



## Review Article

# Peri-operative care pathways: re-engineering care to achieve the 'triple aim'

M. P. W. Grocott,<sup>1,2</sup> M. Edwards,<sup>1,2</sup> M. G. Mythen<sup>2,3</sup> and S. Aronson<sup>2,4</sup>

1 Anaesthesia, Peri-operative Medicine and Critical Care Research Group, Southampton NIHR Biomedical Research Centre, University Hospital Southampton/University of Southampton, UK

2 Morpheus Consortium, Duke University Medical Centre, North Carolina, USA

3 Centre for Anaesthesia, UCLH/UCL NIHR Biomedical Research Centre, London, UK

4 Department of Anaesthesiology, Duke University Medical School, North Carolina, USA

## Summary

Elective surgical pathways offer a particular opportunity to plan radical change in the way care is delivered, based on patient need rather than provider convenience. Peri-operative pathway redesign enables improved patient experience of care (including quality and satisfaction), population/public health, and healthcare value (outcome per unit of currency). Among physicians with the skills to work within peri-operative medicine, anaesthetists are well positioned to lead the re-engineering of such pathways. Re-engineered pre-operative pathways open up opportunities for intervention before surgery including shared decision-making, comorbidity management and collaborative behavioural change. Individualised, risk-adapted, intra-operative interventions will drive more reliable and consistent care. Risk-adapted postoperative care, particularly around transitions of care, has a significant role in improving value through peri-operative medicine. Improved integration with primary care providers offers the potential for minimising errors around transitions of care before and after surgery, as well as maximising opportunities for population health interventions, including lifestyle modification (e.g. activity/exercise, smoking and/or alcohol cessation), pain management and sleep medicine. Systematic data collection focused on quality improvement is essential to drive continuous clinical improvement and will be enabled by technological development in predictive analytics, systems modelling and artificial intelligence.

Correspondence to: M. Grocott

Email: [mike.grocott@soton.ac.uk](mailto:mike.grocott@soton.ac.uk)

Accepted: 20 October 2018

Keywords: pre-operative assessment; peri-operative medicine; surgical care pathways; prehabilitation; process re-engineering

Twitter: @mike\_grocott

## Introduction

The practice of peri-operative medicine is defined as the integrated, multidisciplinary medical care of patients from the moment of contemplation of surgery until full recovery [1, 2]. This simple definition has important and revolutionary implications for the care of patients for whom surgery may offer a treatment option. It also has profound implications for the future of anaesthesia as a medical specialty.

Peri-operative medicine is a new and rapidly evolving clinical science that addresses the needs of a growing patient population with increasingly complex medical needs. Peri-operative medicine offers the opportunity to go beyond the traditional anaesthetic and surgical focus on the care of a single patient in the immediate peri-operative period and to contribute as well to improving public/population health on a wider scale, thereby improving the

value proposition of anaesthesia as a specialty. Such an approach is perfectly aligned with the US Institute for Healthcare Improvement's widely supported 'triple aim' of improving patients' experience of care (including quality and satisfaction); improving population/public health; and reducing the per capita costs of healthcare [3, 4]. This 'triple aim' framework has now been explicitly integrated into the UK NHS Five Year Forward View [5]. Population health initiatives have typically focused on preventing, or slowing the progression of, chronic conditions. Less attention has been directed towards episodic peri-operative care, although in some systems such care accounts for over half of hospital costs [6]. Furthermore, elective peri-operative care takes place in a setting with substantial opportunities to rationalise and redesign pathways of care for patient benefit.

Delivering care based on the risk of adverse outcome for patients, a so-called risk-adapted approach, is essential to enhance healthcare value in the face of rising demand and inevitable resource constraints. Although such an approach may seem self-evident, many aspects of care have traditionally been organised around specialties or procedures, rather than around patient need. The growing prevalence of comorbid conditions [6], and harmful lifestyle characteristics (e.g. inactivity) coupled with an understanding that some surgery may be unnecessary or even harmful [7] are driving a re-appraisal of peri-operative processes. Approaches such as business process re-engineering are being applied with the aim of achieving fundamental systems redesign based on a comprehensive re-evaluation of process aims [8].

Patients who are candidates for surgery are often not ready for surgery. The implications of clusters of behavioural factors (activity/exercise, nutrition, consumption of social drugs) [9] and long-term conditions (comorbidity/multimorbidity) [10] are not well understood. The degree to which modification of such factors will affect outcome is also unclear. The incremental value of allocating resources to modify such risks adds a further layer of complexity. Costs are typically concentrated in a small proportion of care episodes with a high level of complexity [11]. Significant opportunity for value enhancement therefore lies within the understanding of these most complex episodes of care for the sickest patients. Finally, managing care around specialist 'silos' based on provider convenience is increasingly recognised as resulting in inefficient and ineffective care instead of serving patients' best interests.

