

Lean pathways in orthopaedics: multiple wins for sustainability

Scarlett McNally
 Emily Charlotte Phizacklea
 Victoria Naomi Gibbs
 Robyn Brown
 Katharine Vanessa Wilcocks
 Scarlett O'Brien
 Holly Kate Burton
 Steven Evans
 Martinique Vella-Baldacchino
 Alaa Khader
 Irrum Afzal
 Roshana Mehdian
 Kerl Michelle Power

Abstract

Sustainability means reducing waste, principally through 'reduce-reuse-recycle'. Lean pathways for orthopaedics surgery are an example of sustainable healthcare by reducing waste. Streamlining care and processes at every stage improves patient outcomes, minimizes costs and reduces carbon emissions. Perioperative care, from the moment an operation is contemplated until full recovery, has variability in practice. Preoperative assessment should be linked to optimization. Interventions such as exercise reduce complications by between 30% and 80%. Successful interventions include: 'surgery

Scarlett McNally BSc MB BChir FRCS(Tr&Orth) MA MBA, Consultant Orthopaedic Surgeon, Orthopaedic Department, East Sussex Healthcare NHS Trust and Deputy Director, Centre for Perioperative Care, London, UK. Conflicts of interest: none declared.

Emily Charlotte Phizacklea BMBS BSc (Hons) FRCAP, Anaesthetics Staff Grade, Anaesthetic Department, Queen Alexandra Hospital, Portsmouth, UK. Conflicts of interest: none declared.

Victoria Naomi Gibbs BA (Oxon) MBBS MRCS, Clinical Research Fellow, Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Sciences, Oxford University, UK. Conflicts of interest: none declared.

Robyn Brown MBBS MRCS BSc MSc, Orthopaedic Registrar, Severn Deanery, Gloucestershire NHS Foundation Trust, UK. Conflicts of interest: none declared.

Katharine Vanessa Wilcocks MA BSc (Hons) MCSP, Physiotherapist, Department of Orthopaedic Therapy, Salisbury NHS Foundation Trust, UK. Conflicts of interest: none declared.

Scarlett O'Brien MB BCh BAO MRCS, Core Surgical Trainee, Orthopaedic Department, Royal Victoria Hospital, Belfast, UK. Conflicts of interest: none declared.

schools'; early detection of anaemia; pre-emptive discharge planning; preoperative introduction of walking aids; planning of intraoperative equipment; techniques that allow early mobilization/discharge and reduced use of anaesthetic vapours. New streamlined pathways should be developed with the whole multidisciplinary team (MDT) focusing on practicalities. A 'trans-disciplinary team' approach, sharing skills, works better than silos. A standardized pathway allows care to be individualized where needed. In trauma care, lean pathways mean common issues can be pre-empted. For example, good patient information given by the emergency department, shared decision-making in fracture clinic and planning for day-case trauma lists. Change management is difficult. Tips include: learning from other sites; creating good information for patients; analysing unit data comparative to other sites; and discussing improvements as a whole team.

Keywords lean pathways; multidisciplinary team; perioperative care; process mapping; surgical efficiency

Introduction

Climate change poses one of the largest health emergencies threatening mankind today. The UK NHS is the largest single contributor of greenhouse gas emissions in the public sector. The carbon footprint of the NHS in England is estimated at 24.9 million tonnes CO₂ emitted (e) annually, and that of an operating department within a large UK hospital at 5000 tonnes CO₂e/year and a single operation up to 814 kg CO₂e.¹ There is a significant challenge ahead to enable surgery to meet net zero carbon by 2045, in line with the Greener NHS strategy. A sustainable healthcare system, as set out by the Academy of Medical Royal Colleges (AoMRC) encourages organizations to consider the 'triple bottom line' framework consisting of economic, environmental and social factors.²

Holly Kate Burton MBBCh BSc (Hons), Foundation Doctor, Department of Colorectal Surgery, Lancashire Teaching Trust, Preston, UK. Conflicts of interest: none declared.

Steven Evans BMedSci BMBS FRCA, Anaesthetic Registrar, Anaesthetic Department, Derriford Hospital, Plymouth, UK. Conflicts of interest: none declared.

Martinique Vella-Baldacchino MD MRCS(Eng) PgCert (Int health Leadership & Management), Trauma and Orthopaedic Registrar, Musculoskeletal Laboratory, Imperial College London, UK. Conflicts of interest: none declared.

Alaa Khader, Medical Student, Gezira University, Wadmedani, Gezira State, Sudan. Conflicts of interest: none declared.

Irrum Afzal MICR MRQA MPH DIC BSc (Hons), Research and Outcomes Manager, Academic Surgical Unit, South West London Elective Orthopaedic Centre, Epsom, UK. Conflicts of interest: none declared.

Roshana Mehdian MBChB BMSc (Hons) PGDipMedEd MRCS(Eng), Trauma and Orthopaedic Registrar, South West London Orthopaedic Deanery, London, UK. Conflicts of interest: none declared.

Kerl Michelle Power RGN Dip HSM BSc (Hons) PG Cert Ed, Specialist Theatre Practitioner, School of Health Sciences, University of Brighton, UK. Conflicts of interest: none declared.

