Digital technology in Perioperative Care

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Abstract

Digital technology is becoming integral part of modern medicine. In this article we will describe various digital technologies used along the journey of perioperative care of the patients which can be used ranging from ambulatory surgery to major surgery. Electronic patient record is key component in integrated care programme and virtual clinics. Apps and wearable technology might play vital role in remote monitoring underpinning perioperative journey of patient ranging from pre-habilitation to rehabilitation. We will discuss the pitfalls of digital technology that can lead to digital inequalities.

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Introduction

Digital health, the use of digital technology in health is rapidly changing the practice of medicine from online education to robotic surgery; the way patients and healthcare professionals engage; improving the efficiency, access and quality of health and care; and supporting policy making decisions.

The World Health Organisation (WHO) recognises the value of e-Health which it defines as "the cost-effective and secure use of information and communication technologies (ICT) in support of health and health-related fields". This includes telehealth, telemedicine, mobile health (m-Health), electronic medical or health records (EMR/EHR), big data, wearables and artificial intelligence (AI)(1).

The field of perioperative medicine (POM) has undergone radical change in the last 30 years witnessing major advances in anaesthetic and surgical techniques whilst challenging what can be feasible in ambulatory surgery. With growing global aging population having complex medical needs undergoing surgery, personalised perioperative care pathways are required.

The COVID-19 pandemic has major impact on healthcare and delivery of perioperative care to patients. It is estimated that more than 2 million elective surgeries were cancelled or postponed worldwide during 12 weeks of peak disruption during the first wave of pandemic and this shortfall will be added up with subsequent waves of infection. At the end of November 2020, a total of 192,169 patients had been waiting more than 52 weeks for planned surgery in the National Health Service (NHS) while in the same month in 2019 the number was just 1398 (2).

With the coronavirus pandemic, there has been an acceleration in adoption of digital technologies across the NHS and globally. In this article we aim to discuss the use of digital technologies in the perioperative journey of patients in the NHS with focus on benefits and pitfalls that can be applicable to ambulatory surgery worldwide.

e-Health in perioperative medicine

The involvement of the NHS in digital health can be tracked back to over three decades with the first national information technology (IT) strategy for the NHS in 1992 (NHS Management Executive 1992) with subsequent strategies in 1998 and 2002. This led to the National Programme for IT (NPfIT) with the ambitious aim of creating a single national EPR connecting primary and secondary care. While it failed to meet objectives and was eventually abandoned, the digital agenda has continued to be pursued strategically in the NHS Five Year Forward View and in the Wachter, Carter and Topol reviews.

In 2015, the perioperative medicine (POM) programme was adopted into the Royal College of Anaesthetists (RCoA) curriculum leading to the establishment of the cross-organisational Centre of Perioperative Care (CPOC) in 2019. CPOC has produced three evidence reviews exploring impact, multidisciplinary team (MDT) working and perceptions in perioperative care; highlighting the learning to benefit to patients, health service and workforce; and to define their six strategic priorities one of which is harnessing digital technology (3).

These digital technologies revolve around the patient, supporting their self-care, their pre- and post-operative care; and the health and care professionals delivering it (Table 1) involving mobile devices, remote diagnostic and advanced computing (Table 2).

Table 1 Harnessing digital technology (adapted Strategy for the Centre for Perioperative Care (3))..

Patients	Staff	Pathways
Pre and post-op information	Accessible and scalable training	Automation and AI
Virtual clinics	Develop education programmes	Accessible shared records
Remote assessment and monitoring	Improved team communication	Structured multidisciplinary working and communication
Communication	Virtual meetings	Data collection

Telehealth and telemedicine

Face to face (F2F) consultations were the norm for perioperative medicine clinics but these were interrupted due to the potential risk of coronavirus infection spread to patients and healthcare professionals. Virtual consultation involving the use of video or voice calls via mobile phone and computing devices became an alternative to F2F consultation and was rapidly implemented around the world.

