ICU admission after surgery: who benefits?

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Purpose of review
Death following surgery remains a major cause of death worldwide, and ICU admission following major surgery is considered a standard of care in many healthcare systems. However, ICU resources are finite and expensive, thus identifying those most likely to benefit is of great importance.

Recent findings
Advances in surgical and perioperative management have moved the focus of postoperative care to preventing complications and reducing duration of hospitalisation. Recent health services research has failed to find association between ICU admission and improved outcome in many types of elective major noncardiac surgery. Use of alternatives to ICU such as post anaesthesia care units (PACUs), high dependency units (HDUs) or specialist wards with enhanced nursing care are able to perform some elements of ICU monitoring in a less intensive environment, and may provide a better alternative to the traditional model of ICU admission for many patients having major surgery. ICU admission should still be considered for very high-risk patients and those having complex or emergency surgery. Improved triage tools are required to identify those at the highest risk of death or complications.

Summary
Identifying those most at risk of death and complications following surgery and preventing them is the major challenge of perioperative care in the coming decades. Future research should focus on how postoperative care can best be structured to provide optimum care to patients within available resources. Incidence of complications or failure to rescue (FtR) may provide useful metrics in future research.

Keywords
high-risk surgical patients, intensive care, risk assessment, surgery

INTRODUCTION

The global volume of surgery continues to grow: Weiser *et al.* [1▪] reported a 6% increase in surgical cases over an 8-year period, an estimated 310 million cases in 2012 worldwide. The last decade has also witnessed improvements in perioperative care, which has led to reductions in perioperative mortality [2,3]. Overall rate of mortality following surgery is low, less than 0.5% in recent global data. However, complication rates are higher, a recent global study suggested an overall complication rate of 16% following surgery and this was associated with a five-fold increase in mortality. The rate of death following complications has become known as the failure to rescue (FtR) rate [4▪]. Based on these figures there may be as many as 1.5 million deaths per year following surgery worldwide, a similar amount to deaths from road trauma.

The incidence of adverse outcomes following surgery varies between institutions, regions and nations [5–7,8▪] and differences in processes of care are often cited as the cause, particularly access to ICU beds in the perioperative period [9]. Admission to ICU has been a standard of care following many types of surgery for decades, however, ICU admission is often arbitrary, driven by local practice or bed availability, and not always possible in low-income or middle-income countries. ICU resources are limited and expensive, thus identification of which patients are most likely to benefit from ICU admission is a major issue for those involved in delivering perioperative care. The need to identify high-risk patients, develop strategies for appropriate postoperative placement, either in an ICU or suitable alternative, and to allow early detection of the

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KEY POINTS

- Evidence from large epidemiological studies suggests that for many patients undergoing major elective surgery routine admission to an ICU may not be associated with additional benefit and may, in some settings increase length of hospitalisation and costs.
- Use of post anaesthesia care units (PACU) and high dependency units (HDU) or specialist wards provides the enhanced monitoring and nursing care usually provided by an ICU and postoperative interventions such as noninvasive respiratory support, goal-directed therapy and analgesia.
- Evidence suggests that patients undergoing major emergency surgery, where there is insufficient time to optimise comorbidity or where there is major physiological derangement are still best managed in an ICU setting.
- Incidence of postoperative complications or 'failure to rescue' (FtR), the rate of patients who die following postoperative complications, may provide useful metrics for future research in these patients.

deteriorating patient is vital both to improve outcomes in this group and to best utilise finite resources.

HOW IS AN ICU BED DEFINED, AND WHAT ALTERNATIVES EXIST?

Definitions

Caring for patients after surgery was instrumental in the development of the specialty of critical care. However, after more than half a century of implementation on a global scale, the definition of what constitutes an ICU bed or unit remains subject to wide geographical variations. In North America, definitions reflect the provision of nurse and physician staffing whereas in many European countries ICU beds are defined on ability to provide support for one or more failing organ systems. Existing international comparisons also highlight differences in per capita provision, availability and admission practices for ICU resources. Thus, international comparisons of the effect of ICU care on outcome after surgery are difficult [10–12].