For surgery, sustainability means reducing waste, focusing on reduce-reuse-recycle. Multiple steps in surgical pathways can be improved. ‘Reduce’ includes undertaking fewer unwarranted operations, reducing waste and minimizing complications. The scope for improvement is clear. Half a hospital’s costs are caused by 7% of patients and 10% of operations are burdened by complications. Interventions to improve modifiable risk factors, such as smoking and physical inactivity, can reduce complications by up to 80%.³

Perioperative care is the practice of patient-centred, multidisciplinary and integrated medical care of patients from the moment of contemplation of surgery until full recovery (see Figure 1). This is proven to be safe, cost-effective and reduces postoperative complication rates by 30–80% and length of stay by 1–2 days. Embedding a shared decision-making (SDM) approach within the preoperative phase will empower both patients and clinicians to make the correct choice. About 14% of patients experience surgical regret and by reducing unwarranted surgical procedures and minimizing post-operative complication rates this will reduce the resource burden and help make the health service more streamlined.

Streamlining services and pathways to be more efficient is the key to sustainability in surgery. The Get It Right First Time (GIRFT) programme aims for the right *first* intervention to reduce the need for reoperation or revision. Orthopaedics, the first specialty to implement GIRFT in 2012, reduced costs by £696 million in its first 5 years.⁴

Preoperative phase

The preoperative phase should be used pro-actively for assessment and optimization. There are a finite number of interventions that improve outcomes from surgery. Most address modifiable risk factors and include empowering patients. The pre-assessment team should use assessment as a driver to recommend optimization.⁵

Exercise

The intervention with most evidence of efficacy is preoperative exercise. Four modalities are helpful:

- cardiovascular fitness, aiming for 150 minutes/week of moderately intense exercise (eg static bike, electric-cycle or swimming)

- strength – twice per week, including squats to help with getting out of bed
- deep breathing exercises
- practising use of mobility aids, balancing on non-involved leg, being ready for ‘hip precautions’.

Prehabilitation: is a formal individualized coached exercise programme, with additional smoking or alcohol advice and psychological support. Many centres report success with these. Even advising patients to walk every day or use a static exercise bike is helpful.

Surgery schools: patients may be invited to a one-off session of group surgery school, focusing on preparing for their surgery alongside other patients, with education, discussion and practising of skills. These reduce length of stay and improve outcomes. On-line sessions have been successful in the pandemic, but they need a local, interactive format, with the ability to ask questions and discuss suggestions, to gain benefit.

Results of exercise and how to maximize them: the coronavirus disease (COVID-19) pandemic has led to an increase in waiting times for planned orthopaedic surgery, with deconditioning of patients on waiting lists. UK National Institute for Health and Care Excellence (NICE) guidelines (NG157) recommend providing preparatory information to reduce patients’ fear and anxiety in various formats, from the time of listing. Patients benefit from interacting with healthcare professionals and other patients in a group situation. All, however, require reinforcement through written material or media that can be viewed more than once. The information should include what to expect before, during and after surgery; information on how to prepare for surgery, including exercises to do before and after surgery, and lifestyle management.

Studies of preoperative exercise show significant improvements in quadriceps strength with reduced postoperative pain and length of stay.⁶ In addition to the traditional ‘physiotherapy’ input, every contact with the patient should be used as an opportunity to address modifiable risk factors, such as diet and psychological preparation and to set expectations. Rehabilitation should not wait until after surgery.



Figure 1 The perioperative pathway from www.cpoc.org.uk.

Nutrition

Nearly 50% of patients admitted to hospital are malnourished or at risk of malnutrition.¹⁰ Prospective cohort studies from around the world suggest that malnourished hospitalized and surgical patients have significantly worse clinical outcomes, with a fourfold greater risk of mortality, increased complications and re-admissions, prolonged hospitalizations and increased healthcare costs.⁷

Interventions should focus on fruit, vegetables and protein to help wound healing, with specific additions, such as iron-rich foods.

Some orthopaedic commissioning guidance restricts arthroplasty for patients with body mass index (BMI) of over 30 kg/m², the definition of obesity. Obesity can be hard to tackle with traditional calorie restriction. There is increasing evidence of effectiveness of low carbohydrate diets, portion control and intermittent fasting combined with daily exercise.⁸

Early postoperative nutritional support can reduce surgical trauma-related high metabolism, maintain the functions of the intestinal mucosal barrier and decrease the incidence of intestinal-borne infections, improving recovery of patients.

Anaemia

One-third of patients are anaemic prior to a hip or knee arthroplasty.⁹ Preoperative anaemia has been associated with an increased risk of adverse outcomes including mortality. Cohort studies of over 500,000 patients demonstrate an independent association between preoperative anaemia and 30-day morbidity (OR 1.41 95% CI 1.30 to 1.40) and mortality (OR 1.42 95% CI 1.31 to 1.54).¹⁰

Overtwo-thirds of cases of preoperative anaemia are secondary to iron deficiency and preoperative iron supplementation in these patients has been shown to improve postoperative morbidity and mortality. This suggests that preoperative anaemia is a modifiable risk factor rather than purely a marker of comorbidity. Improving preoperative anaemia reduces transfusion rates and length of stay. The current recommended best practice is to delay surgery for patients with anaemia until they have been optimized. Imminent new national guidance from the Centre for Perioperative Care (CPOC) demands early detection of anaemia, including its type and cause, with haemoglobin (Hb) estimation at referral or at first surgical consultation. This reinforces the concept of the waiting list as preparation time. Interventions include diet, oral iron, intravenous iron, vitamin B₁₂ and transfusion can be effective. The PREVENTT study was underpowered to show significant reductions in complications with intravenous iron but did reduce length of stay and use of blood transfusion.¹¹

Each patient should have a patient blood management (PBM) approach, involving all aspects of the MDT, to improve preoperative anaemia and conserve blood throughout the surgical journey. Strategies include identification of anaemia status early, identifying the cause of anaemia, providing effective treatment, reassessing anaemia status prior to surgery and minimizing intraoperative blood loss. This seldom occurs.