The aims of this article are: to review the background and context of the current focus on innovation in peri-operative pathways; to summarise opportunities to improve

peri-operative care through pathway re-engineering; and to highlight opportunities for further innovation to maximise value. To achieve these aims the manuscript is divided into two sections. The first section focuses on the contextual and conceptual issues underlying the evolution of peri-operative care and explores how peri-operative medicine meets the challenge of the 'triple aim': improved population health, healthcare and value. The second section focuses on specific opportunities to improve care and value through pathway modification in the pre-operative, intra-operative and postoperative phases.

## **Innovation, value and peri-operative care**

### ***The practice of anaesthesia and the pathway to surgery***

Traditionally, the role of anaesthetists has been defined by the operating theatre, typically in the context of an in-patient episode. Patient assessment before surgery was considered important, but for in-patients (historically the vast majority of patients), routinely took place on the night before surgery. In the late 1980s and early 1990s, the move towards day-case or ambulatory surgery changed this framework. Pre-assessment clinics developed rapidly and patients were evaluated at a time separated from their in-patient episode. This trend was reinforced by the emphasis on day-of-surgery admission within Enhanced Recovery programmes and is now almost universal for most major operations. The benefit has been a substantial reduction in the in-patient bed utilisation associated with major surgery, alongside an increase in resources directed towards pre-operative assessment on an outpatient basis. However, for most patients travelling this 'journey', pre-assessment takes place a short time before surgery. A checklist approach effectively documents patient characteristics, and risk may be evaluated, but little can be achieved in the limited remaining time. The opportunity to intervene to improve health, either through optimising inter-current chronic illnesses (comorbidities) or through encouraging patients towards more healthy behaviours, has been lost. Critically, shared decision-making around choice of surgical and other treatments is much more challenging when the patient has been offered a surgical management plan several weeks previously. The opportunity to contribute to the care planning process and improve patient outcomes has been diminished, if not lost. Starting such conversations at a late stage in the process will also impoverish the patient experience: patients rightly expect that the teams offering options for the treatment of their underlying condition should act in a co-ordinated fashion as an integrated whole.

### **Value and peri-operative medicine pathways**

The Harvard economist Michael Porter has written persuasively on the challenges of measuring and improving value, defined as outcome per unit currency, within healthcare [12]. Better value may be achieved through improving efficiency of particular processes with respect to cost (achieving more for the same or less) or through reducing demand for inefficient or ineffective processes. Peri-operative pathway modification may contribute to improving value in a variety of ways [8]. Streamlining pre-operative assessment through reducing the burden on low-risk patients may improve the efficiency of this process and free resources for higher risk patients. Collaborative (shared) decision-making [7] may result in patients at the highest risk of complications and prolonged length of stay choosing not to undertake surgery in circumstances when harm may outweigh benefit. Early intervention to manage comorbidities and initiate 'prehabilitation' may improve both short-term peri-operative outcome and long-term patient health [9]. The consequences of such interventions are not only better outcomes for the individual patient but also more efficient resource use for the healthcare system through economical delivery of effective interventions and avoidance of ineffective high-cost interventions. The resources so freed are then available to support better patient care and further public/population health initiatives.

### **Population/public health and peri-operative care**

The closely intertwined concepts 'public health' and 'population health' encompass the notion of considering health at the level of the group, community or population level rather than at an individual level. Although nuances of definition may be important for those directly involved in these fields, in general the terms may be used interchangeably, with clinicians tending to refer to 'population health', and government and provider agencies tending to talk about 'public health'. The simple formulation that '*population health includes health outcomes, patterns of health determinants, and policies and interventions that link these two*' [13], whereas '*public health refers to the organised efforts of society to promote and protect people's health and wellbeing, and to prevent ill-health*' [14] may be useful.

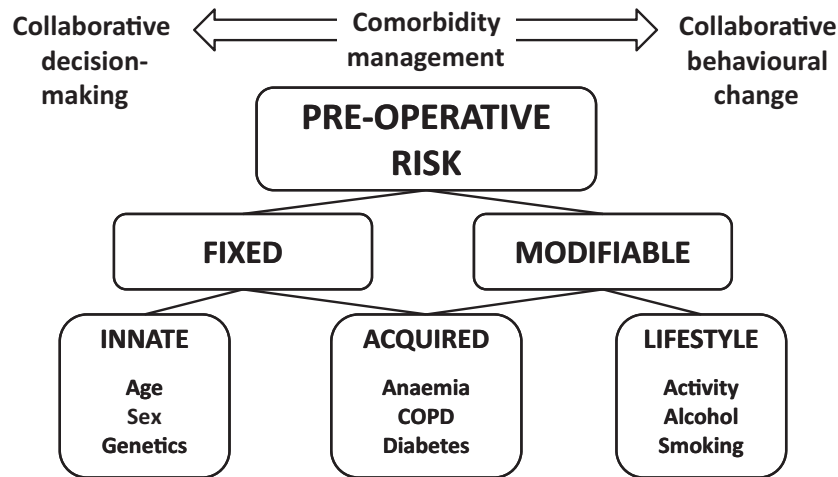
Within this framework, the combination of progressive improvements in longevity, coupled with the increasing prevalence of multimorbidity with age [15], has resulted in a growing number of surgical procedures taking place in elderly patients with co-existing medical conditions [6]. Patients are living longer in chronic ill health; the requirement for surgery is both a consequence of that, and

