotic leak by implementing machine learning

Anastomotic leak is a significant complication of colorectal surgery that carries high morbidity and mortality. Even when surgery is performed by experienced surgeons, leak rates can range from 2 to 7% (6). The pathophysiology of leak is still unclear with several large knowledge gaps around cause and prevention. A project in collaboration with Open Source Research Collaboration (5) was described which uses pre-operative computerized tomography scans to assess colonic blood supply. The project is based on image segmentation concept and extracting patterns of blood supply. These patterns can be correlated with clinical data from healthcare records to understand the risk of leaks.

Machine Learning implementation in surgery has been slow, demonstrating a growing need to educate surgeons and researchers to use this powerful tool. Computer scientists can provide solutions but the analysis of the clinical challenge and the specifications of the solutions can only be provided by experienced surgeon-researchers. The future direction is to build collaborative network that join forces of academic centres, medical industry, and non-governmental organisations to work on need-driven, machine-learning powered solutions.

Table 1: Summary of the three projects showing the potential implementation of Machine Learning approaches in surgical research

	Limitation of conventional approach	**Perspectives of implementing Machine Learning approach**
Project 1: Analysis of surgical procedures video films		
	1. Subjective assessment 2. Time consuming 3. Difficult to reproduce	1. Objective assessment 2. Time saving 3. Can be automated and made available in real-time
Project 2: Predicting the impact of surgery on human physiology		
	1. Surgical stress response has great individual variation 2. Difficulties and costs of analysing cytokines 3. Correlating the changes with outcome measures might be biased	1. Individual variations are adjusted according to individual baseline physiology 2. Monitoring instruments are re-usable and most are already in use by anaesthesiologists 3. Better correlation with outcome measures because of bias reduction
Project 3: Understanding anastomotic leak by implementing machine learning		
	1. Difficult to adjust for all the factors that might affect the anastomotic leak 2. The role of blood supply is poorly understood	1. Adjusting for a wide range of factors that affect leak including the use of objective data (e.g. scans) 2. Help to understand the role of blood supply and pave the way to more innovation in this area

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OpenSourceResearch collaboration is an international independent organization with special focus on implementing information technologies and artificial intelligence in clinical research. More about the organization and its projects can be found on its website: OSRC.network

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