Patient information and empowerment

One of the four pillars of medical ethics is autonomy, meaning the patient has the final say over their treatment. The patient requires information. SDM means collaboration between the

clinician (and team) and the patient. NICE now mandates SDM (NG197). NICE evidence reviews found that the most effective way to implement SDM is from an organizational (higher) level and it requires high-quality information resources for patients. SDM should start before the first consultation. Patients should be primed to ask about the 'Benefits, Risks, Alternatives and what happens if they do Nothing' or 'BRAN'.¹² They should understand how the operation might fit in their life and how to prepare for it. Alternative options should be discussed in SDM and this can result in a lower uptake of the surgical management. Decision aids allows risk to be better understood and SDM reduces decisional conflict.¹³

Clearly SDM is best done with time and ample opportunities to discuss management options. SDM needs to be incorporated into all pathways – elective and emergency, and is most relevant when there is clinical uncertainty and more time for optimization. The patient should also be supported to prepare for the operation, addressing all modifiable risk factors.

Team-working

Lean pathways require all staff to focus on sustainability. A wide range of healthcare professionals are involved at different stages of a patient's pathway. Paradoxically, MDTs can invoke deference to the expertise of another staff group, meaning care is delivered in silos or patients wait for staff due to workforce constraints. The Academy of Medical Royal Colleges recommended a different model of working across professional groups of 'trans-disciplinary teams'.¹⁴ This means that each member of staff shares their key skills; other staff can give clear information and understand the critical aspects of an assessment; this works even when a key staff member is absent. Trans-disciplinary teams include administrative, managerial and support staff who should understand the common pathways and general advice that should be given. Where team-working works well, patient expectations are set, complications and patient length of stay are reduced.

Good team-working involves being very clear. Examples include: early identification of whether a patient requires a special deviation from a pathway and preoperative confirmation of whether a patient will require 'hip precautions'. Teams should look at their data together, inviting suggestions for improvement from all and all should share a common goal. Where care is protocolized, every staff member and patient is clear about the expectations.

IT support

The COVID-19 pandemic produced a significant challenge to the orthopaedic community. Patients were unable to attend face-to-face appointments and elective surgery was largely halted. The development and adaptations of digital health technologies to maintain social distancing became an important tool in the delivery, communication and care of orthopaedic patients. Digital pathways, which allow for fewer appointments and remote follow-up, reduce the carbon footprint, infection and costs.¹⁵ NHS England aims to support the digital transformation of the UK NHS and social care, and there are several 'digital playbooks' by which clinical teams can redesign care pathways to suit to their individual trust's needs.¹⁶

The preoperative assessment pathway has been successfully digitalized. South West London Elective Orthopaedic Centre

streamlined their service with a digital platform (Definition LifeBox preoperative health assessment (ePOA) app) which enabled patients to enter data from home, receive key information and access videos, prompts and procedure information. Clinicians can digitally interact with patients and access their patient assessment to identify high-risk patients earlier, which provides time to optimize these patients prior to surgery. Patients found to be at high risk attend a face-to-face appointment with an anaesthetist and further investigations are then requested. This process reduced face-to-face appointments by 60%, saved the patient on average 1.92 hours and reduced costs by £96,000 for every 5000 patients.¹⁵ Fewer than 8% of patients needed assistance. High patient satisfaction scores are encouraging.

Lean intraoperative care

As one of the most expensive and valuable resources within a hospital, it is crucial that operating theatres are used effectively. An efficient theatre department is essential to helping provide high-quality, safe care and reduce delays and cancellations. In 2009, NHS Improvement produced a dedicated and comprehensive toolkit about 'The Productive Operating Theatre' (TPOT)¹⁷ to guide theatre teams on a structured approach to interventions. Published reports show significant improvements in start time and reduced overrunning of lists.¹⁸ Key areas of focus include session scheduling, start-up time, patient preparation, patient turnaround, theatre environment, equipment and consumables and operational status monitoring.

Effective scheduling makes the most of available theatre sessions. Successful interventions have included the 'golden patient', planning dedicated hip fracture lists and prioritizing day-case procedures first to allow early discharges. A golden patient is a patient pre-selected to be first on the operating list, who is medically fit, appropriately investigated and has a clear surgical plan. This strategy results in a significant improvement in patient arrival time in the theatre, an earlier start of the first procedure, increased mean operating time per list, increased total case number and reduced cancellations. Dedicated hip fracture trauma lists with assigned regular experienced anaesthetists reduce cancellations of general trauma cases by liberating valuable operating time, with one trust demonstrating orthopaedic trauma cancellations due to systems failure reducing from 20.2% to 10.3% as a direct result.¹⁹

Efficient theatre session start times can be plagued by a lack of awareness of the importance of a prompt start, conflicting priorities and suboptimal communication between team members. Financial incentives, educational approaches, system-based techniques, communication, the 'golden patient' initiative and 'the productive operating theatre' scheme have all been shown to improve start time and are detailed by a comprehensive systematic review by Halim et al.²⁰ Specifically, a structured team briefing and debriefing with clear discussion points (including kit requirements) was demonstrated to significantly decrease start-up time by almost half. Other interventions highlighted by TPOT include the introduction of a Standard Operating Procedure to identify key tasks and roles for the team during the set-up period. This was shown to focus team members and share workload, thus increasing efficiency.