also made more complex by it. From a public/population health perspective, this group of patients offers extraordinary opportunities to intervene before the predictable 'injury' of surgery [6, 16-19]. Although this injury is viewed as necessary to improve the quality and/or quantity of life through treating the surgical problem, it may also bring unintended harm. Prehabilitation to improve patients' physical and psychological resilience to surgical injury focuses on improving physical activity/exercise, nutrition and psychological resilience, alongside behavioural change initiatives to minimise harmful social consumption of tobacco and alcohol [9]. Comorbidity management seeks to optimise management of long-term conditions such as anaemia and diabetes before surgery [9]. Both approaches offer the potential to improve short-term peri-operative outcomes and longer term postoperative health outcomes, given the well-recognised relationship between short-term harm and long-term mortality. Moreover, prehabilitation offers the possibility of long-term behavioural change, catalysed during the 'teachable moment' before surgery, with consequent improvements in individual and population level health outcomes. Shared (collaborative) decision making provides a mechanism to improve the patient experience and to better match clinical need with likely benefit [7]. Although some models of healthcare payment may work against such an integrated approach (e.g. fee-for-service), alternative mechanisms such as bundled payments or capitation may serve as a positive incentive.

### **Risk and surgery**

Risk is the product of likelihood and consequence for an adverse event. The likelihood of any given peri-operative event is governed by two categories of risk determinant: patient characteristics and healthcare characteristics (including the types and magnitude of surgery and other elements of peri-operative care). Both of these categories of risk determinant may be lessened through changes to the peri-operative pathway.

Patient risk factors may be divided into those that are fixed and those that can be modified in the time available before surgery (Fig. 1). Some contributory risk factors, such as chronological age, sex, and genetic constitution, cannot be modified before surgery under any circumstances. Others may be partially modifiable; for instance, some aspects of chronic illness may in part be fixed (e.g. emphysema, myocardial injury) but in part modifiable (e.g. reversible airways disease, anaemia). Risks linked to patient lifestyle and behaviour may be substantially modifiable: activity/exercise, tobacco and alcohol consumption, diet



**Figure 1** Fixed and modifiable patient risk factors.

and psychological wellbeing are all amenable to substantial change. Although the achievement of such a change may be challenging, the peri-operative period arguably offers unique opportunities ('teachable moments') to improve patient health and system value. From this framework, three categories of opportunity to improve pre-operative care present themselves: (1) shared (collaborative) decision-making; (2) comorbidity management; and (3) collaborative behavioural change. Fixed patient risk factors may shape the process of shared decision-making but are of less relevance to endeavours to manage comorbidities or patient behaviours. Modifiable comorbidities may be amenable to improved care through clinical input from peri-operative care teams or through specialist referrals. Modifiable behaviours are candidates for collaborative behavioural change interventions in patients who consent to such approaches. Each of these categories of peri-operative care modification will be considered in more detail below, and in other articles within this special issue of *Anaesthesia*.

### Peri-operative care pathways

Adopting a patient perspective, the peri-operative care pathway should encompass five basic elements, the first of which leads inevitably to the remaining four. First, the patient should be at the centre of their own care, and their wishes, opinions and expectations should be central to the care process. Second, decision-making around surgery should result in their best interests being served. Third, they will be adequately prepared for surgery. Fourth, care during the peri-operative episode will be safe and effective. And finally, they will experience a full and timely recovery.

These patient expectations map onto different categories of clinical care. Decision-making about what care patients would like to receive is best served by formulating a pre-operative plan through a shared (collaborative) approach early in the peri-operative pathway [7]. Adequate preparation for surgery is addressed through efficient and effective comorbidity management and collaborative behavioural change (prehabilitation) [9]. To be effective, each of these three interventions must be commenced as early as possible after surgery is contemplated [8]. This requirement is the overriding justification for re-engineering the peri-operative pathway, so that patient evaluation can proceed in parallel with pathology evaluation [8]. In order to achieve this goal, early risk 'triage' to identify patients who will benefit from each of these three processes should occur as soon as possible after the initial contemplation of surgery, and the peri-operative physician (typically an anaesthetist) and patient should meet soon thereafter. Figures 2 and 3 illustrate the differences between a traditional pre-operative pathway and one set up to achieve the aims described above [8]. Safe, effective peri-operative care and a full and timely recovery are best achieved through individualised intra-operative and postoperative care plans based on a standardised 'menu' of options (see below). Individualisation of the intra-operative and postoperative care plans should be based on a careful evaluation of pre-operative risk factors and any changes that occur during the pre-operative journey.