A virtual clinic is a planned contact by the healthcare professional responsible for care with a patient for the purposes of clinical consultation, advice and treatment planning. It may range from telephone contact, telemedicine, teleconference or video link.

The concept of virtual clinics is not new and was being used in other specialties but acceptance across the NHS was slow due to various governance, cost, infrastructure, and clinical barriers but adoption has been accelerated during the pandemic with direct government support.

Table 2 Digital technologies and clinical utilisation..

Digital technology	Digital solution example	Clinical use example
Smart phone and mobile computers	• Voice and video calls • SMS messages and e-mail • Healthcare and lifestyle apps • 4G, 5G and data transfer speeds	• Virtual clinics • Remote consultation/ assessment • Education and training • Behavioural change • Pre- and re-habilitation
Cloud storage	• Shared care records • EHR/EPR • Remote access	• Facilitate MDT • Access to medical records
Wearables and smart diagnostics	• Biometric data collection e.g. heart rate, blood pressure, blood glucose	• Patient self-care • Remote consultation/ assessment • Virtual wards • Pre- and re-habilitation
Computing and computer science	• Robotic process automation • Artificial intelligence • Predictive analytics • Big data	• Smart triage and referral • Pathway optimisation • Population health • Personalised medicine

NHS England (NHSE) provided a national procurement framework for online consultation to implementation across all care settings including mental health and community during the outbreak. NHSE and other governing bodies also developed guidance to support implementation and usage of these online digital platforms (see Table 3).

Table 3 Remote consultation guidelines during COVID pandemic.

Digital technology	Digital solution example
Clinical guide for the management of remote consultations and remote working in secondary care during the coronavirus pandemic (Nov 2020)	NICE UK & NHS England https://www.nice.org.uk/media/default/about/covid-19/specialty-guides/specialty-guide-virtual-working-and-coronavirus.pdf
Principles for supporting high quality consultations by video in general practice during COVID-19 (Aug 2020)	RCGP/ NHS England https://www.england.nhs.uk/coronavirus/wp-content/uploads/sites/52/2020/03/C0479-principles-of-safe-video-consulting-in-general-practice-updated-29-may.pdf
Remote consultations	GMC https://www.gmc-uk.org/ethical-guidance/ethical-hub/remote-consultations

Virtual consultations were on rise even before the pandemic, but coronavirus became the catalyst for further use to limit patient contact with infectious exposure and enabled clinicians who were shielding to continue medical care. This technology has been successfully harnessed in various ways ranging from virtual pre-assessment, prehabilitation and rehabilitation clinics to remote MDT reducing patient's travel time, costs and exposure to hospital acquired infections; potentially improving their experience whilst simultaneously reducing clinic non-attendance. Like any technology, virtual clinics has its advantages and disadvantages which are tabled below (See Table 4).

Table 4 Advantages and disadvantages of telehealth and telemedicine..

	Advantages	Disadvantages
Patients	• Convenience • Reduced travel and costs • Reduced exposure to infection • Patient engagement	• Equity of access to healthcare • Digital literacy and training requirement • Sustainability • Loss of personal touch
Health and care professionals	• Convenience • Improve efficiency of consult • Access to records • Reduce clinic non-attendance	• Digital literacy and training requirement • Inability to perform physical examination • Access to equipment • Loss of personal interaction • Regulatory risks
Pathways	• Improve efficiency and productivity • Facilitate MDT	• Infrastructure and equipment costs • Regulatory requirements • Equity of access

In the NHS, around 10% of outpatient appointments were classed as telemedicine in March 2020, compared to just 3.5% in March 2019 (4).

While virtual consultations cannot replace essential hospital visits, they can nevertheless complement the delivery of health services and have been successfully piloted as alternative to face-to-face therapy in the delivery of postsurgical rehabilitation (5), prehabilitation (6) and effective to deliver nutritional and psychological counselling (7).

Wearables and apps: Patient self-care, prehabilitation and rehabilitation

As life expectancy continues to improve and with medical advancements patients requiring surgery with complex healthcare needs will continue to increase; and technological advances will have an important role to play in perioperative care of patients.