Streamlining the preparation and arrival of each patient, as well as turnaround time between patients is also key to

improving overall efficiency. Intraoperatively, this is ensuring each patient arrives in theatre at the correct time, consented, marked and with notes available.

Strategies that successfully reduce turnaround time include: focus on this in the team brief of the World Health Organization (WHO) checklist; an optimal 'trigger point' during surgery when the next patient is sent for (for West Middlesex Hospital – first swab count at the start of wound closure),¹⁷ creating a dedicated receiving area within the theatre complex (e.g. West Middlesex Hospital's Day of Surgery Admission (DOSA) area); and operational status monitoring, with live-time electronic status boards shared amongst theatre and non-theatre-based staff to respond to unexpected changes and staffing issues (e.g. The Shrewsbury and Telford Hospital NHS Trust's Staff allocation board on a plasma screen).¹⁷

Finally, the physical theatre environment, including equipment and stock availability, makes a significant impact on theatre efficiency, costs and sustainability. Simplifying the inventory reduces unnecessary kit orders, storage, cleaning, wastage and staff time. For example, Devon NHS reduced the number of suture lines held in stock from 43 to 30 by contacting all surgeons and simplifying what was required, saving the trust £15,000.¹⁷ Betsi Cadwaladr University Health Board in North Wales produced an award-winning 'Green Patient Pathway' for carpal tunnel release by simplifying equipment to be autoclaved, removing single-use surgical equipment and eliminating the need for ward admission.²¹ In summary, a combination of optimizing communication, simplifying the environment, and standardizing activity can optimize the efficiency of the patient pathway intraoperatively.

Minimizing anaesthetic gas usage

Although the choice of anaesthetic technique has traditionally been seen as dependent wholly on the clinical judgement of an anaesthetist in relation to a specific patient, a lean approach requires developing standard protocols, with deviation for clinical judgement reserved for medically complex patients. Knowledge about newer anaesthetic options and their impact on the environment and patient recovery is not widely held by orthopaedic surgeons, so the following details are important to those planning services.

Vapours have been the mainstay of anaesthetic practice since their first use with nitrous oxide, a gas we still use today. While there has been huge development within anaesthetic vapours, they are mostly still based on the same underlying principle of halogenated ethers, as were many of the original vapours including diethyl ether. The anaesthetic gases used most today are the hydrofluorocarbons sevoflurane and desflurane, the chlorofluorocarbon isoflurane and nitrous oxide as an adjunct. After being used, they are vented into the environment. While they are undeniably useful in anaesthetic practice, they have some very significant drawbacks. The key one of these when considering lean perioperative pathways is their impact on the environment, as they all act as powerful greenhouse gasses. Anaesthetic gasses account for 5% of the carbon footprint of the entire NHS. The use of desflurane for 1 hour is equivalent to driving 230 miles in a modern car.²²

There are easy alternatives to anaesthetic vapours, principally regional anaesthetics and total intravenous anaesthetic (TIVA).

Both remove the need for anaesthetic vapours. These are not without issue, however, and balancing the individual clinical needs of the patient when selecting the type of anaesthetic used versus the potential harm to people globally by contributing to greenhouse gases and global warming. TIVA itself is also not guilt-free when considering the environment. The plastic needed for syringes and giving sets is significant, propofol is generated from soybean oil and the propofol has been proven to be toxic should and when it reaches the water system.²³ As it is excreted renally, this is relatively inevitable. Individual anaesthetists also have individual opinions and allegiances to specific anaesthetic techniques, meaning that it is not as simple as just not ever using a gas again. There are important risks and benefits to every anaesthetic option.

There is no easy solution to address the environmental impact of anaesthesia, but there is a large amount of ongoing debate and discussion. There are multiple ways in which it may be mitigated, including education, altered ways of using vapours, technological advances and novel agents. The importance of education cannot be overstated. If every anaesthetist is aware of the impact of every option, they can then balance the risks to the patient versus the risk to the environment. Education alone has led to drastically reduced quantities of desflurane being used, since it has become better known that it is over 75 times more environmentally damaging than sevoflurane when used like for like.²⁴ Educational opportunities can also promote 'low-flow' anaesthesia, where overall less anaesthetic gas is used.

Technological advances can improve how the exhaled anaesthetic gases are managed. These developments can trap the vapours allowing them to be either destroyed or re-processed. One future option may be zeolite filters, which can absorb vapours, allowing them to be processed and re-used.

Finally, novel anaesthetic agents can reduce the need for the current anaesthetic vapours. The most promising of these is xenon. It is an alternative to nitrous oxide, useful for its analgesic properties, rapid induction and in the case of emergencies, its negligible impact on intracranial pressure and oxygen use, haemodynamic stability and the absence of impact on the environment when released into the atmosphere. The main drawbacks of xenon currently, however, are its prohibitively high price and difficulties with production.

Regional anaesthetic techniques are often advantageous, reducing the need for general anaesthesia, hence having lower impact on the environment and reducing the intensity of postoperative patient care.

In summary, anaesthesia can have a huge impact on the environment and it should be a responsibility of all who design lean pathways to consider environmental stewardship. There is no perfect solution. However, by tackling the issue on a number of fronts including education to mitigate their impact when they are used, alternative anaesthetic options including regional anaesthetics and TIVA and pushing for the technological advances, the environmental impact can be drastically reduced.