#### Pre-operative care

Shared decision-making offers the potential for avoiding 'wrong-patient surgery', at the same time serving patients' best interests, reducing healthcare costs and improving the

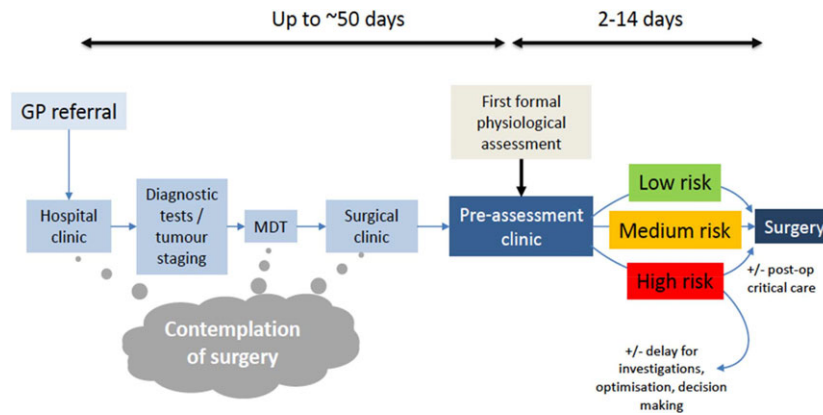


Figure 2 Traditional pre-operative pathway. MDT, multidisciplinary team.

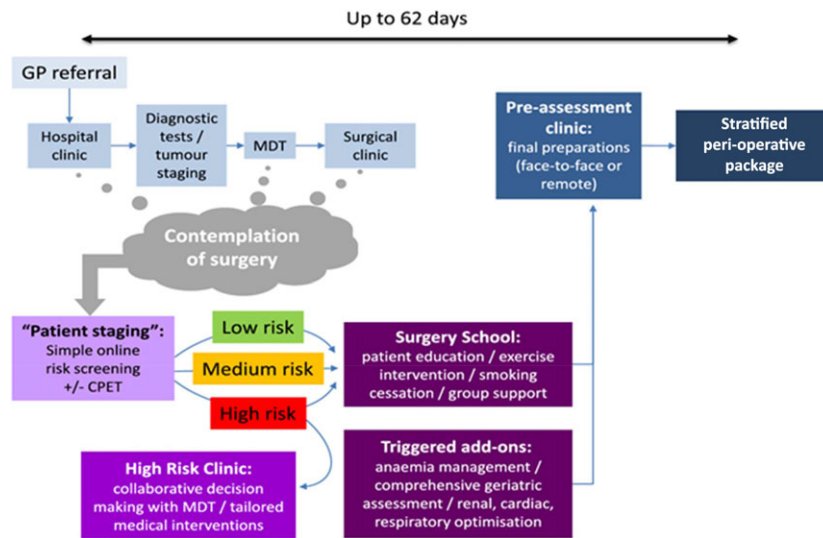


Figure 3 Proposed 're-engineered' pre-operative pathway.

patient and physician experience. Shared decision-making is covered in detail elsewhere in this journal Supplement [20]. An important implication of shared decision-making is that those patients most likely to choose not to have surgery are, in general, those patients who are at highest risk of adverse outcomes following surgery. Such patients are those in whom the harms of operative intervention do, or at least may, outweigh any potential benefits of surgery, and therefore they quite rationally make alternative healthcare choices (e.g. less aggressive surgery, alternative medical treatments including chemotherapy and palliative care). Importantly, patients at high risk of adverse outcomes contribute disproportionately to healthcare costs. Complications following surgery cost, on average, two or three times more than straightforward care [21] and those patients at the highest risk cost the most. The notion that a

small number of patients contribute disproportionately to total cost is well recognised, both at an individual patient level (patient level cost attribution) and at a population level [11]. It is important to note that shared decision-making does not force patients to make decisions. Although some patients may choose, within a shared decision-making context, to accept advice from their doctor in a more paternalistic mode, others will seek to make their own independent decisions based on information provided by physicians. Many others lie on a spectrum between these two positions.

Co-existing disease is a powerful influence on risk in people undergoing major surgery, and the effective management of comorbidities is an important means of mitigating this risk. A variety of models of dedicated pre-operative clinics have emerged in recent years but a

number of themes are becoming clear. Such clinics are typically addressing common problems (e.g. anaemia, diabetes) and are based on an algorithmic approach supported by the contribution of specialists. These clinics may be face-to-face, or more commonly, 'virtual' clinics, with a face-to-face specialist clinic available for more complex cases. Pre-operative anaemia clinics are probably the most widespread at present and a number of reports from early adopters have appeared [22]. For pre-operative anaemia clinics, the savings achieved through reduced peri-operative blood transfusion readily supports the business case for establishing such a clinic; this may be more difficult for other diseases for which less evidence is available. Comorbid disease management before surgery may relate to patients with long-established diagnoses, in which case a conversation with, or even referral to, the long-term care specialist physician will be appropriate. Alternatively, new diagnoses may emerge during pre-operative preparations that are initially managed within the dedicated peri-operative clinic. For some patients, encounters with peri-operative physicians before surgery may constitute their first substantive health evaluation for many years. Established peri-operative clinics include: anaemia, diabetes, heart failure, cardiac ischaemia, cardiac devices (pacemakers, implantable cardiac devices), chronic obstructive airways disease, sleep/obstructive sleep apnoea and pain. Pre-operative pain clinics have become increasingly important with the emergence of the 'opioid epidemic', particularly in the US [23]. Peri-operative management of opioid dependence, whether from prescription, 'bystander' (consumption of someone else's prescription) or illicit drug use, is rapidly becoming more sophisticated with the extensive experience being accumulated in the US. Pathway re-engineering enables the effective delivery of such clinics by providing the necessary time for evaluation and intervention before surgery.

