BJA

British Journal of Anaesthesia, 00 (0): 1–9 (2017)

doi: 10.1093/bja/aex140
Review Article

REVIEW ARTICLE

Digital innovations and emerging technologies for enhanced recovery programmes

F. Michard[1,*], T. J Gan[2] and H. Kehlet[3]

[1]MiCo, Chemin de Chapallaz 4, Denens, Switzerland, [2]Department of Anesthesiology, Stony Brook University, Stony Brook, NY 11794-8480, USA and [3]Section for Surgical Pathophysiology 7621, Rigshospitalet, Blegdamsvej, 92100 Copenhagen, Denmark

*Corresponding author. E-mail: frederic.michard@bluewin.ch

Abstract

Enhanced recovery programmes (ERPs) are increasingly used to improve post-surgical recovery. However, compliance to various components of ERPs—a key determinant of success—remains sub-optimal. Emerging technologies have the potential to help patients and caregivers to improve compliance with ERPs.

Preoperative physical condition, a major determinant of postoperative outcome, could be optimized with the use of text messages (SMS) or digital applications (Apps) designed to facilitate smoking cessation, modify physical activity, and better manage hypertension and diabetes. Several non-invasive haemodynamic monitoring techniques and decision support tools are now available to individualize perioperative fluid management, a key component of ERPs. Objective nociceptive assessment may help to rationalize the use of pain medications, including opioids. Wearable sensors designed to monitor cardio-respiratory function may help in the early detection of clinical deterioration during the postoperative recovery and to address 'failure to rescue'. Activity trackers may be useful to monitor early mobilization, another major element of ERPs. Finally, electronic checklists have been developed to ensure that none of the above-mentioned ERP elements is omitted during the surgical journey.

By optimizing compliance to the multiple components of ERPs, digital innovations, non-invasive techniques and wearable sensors have the potential to magnify the clinical and economic benefits of ERPs. Among the growing number of technical innovations, studies are needed to clarify which tools and solutions have real clinical value and are cost-effective.

Key words: enhanced recovery programme; digital innovation; wearable sensor

Since the initial description and implementation by Henrik Kehlet in 1997,[1] enhanced recovery programmes (ERPs) have been increasingly used to improve quality of surgical care across multiple specialties and countries. Although the name of such programmes may differ (ERAS for enhanced recovery after surgery, PSH for perioperative surgical home, ERIN for enhanced recovery in National Surgical Quality Improvement Program (NSQIP)), the process and goals are similar: establish a structure, organize and facilitate the integration of evidence-based components of care into practice over the entire duration of the surgical journey. Multiple studies have shown, and several meta-analyses have confirmed, the ability of ERPs to decrease postoperative complications and costs, and to shorten hospital length of stay.[2–4]

However, many clinicians have found the multifaceted and multiple elements of ERPs are difficult to implement and track.[5 6] In this regard, several studies have shown that compliance to ERPs is not always consistent, and that outcome benefits are directly proportional to the level of adherence.[7–9] Although leadership, motivation and coordination between stakeholders (surgeons, anaesthesiologists, nurse anaesthetists, nurses, physiotherapists, quality officers, etc.) play a major role in the successful implementation of ERPs,[10] emerging technologies can potentially

help in many ways. The goal of the present narrative review is to describe and discuss the potential value of digital innovations, non-invasive technologies and wearable sensors to improve compliance to ERPs before, during and after surgery.

Smartphone applications (Apps) and text messages (SMS) for prehabilitation

The preoperative visit presents an opportunity to assess and optimize patient physiological condition before surgery, a major predictor of postoperative outcome.[11–13] Many Apps, downloaded on mobile phones or electronic tablets, may help prehabilitation by allowing improved management of risk factors.[14] Several of these Apps allow the connection between a smartphone and an electronic scale, a wireless blood pressure cuff, a glucometer, a wrist band or a watch equipped with accelerometers tracking physical activity. These Apps can be used to visualize trends over time, and thus provide an incentive for patients to maintain their weight, blood pressure and blood glucose within the normal range, as well as to increase their physical activity. Sending SMS to remind patients on preventative lifestyle and dietary measures has also been proposed to better manage the risk factors.[15] Systematic reviews and meta-analyses have confirmed that digital Apps and SMS may help to reduce body weight,[16] control hypertension,[17] improve glycaemic control,[18] increase physical activity[19] and for smoking cessation.[20] Because of frequent user dropout, the long-term effect of digital health interventions (Apps and SMS) has been questioned in the general population or in patients with chronic diseases.[14 15] However, this should be less of a problem over short periods of time before surgery. Finally, Apps and SMS could also be used to remind patients when to take or stop their medications, and may therefore have value to ensure patients adhere to preoperative recommendations.[21] Because digital interventions are inexpensive, studies are urgently needed to confirm their ability to facilitate and improve prehabilitation.