Analgesia

Analgesia protocols should be instituted to minimize wasted medications and prevent delayed discharges for pain control. Achieving suitable analgesic control following surgery improves

patient outcomes and decreases length of stay. The most important factors are decreased physiological stress, leading to improved healing, and improved mobilization, postoperative physiotherapy and rehabilitation. This in turn leads to a shorter length of stay and fewer complications.

Whilst there is no consensus, there are some common themes amongst analgesia protocols irrespective of the surgery taking place, or the anaesthetist involved.^{25,26} These are:

- c patient education
- pre-emptive analgesics including steroids and gabapentinoids
- intraoperative steroids
- regional blockade where appropriate
- multimodal analgesia
- adjuncts to minimize side effects including laxatives and anti-emetics
- minimization of postoperative opioid use where possible.

Analgesia for elective hip arthroplasty

Use of pre-emptive analgesia down-regulates the central response to pain, reducing the risk of chronic pain post-operatively.²⁵ There is mixed evidence regarding opioids, but stronger evidence for the use of gabapentinoids. The specific type of anaesthetic may also have an important role in postoperative pain relief. Regional anaesthesia, such as spinal, epidural, fascia iliaca block, subclavian or axillary block, is more effective than general anaesthesia in reducing the quantity of post-operative opioids required and probably also at reducing generalized operative risks.

When considering postoperative pain, a multi-modal approach, including paracetamol, non-steroidal anti-inflammatory drugs (NSAIDs) or COX inhibitors, and gabapentinoids is important. Opioids are still highly likely to be required however. There is some evidence that the best pain scores with opioids are achieved with a patient-controlled analgesia (PCA) pump. This both psychologically empowers the patient and reduces the risk of time delays between request for analgesia and administration. PCAs require an intravenous line attached to a pump which can logistically prevent the patient from mobilizing and increase the general 'medicalization' of the patient.

When oral opioids are required, utilizing longer acting opioids such as oxycodone is a better approach than short 'quick on quick off' which can result in ongoing breakthrough pain, higher dosing and increased side effects.²⁶

Analgesia for elective knee arthroplasties

Total knee arthroplasties have greater analgesic requirements postoperatively than hips. There is a major benefit to regional blockade but it is important to preserve motor function to allow good rehabilitation postoperatively, and prevent delay to mobilization. Block options include femoral, sciatic, obturator and lumbar plexus blocks. None is preferred over another, but large volume nerve blocks have a very high associated rate of dense motor block and are therefore less favourable.²⁶

Intra-articular injection by the surgeons at time of surgery also has significant benefits, most when combining opioids and local anaesthetic; however, ketorolac, clonidine and steroids can also be used. There is no consensus about the optimal dosage and composition.

Postoperative mobilization

Financial pressures on the NHS are significant; these pressures are affecting the services provided with a growing gap between demand and capacity with little to no investment in increased staffing. Following surgery, the first mobilization of a patient is traditionally the role of the physiotherapist. With the benefits of early mobilization well documented,²⁷ it is, however, important that this opportunity is available to the patient regardless of the time of their surgery throughout the 24-hour period. Training should be provided to the MDT so that any appropriately trained member of the team can be the first to mobilize the patient post-operatively, facilitating earlier mobilization.

For planned orthopaedics and trauma, a culture of rehabilitation is needed across all disciplines to support the patient pathway, facilitate criteria-led discharge and improve patient outcomes and experience.

Staff involved in postoperative rehabilitation should liaise with the preoperative assessment team and fracture clinic team for ambulatory patients, to ensure tips, exercises and ideally practise with appropriate walking aids can occur before the operation.

Day case pathways

CPOC, GIRFT and the British Association of Day Surgery have written a Day Surgery Delivery pack highlighting how pathways and patient preparation can be improved to permit more operations to be performed on a day case basis; this includes patients with dementia and diabetes and ambulatory trauma patients.²⁸ Many units now run successful day case arthroplasty pathways. These units show that attention to multiple steps shows good results. The key feature is pre-empting care needs and standardizing pathways. For example, the University College London Hospitals (UCLH) day case arthroplasty protocol includes:

- in the outpatient clinic – an early Hb check and information given
- in pre-assessment – therapy-led education including practice with walking aids, health screening, tests and optimization
- Intraoperatively – careful anaesthesia, warming and fluids, minimization of soft tissue trauma, using tranexamic acid to reduce bleeding
- in recovery/ward – analgesia, Hb check, X-ray and physiotherapy.

Day case arthroplasty is currently limited with patient selection for fit and motivated patients. All-day operating lists mean patients may be operated on too late to go home. Delivering a day case arthroplasty service improves the sustainability of pathways for all other patients, by ensuring everything that can be done in advance and everything that might streamline care is done.²⁹

Postoperative X-rays

Waiting for a postoperative X-ray to be performed or reviewed may delay either mobilization or discharge.³⁰ Following total knee arthroplasty, one study of 624 postoperative X-rays found only 0.1% had fracture, dislocation or other significant abnormalities.³⁰ The postoperative X-ray may be better scheduled on

the patient's first postoperative clinic visit. Following hemiarthroplasty for intracapsular neck of femur fracture, some hospitals stopped routine X-rays to reduce the movement of patients and nosocomial transmission of COVID-19, with no change to the acute management of patients undergoing hemiarthroplasty.³¹ Following total hip replacement, patients are more active and should have baseline routine radiographs to help in the future when assessing implant migration or loosening.