Collaborative behavioural change becomes possible during the pre-operative period, as patients may be more susceptible to behaviour change interventions than during their 'normal' lives. Such interventions also offer a psychological boost at a time when patients may feel very limited control of their immediate destiny. Smoking cessation [24], alcohol cessation [25], nutritional optimisation [26] and physical activity and exercise [27] are covered in detail elsewhere in this supplement [28–31]. In each case, despite the current very limited evidence base, there are data available to point to the likelihood of significant clinical benefit in terms of improvements in short-term clinical outcomes. The notion that such changes in behaviour around the time of surgery may be long-lasting is

intriguing and contributes to the paradigm that the practice of peri-operative medicine may provide population health benefits.

### ***Intra-operative care***

Developments in individualised, risk-adapted, intra-operative interventions should lead to more reliable, consistent care. Increasingly persuasive data suggest that many aspects of intra-operative care received by patients do not appear to represent either the best available evidence or a sound physiological basis: the factors that we might expect to drive delivered care are not necessarily those that do in 'real life' practice. An excellent example is that of fluid therapy, where recent studies in the US have demonstrated very substantial between-patient variations in volumes of fluid administered during major surgery [32]. Although we might expect such variation to be based on patient (e.g. age, risk) or surgical (e.g. duration, blood loss) characteristics, in fact the biggest determinants were the identity of the anaesthesia and surgical providers [32]. In other words, the clinicians' personal behaviours were more important than the patients' clinical situation. Furthermore, this variability is linked to clinical outcomes [33]. Similar patterns of variation in care pertain in peri-operative blood transfusion [34], oxygen therapy [35] and peri-operative ventilation [36]. These observations support the notion that intra-operative care should be both standardised and individualised; standardised to drive consistent patterns of care between different patients, and individualised to ensure that such care is based on individual patients' clinical risk. The adoption of a standardised risk-adapted approach to peri-operative fluid therapy [37] is an example of such an approach: standardised in that all patients are treated using the same risk-adapted framework, and individualised in that the precise management approach is based on the characteristics of the individual patient and their surgery [37]. An additional advantage of such a consistent approach to intra-operative patient management, and indeed to care in general, is that the evaluation of new interventions becomes easier due to an improvement in the relationship between 'signal' and 'noise'. Consistent routine care improves the likelihood that any signal of benefit (or harm) will be detected during formal evaluation such as quality improvement initiative or randomised controlled trial.

### ***Postoperative care***

Risk-adapted postoperative management, particularly around individualised care and transitions of care, has a significant role in improving value through peri-operative

medicine. In the short term, effective pre-operative risk characterisation and responsive postoperative care provision should ensure effective allocation of postoperative resources to those in need of them. Low-risk patients experiencing an uncomplicated recovery should be encouraged to return to normal function and discharged home as quickly as possible. Patients at higher risk of adverse outcome and/or who develop postoperative complications should be provided with the appropriate level of care in a timely manner, and on a preventative basis where possible. Effective management of the transitions from theatre to postoperative care, between postoperative care environments and from hospital to the community should maximise the benefit of previous interventions (surgery, behavioural change, comorbidity management) and minimise the risk of errors (e.g. failure to restart important long-term medications after surgery). Furthermore, linkage between primary and community care offers further opportunities to contribute to public health benefit by ensuring continuity of pre-operative behavioural change and comorbidity management interventions.

A number of principles can be seen to underpin effective postoperative care. First, the targeting of the limited available resources based on effectiveness of use, not traditional care silos: risk-adapted postoperative management. Second, achieving a balance between enhanced recovery principles and augmented care after surgery. Third, redefining postoperative care environments to meet the needs of patients that fall outside the current classification of levels of care (see next section). Fourth, the flexible use of physical medical and nursing/allied health professional resources to maximise effectiveness. Fifth, minimising risks inherent in transitions of care through more effective communication and implementation of systems (e.g. checklists) based on knowledge of human factors (see section below).

The individualised allocation of postoperative resources implies a move beyond current practice. Typically, a hospital offering major (in-patient) surgery will be able to offer some or all of the following range of postoperative care environments: Intensive Care (Level 3); Surgical High Dependency Care (Level 2); Postoperative Care Unit/Overnight Intensive Care (short stay unit that offers some level-3 facilities); augmented ward care; a postoperative outreach team and a peri-operative medicine team. Although the 'typical' postoperative journey involves the patients spending a few hours in recovery before returning to a surgical specialty ward, the variety of alternatives to this is increasing and the basis on which

patients are triaged to different postoperative environments is changing.