There is a positive association of physical activity and surgical outcomes (8) and increased physical activity may slow frailty (9). Traditionally, physical activity evaluated by questionnaires and the gold standard like CPET to assess fitness needs time and resources. Wearable technology (wearables) containing various sensors such as accelerometer, gyroscope, compass, ambient light, and optical heartbeat; can enable the continuous monitoring of human physical activities and behaviours, as well as physiological and biochemical parameters during daily life and the evidence of benefit is growing (10,11).

Wearables in healthcare range from fitness trackers, smartwatches, wearable ECG & blood pressure monitors and continuous blood

glucose sensors; which combine software, hardware and data storage to capture patient health information. A smartphone is typically used to collect information and transmit it to a remote server for storage and analysis via an app.

Prehabilitation, defined as lifestyle interventions aimed to prepare patients for the physiological stress associated with surgeries, has demonstrable clinical importance in enhancing perioperative function and recovery (12) with information gathered from wearables that can be used to optimise medical conditions and increase physical activity (10) before surgery and improving patient outcomes.

NICE has developed standards that ensure new technologies are clinically effective and offer economic value. Apps providing real time data from patients to clinicians that can help in improving care with studies that are under way attempting to leverage consumer wearable sensing technologies to aid in clinical diagnosis of common diseases.

As an example, the Apple Heart Study is evaluating whether the Apple Watch can identify irregular heart rhythms such as atrial fibrillation (13). Data recorded by the wearable device was able to consistently approximate CPET results (14). This highlights the potential utility of wearable devices in formal assessment of physical functioning and suggests they could play a larger role in pre-operative risk assessment.

Pre-habilitation interventions can optimise the delivery of perioperative care, but accessibility to such interventions can be limited by geographic situation, lack of transportation and financial issues. Using video conferencing mobile technologies can help overcome those obstacles and tele-prehabilitation using mobile technology appears safe, feasible and generates good satisfaction with patients (15).

In rehabilitation, there have been a large number of studies involving these sensors that have focused on the upper body following stroke showing clinical evidence of small improvements (16). The wider range of wearable sensor systems that may assist in home-based rehabilitation, including body sensor networks, smart clothing, and wearable cameras that provide complementary information to these movement sensors are also helping self-care.

The big data generated by wearable devices is both a challenge and opportunity for researchers who can apply artificial intelligence (AI) techniques on these data in the future.

Smartphones and tablets have unique role to play in the perioperative care of the patients with the use of health applications (Apps). Mobile apps which commonly interface with wearables can provide a real-time dataset by enabling a much faster feedback loop between patients and their care teams. Their ease of use, smartness, accessibility, mobility, and connectivity create unique opportunities to transform medicine and improve quality of care. These apps provide an avenue for patients to become participants in co-creating their care pathway and open the door for shared decision-making, which may have other behavioural benefits in terms of adherence and encouraging gamification of health. Apps are available for self-management of chronic diseases which can be monitored remotely by responsible clinicians. While there are many health and care related apps to download, NHS digital have assessed and approved disease specific, fitness, nutrition and mindfulness apps in their library which clinicians can recommend and patients can access. This is important as the UK Medicines and Healthcare Products Regulatory Agency (MHRA) have recently introduced regulation around apps that aid diagnosis or recommend treatment (17).

Remote monitoring

Remote patient monitoring is a method of healthcare delivery that uses information technology to gather patient data outside of traditional healthcare settings. It can improve condition management for both patients and clinicians by providing care closer to home, enhancing the quality of life and outcomes for patients; and delivering a more efficient health service through patient self-management and fewer hospitalisations. This has involved telephonic consultations but more recently virtual video consultations and the use of various apps and wearable devices. Remote patient monitoring can use an array of technologies that vary according to a particular condition and tracked metrics. This can be utilised for expanding the complexity of cases done under ambulatory care.