Enhanced care units

The medical complexity of patients has increased in recent decades. The COVID-19 pandemic has worsened this, with delayed presentations and deconditioning. This has led to an escalating need for critical care beds, which are in significantly short supply and are expensive. The commonest reason for short notice cancellation of patients for elective surgery is lack of a ward bed or lack of a critical care bed.³²

Many of the patients who go to critical care do not require organ support but are too high risk for ward care. There are several levels of care defined by the Intensive Care Society³³:

- Level 0 – requires hospitalization and ward care, but monitoring less than 4 hourly
- Level 1 – enhanced care – in need of additional monitoring/clinical interventions, clinical input or advice
- Level 2 – requires one-organ support (renal, cardiovascular, basic respiratory)
- Level 3 – requires advanced respiratory support or two-organ support.

Sometimes a general ward is used as an alternative to cancelling the patient, but negative outcomes are common in patients whose condition deteriorates and they are transferred to a Level 2 or Level 3 unit as an emergency.

A new option is to create enhanced care units (ECUs). These are ring-fenced areas capable of caring for Level 1 patients postoperatively. ICM and CPOC have written guidance on training requirements and capabilities.³⁴

For example, staff may upskill and rotate from the general ward. This approach requires:

- early risk stratification and preoperative optimization
- preoperative anaesthetic review to enable SDM and planning of the most appropriate postoperative destination
- structured guidelines and proformas for admission, daily review, escalation and discharge
- enhanced nursing training and improved monitoring facilities
- dedicated, ring-fenced beds in a designated ward area.

ECUs have repeatedly been shown to reduce patient morbidity and mortality. In addition to this, they reduce unnecessary intensive care unit admissions, reduce short-notice cancellations and improve waiting times. These features improve the leanness of the patient pathway while also improving patient safety and patient outcomes. This is a developing field and enhanced care has real power to improve how we manage high-risk elective patients.

Ward-led discharge or criteria-led discharge

Delays in discharge remain a problem across planned surgery, resulting in hospital flow issues such as cancelled surgeries,

increased costs and poor patient experience. Criteria-led discharge allows a competent allied health professional (AHP) or nurse to discharge a patient when they fulfil pre-agreed clinical criteria for discharge. This removes the need for the patient to wait for the lead clinician, usually the consultant, to approve the discharge. Nurse-led discharge, in comparison to doctor-led discharge has been shown to be more timely. Discharge criteria are identified by the lead clinician and MDT. They are usually standardized for a specific procedure but can be adapted to the individual patient. Functional discharge criteria shorten length of stay, focusing on what the patient can do. Discharge planning should start preoperatively, with patient empowerment and setting expectations of patients, their carers and family.

At present, discharge from physiotherapy as 'safe for discharge' frequently occurs one day before the patient is discharged from hospital. Common delays preventing early, fast track discharge following planned orthopaedic surgery include X-ray review and blood test results. Blood tests are routinely undertaken following arthroplasty surgery in all age groups and fitness levels. Younger, lower American Society of Anesthesiologists (ASA) grade individuals rarely require clinical intervention following joint replacement. With improved surgical techniques leading to reduced blood loss, accurate estimation of perioperative blood loss could reduce unnecessary blood tests. Development of this type of protocol would reduce unnecessary blood tests and reduce delays caused by blood test results requiring review by a doctor prior to discharge.

Creating lean pathways for trauma patients

Although trauma patients have a reduced time for preoperative preparation compared with elective patients, it is possible to design lean pathways for trauma patients that pre-empt and improve care.

Analgesia in trauma patients to streamline care

A standardized approach to pre- and postoperative analgesia should be used. A definitive emergency department protocol for analgesia prescription in fractures improves the numbers of patients receiving good-quality analgesia prior to admission to the ward. A single fascia iliaca block (FIB) preoperatively reduces opioid consumption and increases the likelihood that patients are discharged home postoperatively.³⁵ Standardized analgesia protocols in the postoperative period can improve pain control, which allows patients to mobilize and rehabilitate more quickly, which in turn can improve length of stay. FIBs can be repeated intraoperatively. They are effective for up to 72 hours, which reduces opioid use over this time, as well as nausea. Both pain and nausea are factors that stop patients getting out of bed and beginning rehabilitation, so reducing them is beneficial.

Medical optimization in trauma patients

It is now accepted that all frail, elderly patients should be reviewed by the orthogeriatric team within 72 hours of admission. This is a change from the previous British Orthopaedic Association Standards in Trauma (BOAST) guideline, which discussed hip fracture management only. The updated BOAST advocates all fracture patients are managed in a similar way in terms of medical optimization, analgesia, rehabilitation goals. Meeting this standard means all frail or older patients should

receive timely, appropriate care with the correct professionals involved.³⁶ Early orthogeriatrician input can reduce length of stay, by reducing time from admission to surgery with medical optimization and ensuring timely discharge by limiting medical complications.

Ambulatory trauma surgery

Many patients with fractures or other trauma requiring surgery can be treated on an ambulatory basis. This requires good patient information distributed early by the emergency department. East Sussex Healthcare has information on common injuries available on www.esht.nhs.uk and as a QR code on posters in the waiting room. Sometimes reduction and casting of the fracture is required. A planned fracture clinic appointment allows SDM and surgery can be planned as a day case, or for minimal stay. Many units have reported on no significant increase in complications in ankle fractures managed on an outpatient basis and no difference in 30-day morbidity, even in ASA 3 patients. A wide variety of cases can be performed on a day case basis, with good outcomes.