Long-standing definitions of critical care (Levels 1/2/3) [38] are evolving as the spectrum of facilities becomes increasingly diverse. Although some hospitals offer augmented care within environments defined by these traditional criteria and staffed by intensivists or anaesthetists, other hospitals offer augmented care (monitored beds, cardiovascular support) in a ward-based environment with medical input from the surgical team. Furthermore, the criteria governing which patients are offered such care are changing. The notion that patients undergoing particular procedures are automatically cared for in intensive care or high dependency after surgery, although others are not, is evolving towards a framework of risk-adapted care defined by an individual patient's risk of postoperative harm in general, and specific risks in particular (e.g. airway problems following maxillofacial surgery). Although more 'high-risk' patients are being triaged to augmented care environments, low-risk patients undergoing higher risk procedures are often being 'fast-tracked' to the ward. A corollary of this approach is that it may make more sense to group patients in wards by risk and level of care, rather than by surgical specialty, in the immediate postoperative phase. An important consideration in this regard is that the advantages of a closely monitored, well-staffed environment aimed at avoiding 'failure to rescue' [39] need to be balanced against the more effective delivery of enhanced recovery goals that are typically achieved more effectively on general surgical wards. Consistent with the notion of 'critical care without walls', the characteristics of the care delivered are more important than its location. The level of staffing and monitoring, and the consequent capacity to safely execute complex postoperative interventions (e.g. vasopressors, non-invasive ventilation) is more important than the name over the ward door. Layered over the location of the patient is the availability of appropriately trained specialist postoperative care providers in a prompt and reliable manner. Peri-operative physician and critical care outreach teams may provide regular planned reviews of postoperative recovery as well as a rapid-response function to minimise the risk of failure to rescue. Finally, the concept of DrEaMing (Drinking Eating and Mobilising) [40] is increasingly being seen as important, both as marker of recovery that has utility in managing postoperative care (patients that achieve DrEaMing rarely develop subsequent complications) and as a benchmarking measure of the effectiveness of peri-operative care (see below) [40].

Transitions of postoperative care will still be necessary and effective communication is fundamental to safely managing these. Early transitions between recovery and ward or augmented care environment are best accompanied by direct verbal handover between medical staff to accompany ongoing clinical documentation. Checklist-type approaches are valuable to minimise the risk of human error in this context. Similarly, the lack of integration between secondary and primary care, coupled with the persistent use of out-dated technology (e.g. traditional mail, fax) contribute to patient dissatisfaction around the transition of care from home-to-hospital and hospital-to-home (community). Interventions targeted at improving transitions of care have, in general, been shown to improve clinical outcomes and patient satisfaction [41, 42], but the research literature in the peri-operative setting is very limited. Effective discharge planning commences at the moment that admission is contemplated. Length of hospital stay and requirements for postoperative care and services are largely predictable based on the patient's pre-operative circumstances and the nature of the intervention. Nevertheless, linkage with primary care is often poor, made worse through the limited use of effective electronic communication. The attention now typically given to in-hospital transitions of care should also be applied to transitions between primary and secondary care and within the broader community care network, including social services. Of note, the move within England towards integrated care organisations (e.g. Accountable Care Organisations, ACOs) may facilitate such a collaboration. Continuation of interventions (e.g. exercise rehabilitation) from before surgery, into recovery, and after discharge has the potential to maximise the public health benefits of peri-operative medicine. Effective integration between secondary care peri-operative medicine teams and primary care services can consolidate pre-operative behavioural changes and continue comorbidity management to match the evolving needs of patients following surgery. Two particular examples that merit attention across transitions of care are effective management of polypharmacy, and consistent attention to opioid minimisation/avoidance. Fundamental to the effective delivery of these aspirations will be the development of efficient and effective lines of communication with primary care and community providers. Linking effectively with general practice as well as community health and social care services will increase the likelihood of seamless delivery of care that functions in the patient's best interests.

## Continuous improvement?

Pathway redesign, as with all changes to clinical care, brings with it the possibility of harm as well as benefit. Implementation of change within healthcare is notoriously slow and incomplete. Systematic data collection on processes and outcomes of care should be considered essential for quality care provision. Only through recording, and analysing the reliability of, delivery of processes can we evaluate whether we are actually providing the care we assume we are. Only through the systematic comparison of process reliability and risk-adjusted outcomes with benchmarking against peer institutions can we be confident that our care is the best it can be. Increasingly, such data management will be augmented by more advanced methods of analysis, presentation and modelling, including the use of predictive analytics, topological data analysis, systems modelling and artificial intelligence.

## The professions of anaesthesia

In much of the developed world, anaesthetic care is provided by physicians. In low- and middle-income countries, non-physician providers often provide anaesthesia due to the limited availability of physicians. In the US, there is a long-standing mix of physician and non-physician (Certified Registered Nurse Anesthetists) providers; Certified Registered Nurse Anaesthetists can practice independently in more than half of US states. Technical solutions to the delivery of anaesthesia, including automated intelligent care delivery systems, robotic procedures and predictive analytics, will inevitably change the roles of anaesthesia providers of all types over time. Relying on the practice of anaesthesia delivery within the operating theatre/room to sustain the medical specialty of anaesthesia is likely to result in role displacement and loss of added value in the future. To paraphrase a quote about evolution that is often misattributed to Charles Darwin: *'It is not the most intellectual or the strongest that survives, but rather those that are best able to adapt or adjust to the changing environment in which they find themselves'* [43]. Failure to anticipate and adapt to the changing nature of anaesthetic service provision and technology, and the impact this will have on anaesthesia as a medical profession, risks professional decline and fall. In contrast, anticipation of this future, with a holistic focus on the broader spectrum of medical needs of patients contemplating and undergoing surgery, will ensure the vitality of anaesthesia as a medical specialty. The current time offers a particular opportunity for physician anaesthetists to align their interests with those of



their patients and embrace the future of peri-operative medicine.