Utility in post-operative care:Virtual wards

The use of virtual ward rounds during the covid-19 pandemic enabled hospitals to limit the exposure of their workforce but also allowed medical staff to preserve an element of human connection with patients. In particular, the system has made it easier for nurses who have often needed to be heavily masked when in close patient proximity to have unmasked contact with patients for an hour or more outside their room through the use of virtual intercom systems thereby reducing patients' social isolation.

NHS England has recently published guidance on COVID virtual wards to support the earlier and safe discharge of COVID-19 patients and successfully implemented COVID oximetry@ home pathway for safe admission avoidance (18). This involved the use of oximeters, patient self-reporting via a dedicated app, admission into virtual ward and governance.

Current systems for monitoring patients postoperatively, on surgical wards and after transition to home, are commonly inadequate. The frequency of vital signs monitoring decreases from in the post-operative period, on the in-hospital ward to no vital signs monitoring at home lead to potentially undetected or delayed detection of compromised vital signs in higher risk patients and leading to poor outcomes. Postoperative remote automated monitoring (RAM) on surgical wards and at home can help improve postoperative care by increasing vital signs monitoring when there is limited clinical resource and by directing frontline clinical response. RAM is improving with recent technological advances of medical standard wearables that enable data integration and analysis; and studies have shown improved clinical outcomes particularly in combination with hospital-to-home virtual patient engagement interfaces (19). Such combined systems typically include a Bluetooth-enabled vital signs monitor, a patient tablet interface featuring interactive symptom surveys, and a secure video connection to facilitate clinician assessment and follow-up (20). Preoperative risk stratification presents an opportunity to identify those at sufficient risk to warrant RAM interventions.

Perioperative intelligence

Artificial intelligence and robotic process automation

Artificial intelligence (AI) refers to the ability of a computer system to perform functions and reasoning typical of the human mind and is making space in the field of perioperative medicine called 'Perioperative intelligence'.

Perioperative intelligence provides a framework for collaborative work to deliver safe, timely and affordable perioperative care using artificial intelligence ranging from identification of at-risk patients with referrals, early detection of complications, control of anaesthesia, ultrasound guidance, pain management to operating room logistics (21).

This international AI ecosystem needs best practice and standards including clinical trial protocols (22) with most applications of AI in anaesthesia still in research and development focussing on ways to improve clinical decision making and performance.

Commonly confused with AI is robotic process automation (RPA),

software that uses virtual workers (robots) to perform and automate repetitive administrative tasks. Though established in industry, intelligent automation incorporating RPA and artificial intelligence is being adopted by various NHS hospitals saving time and money by increasing efficiency and productivity such as managing clinic appointments, smart triage, and referral.

Big data

Digital health encompasses a wide range of novel digital technologies related to health and medicine. Such technologies rely on recent advances in the collection and analysis of ever-increasing amounts of 'big data'. Big data is a concept to describe gathering and analysing data which is high in volume, velocity and variety which can give insights that lead to better decisions. As we are dealing with health data, robust governance frameworks should be in place to protect privacy. The OECD has published a set of recommendations for health data governance (23). At the European level, the recently promulgated General Data Protection Regulation (GDPR), which replaced the Data Protection Directive of 1995, aims at creating a more homogeneous legal framework in European Union member states for the governance of personal data, including personal health data. GDPR has considerably raised the bar of accountability on data controllers in comparison with the previous data protection directive.

An electronic health record (EHR) is digital record of information about a person's contact with a health care provider and include various pieces of information (e.g., current treatments, test results, clinical notes, care plans, correspondence between professionals). It has been vastly adopted in primary healthcare but there is fragmented adoption beyond primary care. The integrated care programme by NHS digital is working to join up IT systems across health and social care to make them interoperable so that information can exchanged swiftly across organisations. This will help in improved and quicker decision making with immediate access to records and associated documents but also to drive population health and the use of AI.

Summary

The coronavirus crisis has highlighted the importance of preparing health systems around the world for the threat of future pandemics. The potential for using data and technology more effectively is undeniable not only for patient-facing care but also for management and administrative functions.

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