Rehabilitation after trauma surgery

Patients should be mobilized as early as possible postoperatively to maximize overall rehabilitation potential. Patients and their families should be informed of their rehabilitation goals. A higher proportion of hip fracture patients return to their pre-admission residence if an individualized rehabilitation plan is formulated and patients are personally held accountable for their progress.

Changing to lean pathways

GIRFT has been very effective in changing practice. Within each Trust, it engages with clinicians and healthcare management analysing their own data, with comparisons benchmarked against other organizations. GIRFT offers advice, support and guidance. It aims to nudge all trusts towards top decile performance. GIRFT has designed best practice pathways across integrated systems. These pathways describe each stage of the patient pathway, reduce unwanted variation and recommend interventions that have shown to improve patient flow, produce best patient outcomes, enhance patient experience, reduce length of stay and reduce readmission rates. This has subsequently resulted in significant qualitative and quantitative improvements in orthopaedic surgery.

Change management

Achieving lean pathways requires work to change processes and culture. Change must be managed and practical difficulties anticipated and predicted, otherwise unwanted outcomes are likely. There are several models for the management of change. Bevan describes a J-Curve, with a period of disruption and worsening of productivity and performance, before it eventually improves.³⁷

Another common model describes a series of stages of uptake of change over time as: innovators, early adopters, early majority (pragmatists) late majority (conservatives) and laggards (sceptics), with 'the chasm' between early adopters and early majority. Just setting out the rationale for change is not enough. A wide coalition of support is needed and local data.

Local development of successful preoperative anaemia pathways can be used to illustrate this concept.³⁸ A stepwise selection of measures that fit a local hospital is needed, including identifying leaders of change, widespread education and audits to direct development of protocols. The important concept is to ensure sustained enthusiasm and awareness for the system to remain viable.

Kotter describes an eight-step change model,³⁹ firstly creating an climate for change, then enabling the change, then sustaining it, as:

1. Create urgency
2. Build a coalition
3. Create a vision
4. Communicate that vision
5. Empower others
6. Create quick wins
7. Build on the change
8. Embed the change.

Organizations are encouraged to collect data on their current 'before' practice because quantitative and qualitative data are the most powerful tool to sustain the change. Data are often needed to justify a business case for an improved service.

Even change management itself is changing. Information technology has allowed easier access to data within an organization and an ability to influence through networks between organizations. Other targeted tools are available. For example, the Model Health System is a data-driven improvement tool where NHS trusts can see the data they have submitted and comparisons with other sites, thereby identifying what might be learned from others. Benchmarked data help to identify opportunities for improvement.

Conclusion

Sustainability requires 'reduce, reuse, recycle'. There are multiple opportunities to create lean pathways in orthopaedics, focusing on each step of the patient journey. This requires staff working together across traditional boundaries. If care is standardized, with clear expectations, then it is easier to individualize where needed. Perioperative care, from the moment an operation is contemplated until full recovery, is currently disjointed and inefficient with staff working in silos. Many initiatives to streamline perioperative pathways have shown big improvements in patient satisfaction, complication rate, length of stay, waste and cost. Change to lean pathways involves attention to details, sharing skills between staff in a 'trans-disciplinary team' and empowering patients, with education and support. Learning from successful units, comparing data and measuring improvements all help to sustain changes. ◆