## Conclusion

Peri-operative medicine provides an opportunity to meet the challenge set down by the Institute for Healthcare Improvement's 'triple aim' of improving patient experience and population health while reducing costs. Anaesthetists are well positioned to lead the re-engineering of pre-operative care pathways needed to achieve this goal through shared decision-making, comorbidity management and collaborative behavioural change. Standardised, individualised (risk-adapted) intra-operative care leading to risk-adapted postoperative care, particularly around transitions of care, offers a further opportunity to improve value while contributing to improving patient and population health. Effective operationalisation of these ideas will be enabled by systematic data collection focused on quality improvement and supported by technological development in data analysis and presentation. For the medical specialty of anaesthesia, peri-operative medicine offers the opportunity to achieve a step-change in patient experience and contribute to improving public/population health and value while meeting the challenges associated with technological and workforce changes, that may otherwise result in role displacement and professional decline.

## Acknowledgements

No conflict of interest declared.

## References

- Grocott MP, Pearce RM. Peri-operative medicine. *British Journal of Anaesthesia* 2012; **108**: 723–6.
- Mythen MG, Berry C, Drake S, et al. *Peri-operative medicine: the pathway to better surgical care*. London: Royal College of Anaesthetists, 2015.
- Health Care Cost Institute. *Health care cost and utilization report: 2011*. Washington, DC: Health Care Cost Institute, 2012.
- Berwick DM, Nolan TW, Whittington J. The triple aim: care, health, and cost. *Health Affairs (Millwood)* 2008; **27**: 759–69.
- NHS England. Next steps on the NHS Five Year Forward View. 2017. <https://www.england.nhs.uk/publication/next-steps-on-the-nhs-five-year-forward-view> (accessed 23/10/2018).
- Barnett K, Mercer SW, Norbury M, Watt G, Wyke S, Guthrie B. Epidemiology of multimorbidity and implications for health care, research, and medical education: a cross-sectional study. *Lancet* 2012; **380**: 37–43.
- Glance LG, Osler TM, Neuman MD. Redesigning surgical decision making for high-risk patients. *New England Journal of Medicine* 2014; **370**: 1379–81.
- Grocott MPW, Plumb JOM, Edwards M, Fecher-Jones I, Levett DZH. Re-designing the pathway to surgery: better care and added value. *Perioperative Medicine* 2017; **6**: 9.
- Levett DZ, Edwards M, Grocott M, Mythen M. Preparing the patient for surgery to improve outcomes. *Best Practice and Research: Clinical Anaesthesiology* 2016; **30**: 145–57.
- Academy of Medical Royal Colleges. *Multimorbidity: a priority for global health research*. London: Academy of Medical Royal Colleges, 2018.
- Use of patient-level costing to increase efficiency in NHS trusts, Nuffield Trust, London, 2012. <https://www.nuffieldtrust.org.uk/files/2017-01/patient-level-costing-full-web-final.pdf> (accessed 13/08/2018).
- Porter ME. What is value in health care? *New England Journal of Medicine* 2010; **363**: 2477–81.
- Kindig D, Stoddart G. What is population health? *American Journal of Public Health* 2003; **93**: 380–3.
- The King's Fund. What does improving population health really mean? 2017. <https://www.kingsfund.org.uk/publications/what-does-improving-population-health-mean> (accessed 13/08/2018).
- Barnett K, Mercer SW, Norbury M, Watt G, Wyke S, Guthrie B. Epidemiology of multimorbidity and implications for health care, research, and medical education: a cross-sectional study. *Lancet* 2012; **380**: 37–43.
- Vetter TR, Boudreaux AM, Jones KA, Hunter JM Jr, Pittet JF. The peri-operative surgical home: how anesthesiology can collaboratively achieve and leverage the triple aim in health care. *Anesthesia and Analgesia* 2014; **118**: 1131–6.
- Peden CJ, Mythen MG, Vetter TR. Population health management and peri-operative medicine: the expanding role of the anesthesiologist. *Anesthesia and Analgesia* 2018; **126**: 397–9.
- Aronson S, Sangvai D, McClellan MB. Why a proactive peri-operative medicine policy is crucial for a sustainable population health strategy. *Anesthesia and Analgesia* 2018; **126**: 710–2.
- Aronson S, Westover J, Guinn N, et al. Peri-operative medicine model for population health: an integrated approach for an evolving clinical science. *Anesthesia and Analgesia* 2018; **126**: 682–90.
- Sturgess J, Clapp JT, Fleisher LA. Shared decision-making in peri-operative medicine: a narrative review. *Anaesthesia* 2019; **74** (Suppl. 1): 13–9.
- Eappen S, Lane BH, Rosenberg B, et al. Relationship between occurrence of surgical complications and hospital finances. *Journal of the American Medical Association* 2013; **309**: 1599–606.
- Guinn NR, Guercio JR, Hopkins TJ, et al. How do we develop and implement a pre-operative anemia clinic designed to improve peri-operative outcomes and reduce cost? *Transfusion* 2016; **56**: 297–303.
- Koepke EJ, Manning EL, Miller TE, Ganesh A, Williams DGA, Manning MW. The rising tide of opioid use and abuse: the role of the anesthesiologist. *Perioperative Medicine* 2018; **7**: 16.
- Thomsen T, Villebro N, Møller AM. Interventions for pre-operative smoking cessation. *Cochrane Database of Systematic Reviews* 2014; **3**: CD002294.
- Oppedal K, Møller AM, Pedersen B, et al. Pre-operative alcohol cessation prior to elective surgery. *Cochrane Database of Systematic Reviews* 2012; **7**: CD008343.
- West MA, Wischmeyer PE, Grocott MPW. Prehabilitation and nutritional support to improve peri-operative outcomes. *Current Anesthesiology Report* 2017; **7**: 340–9.
- Richardson K, Levett DZH, Jack S, Grocott MPW. Fit for surgery? Perspectives on pre-operative exercise testing and training. *British Journal of Anaesthesia* 2017; **119** (suppl\_1): i34–432.
- Levy N, Grocott MPW, Carli F. Patient optimisation before surgery: a clear and present challenge in peri-operative care. *Anaesthesia* 2019; **74** (Suppl 1.): 3–6.