New tools for perioperative fluid management

Non-invasive haemodynamic monitoring: Fluid therapy is a key component of perioperative management and a key determinant of postoperative outcome.[22–24] A recent consensus article highlighted the risk of giving too little or too much fluid.[25] In high-risk clinical situations (e.g. estimated blood loss >500 ml, patients with co-morbidities) goal-directed fluid therapy (GDFT) has been proposed to tailor or individualize fluid management.[25 26] Studies have shown that GDFT protocols may decrease postoperative complications and hospital length of stay in various surgical populations.[27 28] Most GDFT protocols are based on flow parameters (stroke volume, cardiac output) or dynamic predictors of fluid responsiveness (pulse pressure variation, stroke volume variation). These haemodynamic parameters are usually measured by invasive haemodynamic monitoring techniques (thermodilution, invasive arterial pressure waveform analysis) or the oesophageal Doppler, a minimally invasive but operator-dependent method. Easy to use and non-invasive technologies have recently emerged[29] (Fig. 1). These new technologies include volume

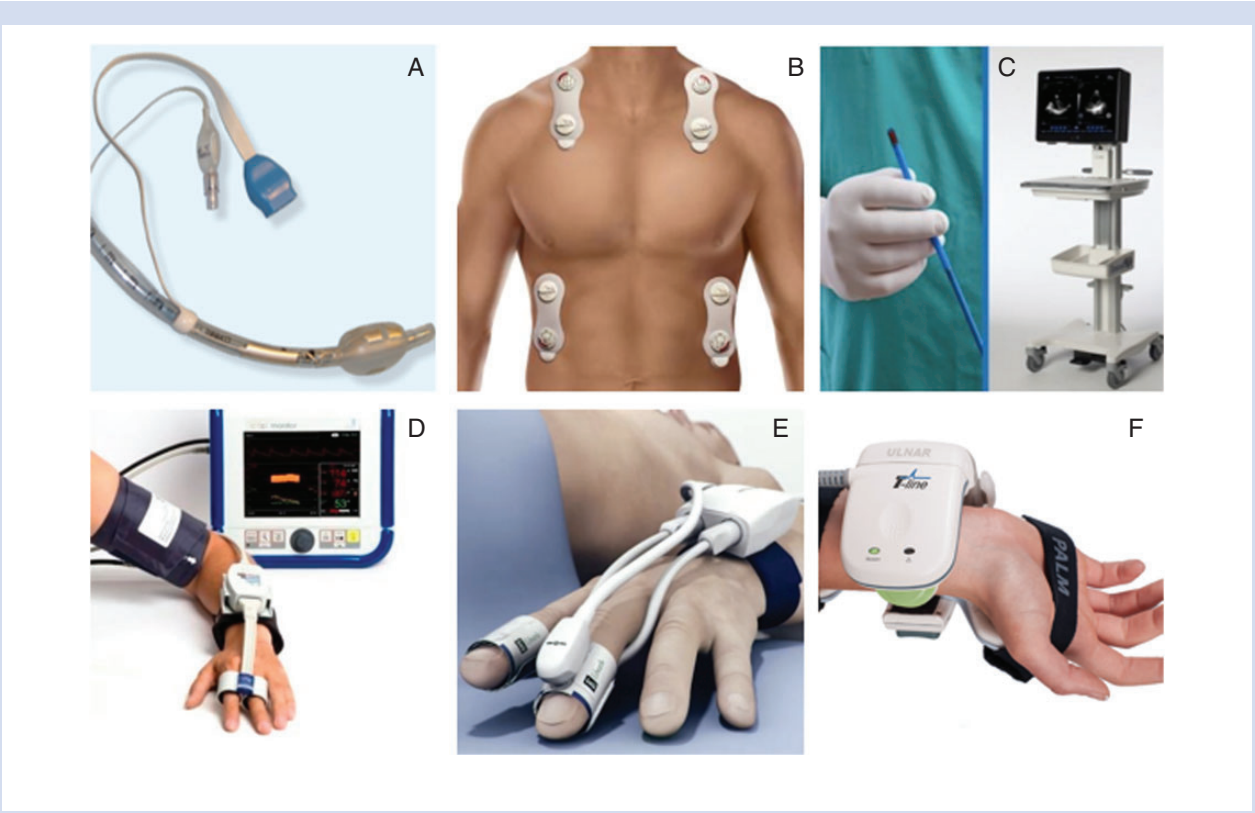

Fig 1 Examples of non-invasive haemodynamic monitoring techniques. (A) Bioimpedance tracheal tube (ECOM, San Juan Capistrano, CA, USA), (B) bioreactance electrodes (Cheetah, Newton Center, MA, USA), (C) miniaturized single-use transoesophageal echocardiography probe (Imacor, Garden City, NY, USA), (D, E) volume clamp finger cuff systems (CNSystems, Graz, Austria and Edwards, Irvine, CA, USA) and (F) applanation tonometry wrist device (Tensys, San Diego, CA, USA).