REFERENCES

- 1 Rizan C, Steinbach I, Nicholson R, Lillywhite R, Reed M, Bhutta MF. The carbon footprint of surgical operations: a systematic review. *Ann Surg* 2020; **272**: 986–95.
- 2 Maughan D, Gibbs R. In: AoMRC, ed. *Facing the future: sustainability for the Medical Royal Colleges*, 2014.
- 3 McNally S. Win—win for sustainability and health. *Bull R Coll Surg Engl* 2020; **102**: 206–9.
- 4 GIRFT. Getting it right in orthopaedics: reflecting on success and reinforcing improvement; A follow-up on the GIRFT national specialty report on orthopaedics, 2020.
- 5 McNally SA, El-Boghdady K, Kua J, Moonesinghe SR. Preoperative assessment and optimisation: the key to good outcomes after the pandemic. MA Healthcare London, 2021; 1–6.
- 6 Soeters R, White PB, Murray-Weir M, Koltsov JCB, Alexiades MM, Ranawat AS. Preoperative physical therapy education reduces time to meet functional milestones after total joint arthroplasty. *Clin Orthop Relat Res* 2018; **476**: 40–8.
- 7 Gillis C, Wischmeyer P. Pre-operative nutrition and the elective surgical patient: why, how and what? *Anaesthesia* 2019; **74**: 27–35.
- 8 SACN. Scientific Advisory Committee on Nutrition SACN report: lower carbohydrate diets for type 2 diabetes. Public Health England, 2021. Available from: www.gov.uk/government/publications/sacn-report-lower-carbohydrate-diets-for-type-2-diabetes
- 9 Muñoz M, Laso-Morales M, Gómez-Ramírez S, Cadellas M, Núñez-Matas M, García-Erce J. Pre-operative haemoglobin levels and iron status in a large multicentre cohort of patients undergoing major elective surgery. *Anaesthesia* 2017; **72**: 826–34.
- 10 Musallam KM, Tamim HM, Richards T, et al. Preoperative anaemia and postoperative outcomes in non-cardiac surgery: a retrospective cohort study. *Lancet* 2011; **378**: 1396–407.
- 11 Richards T, Baikady RR, Clevenger B, et al. Preoperative intravenous iron to treat anaemia before major abdominal surgery (PREVENTT): a randomised, double-blind, controlled trial. *Lancet* 2020; **396**: 1353–61.
- 12 CPOC Centre for Perioperative Care. Shared Decision Making Available from: <https://cpoc.org.uk/shared-decision-making>
- 13 Boss EF, Mehta N, Nagarajan N, et al. Shared decision making and choice for elective surgical care: a systematic review. *Otolaryngol Head Neck Surg* 2016; **154**: 405–20.
- 14 AoMRC Academy of Medical Royal Colleges. Developing professional identity in multi-professional teams, 2020.
- 15 NHS England. Making digital preoperative assessment (POA) the default at South West London Elective Orthopaedic Centre (SWLEOC). 2022. Available from: <https://transform.england.nhs.uk/key-tools-and-info/digital-playbooks/perioperative-digital-playbook/Making-digital-preoperative-assessment-the-default-at-South-West-London-Elective-Orthopaedic-Centre/>
- 16 NHS England. Key tools and information. 2022. Available from: <https://transform.england.nhs.uk/key-tools-and-info/>
- 17 NHS England. The productive operating theatre, 2022.
- 18 Ahmed K, Khan N, Anderson D, et al. Introducing the productive operating theatre programme in urology theatre suites. *Urol Int* 2013; **90**: 417–21.
- 19 Basheer S, Wood D, Shepherd K, McGregor-Riley J. Dedicated hip fracture lists: improving the service received by orthopaedic trauma patients. *Bull R Coll Surg Engl* 2013; **95**: 1–3.
- 20 Halim UA, Khan MA, Ali AM. Strategies to improve start time in the operating theatre: a systematic review. *J Med Syst* 2018; **42**: 160.
- 21 Royal College of Surgeons of England. Introducing team 4 of the green surgery challenge [press release], 2021.
- 22 Ryan SM, Nielsen CJ. Global warming potential of inhaled anaesthetics: application to clinical use. *Anesth Analg* 2010; **111**: 92–8.
- 23 Lane S. The environmental sustainability of propofol use in daily practice. *Br J Anaesth* 2020; **124**: e221–2.
- 24 Vollmer MK, Rhee TS, Rigby M, et al. Modern inhalation anaesthetics: potent greenhouse gases in the global atmosphere. *Geophys Res Lett* 2015; **42**: 1606–11.

- 25 Anger M, Valovska T, Beloeil H, et al. PROSPECT guideline for total hip arthroplasty: a systematic review and procedure-specific postoperative pain management recommendations. *Anaesthesia* 2021; **76**: 1082–97.
- 26 O'Donnell R, Dolan J. Anaesthesia and analgesia for knee joint arthroplasty. *Bja Education* 2018; **18**: 8.
- 27 Sarpong NO, Lakra A, Jennings E, Cooper HJ, Shah RP, Geller JA. Same-day physical therapy following total knee arthroplasty leads to improved inpatient physical therapy performance and decreased inpatient opioid consumption. *J Arthroplasty* 2019; **34**: 2931–6.
- 28 Centre for Perioperative Care. Getting it right first time and British Association of Day Surgery. National day surgery delivery pack, 2022.
- 29 Thompson JW, Wignadasan W, Ibrahim M, et al. Day-case total hip arthroplasty: a literature review and development of a hospital pathway. *Bone Jt Open* 2021; **2**: 93–102.
- 30 Hassan S, Wall A, Ayyaswamy B, Rogers S, Mills SP, Charalambous CP. Is there a need for early post-operative x-rays in primary total knee replacements? Experience of a centre in the UK. *Ann R Coll Surg Engl* 2012; **94**: 199–200.
- 31 Jones A, Lewis H, Kempshall P. Reducing risk and cost in a crisis –are hip check radiographs a necessity? Utilising lessons learned from changes in working patterns during COVID-19. British Orthopaedic Association, 2020. Available at: <https://www.boa.ac.uk/resources/knowledge-hub/reducing-risk-and-cost-in-a-crisis-are-hip-check-radiographs-a-necessity-utilising-lessons-learned-from-changes-in-working-patterns-during-covid-19.html>
- 32 Wong D, Harris S, Moonesinghe S, et al. Cancelled operations: a 7-day cohort study of planned adult inpatient surgery in 245 UK National Health Service hospitals. *Br J Anaesth* 2018; **121**: 730–8.
- 33 Intensive Care Society. Levels of critical care for adult patients, 2009.
- 34 CPOC, Faculty of Intensive Care Medicine. Guidance on establishing and delivering enhanced perioperative care services, 2020.
- 35 Schulte SS, Fernandez I, Van Tienderen R, Reich MS, Adler A, Nguyen MP. Impact of the fascia iliaca block on pain, opioid consumption, and ambulation for patients with hip fractures: a prospective, randomized study. *J Orthop Trauma* 2020; **34**: 533–8.
- 36 British Orthopaedic Association. BOA Standard; the care of the older or frail orthopaedic trauma patient, 2019.
- 37 Bevan H. Rocking the boat and staying in it: being an NHS change agent. 2016, <https://www.nwpgmd.nhs.uk/sites/default/files/Dr%20Helen%20Bevan.pdf>
- 38 Muñoz M, Gómez-Ramírez S, Kozek-Langeneker S, et al. 'Fit to fly': overcoming barriers to preoperative haemoglobin optimization in surgical patients. *Br J Anaesth* 2015; **115**: 15–24.
- 39 Kotter JP. Leading change. Harvard Business Press, 2012.