29. Gillis C, Wischmeyer PE. Pre-operative nutrition and the elective surgical patient: why, how, and what? *Anaesthesia* 2019; **74**(Suppl. 1): 27–35.
30. Scheede-Bergdahl C, Minnella EM, Carli F. Multi-modal prehabilitation: addressing the why, when, what, how, who and where next? *Anaesthesia* 2019; **74**(Suppl. 1): 20–6.
31. Lumb AB. Pre-operative respiratory optimisation: an expert review. *Anaesthesia* 2019; **74**(Suppl. 1): 43–8.
32. Lilot M, Ehrenfeld JM, Lee C, et al. Variability in practice and factors predictive of total crystalloid administration during abdominal surgery: retrospective two-centre analysis. *British Journal of Anaesthesia* 2015; **114**: 767–76.
33. Thacker JK, Mountford WK, Ernst FR, Krukas MR, Mythen MM. Peri-operative fluid utilization variability and association with outcomes: considerations for enhanced recovery efforts in sample US surgical populations. *Annals of Surgery* 2016; **263**: 502–10.
34. Aquina CT, Blumberg N, Probst CP, et al. Significant variation in blood transfusion practice persists following upper GI cancer resection. *Journal of Gastrointestinal Surgery* 2015; **19**: 1927–37.
35. Morkane CM, McKenna H, Cumpstey AF, et al. Intraoperative oxygenation in adult patients undergoing surgery (iOPS): a retrospective observational study across 29 UK hospitals. *Perioperative Medicine* 2018; **7**: 17.
36. Molliex S, Passot S, Morel J, et al. A multicentre observational study on management of general anaesthesia in elderly patients at high-risk of postoperative adverse outcomes. *Anaesthesia Critical Care and Pain Medicine* 2018; pii: S2352-5568(17)30406-X. (e-pub ahead of print).
37. Miller TE, Roche AM, Mythen M. Fluid management and goal-directed therapy as an adjunct to Enhanced Recovery After Surgery (ERAS). *Canadian Journal of Anesthesia* 2015; **62**: 158–68.
38. Department of Health. *Comprehensive Critical Care: a review of adult critical care services*. London: Department of Health, 2000. [http://webarchive.nationalarchives.gov.uk/20121014090959/http://www.dh.gov.uk/prod\\_consum\\_dh/groups/dh\\_digitalassets/@dh/@en/documents/digitalasset/dh\\_4082872.pdf](http://webarchive.nationalarchives.gov.uk/20121014090959/http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/documents/digitalasset/dh_4082872.pdf) (accessed 13/08/2018).
39. Ghaferi AA, Birkmeyer JD, Dimick JB. Variation in hospital mortality associated with inpatient surgery. *New England Journal of Medicine* 2009; **361**: 1368–75.
40. Levy N, Mills P, Mythen M. Is the pursuit of DREAMing (drinking, eating and mobilising) the ultimate goal of anaesthesia? *Anaesthesia* 2016; **71**: 1008–12.
41. Naylor MD, Brooten D, Campbell R, et al. Comprehensive discharge planning and home follow-up of hospitalized elders: a randomized clinical trial. *Journal of the American Medical Association* 1999; **281**: 613–20.
42. Harrison MB, Browne GB, Roberts J, Tugwell P, Gafni A, Graham ID. Quality of life of individuals with heart failure: a randomized trial of the effectiveness of two models of hospital-to-home transition. *Medical Care* 2002; **40**: 271–82.
43. <https://quoteinvestigator.com/2014/05/04/adapt> (accessed 12/9/2018).