Alternatives to ICU

Due to restricted availability and high cost of ICU beds, intermediate-level care has become an attractive alternative for patients who do not need full ICU support but who might benefit from an enhanced level of care to that provided on a standard ward. The concept of step-down unit (SDU) was first introduced in 1968 by Gotsman and Schrire [13]. Nomenclature includes: high dependency unit (HDU), intermediate or transitional care unit [14]. These beds may be co-located within ICUs, in a stand-alone unit, or in an enhanced care area on a specialist ward. The nurse-to-patient ratio on these units varies from 1 : 2 to 1 : 4. Patients treated in these areas form three groups: 'step-down' patients who were being cared for in an ICU but no longer require full ICU support; 'step-up' patients who were being cared for on a standard ward but who now require an increased level of monitoring or support, or who are at risk of deterioration; postoperative patients who are admitted from the operating room or recovery room and who require enhanced care and monitoring due to the nature of their surgery or comorbidity.

Short periods of extended recovery care, typically up to 1 day, have been advocated to allow correction of abnormal physiology, short periods of postoperative ventilation, interventions such as goal-directed haemodynamic therapy [15], or components of an enhanced recovery after surgery (ERAS) intervention. These units are sometimes described as post anaesthesia care units (PACU), overnight intensive recovery (OIR) or 23-h recovery. Patients are typically stepped down to lower levels of care following this [16]. Use of PACU has become increasingly popular in some European countries.

Finally, in addition to extended PACU stay, some hospitals deliver enhanced care in the ward setting with more intensive nursing care, usually at a ratio of 1 : 4. These areas are specialty-specific and patients are cared for by their parent specialty, with care-specific protocols in place. In the UK, these are described as Level 1 areas. These wards may continue elements of ERAS programs, whose pathways are now well integrated into perioperative management of colorectal, orthopaedic, vascular, urology and thoracic patients [17–19].

RISK ASSESSMENT AND TRIAGE

Assessment of the risks of surgery is important, both to allow patients and their physicians to make informed decisions and plan perioperative care. Existing risk assessment tools include scoring systems, cardiopulmonary exercise testing and use of plasma biomarkers.

Scoring systems

Scoring systems, that stratify patient risk based on patient or surgical characteristics, are low cost and easiness to perform. Scoring systems can serve two

functions: to permit comorbidity adjustment across different populations and reduce confounding in comparative audit. They may also assist with prediction of individualised risk for patients undergoing surgery.

The most widely used preoperative scoring system is the American Society of Anaesthetist Physical Status (ASA-PS) score, a subjective assessment of a patient's overall health and physical status. Many studies have shown ASA-PS to correlate well with length of ICU stay, postoperative complications and death [20], but the score has major limitations. It does not consider the scope and nature of the surgery and inconsistencies in both its application and interpretation are well documented [21].

The use of scoring systems for comparative audit to predict risk in individual surgical patients, for example, Acute Physiology and Chronic Health Evaluation (APACHE) II or the Physiological and Operative Severity Score for enumeration of Morbidity and Mortality (POSSUM) have been advocated. As these systems were developed as comparative audit tools and validated in historic populations, their applicability in the wider surgical population is questionable. Portsmouth POSSUM or P-POSSUM has been advocated as a risk prediction tool in some settings, for example, in emergency laparotomy where a predicted mortality of more than 10% has been suggested as a trigger for postoperative ICU admission [22]. Calculation of the score uses 18 variables (12 physiological and 6 operative) to estimate a predicted morbidity and mortality [23], making it complex to calculate. Moreover, some of the variables are unknown until after surgery. Thus, its routine use for risk estimation in individual patients cannot be recommended.

Other scoring systems, including the Surgical Apgar Score (SAS) and Lee Cardiac Risk Index (LCRI), may also be used to guide perioperative management [24,25]. Despite limitations, scoring systems remain in widespread use and their use in detailed risk assessment (beyond calculation of an ASA score) is recommended by many expert groups [26].

Cardiopulmonary exercise testing

Formal assessment of functional capacity using incremental exercise on a cycle ergometer or similar has been used to stratify perioperative risk. Several physiological variables are measured during CPET and these include work rate, maximal oxygen uptake (VO_{2max}), ventilatory equivalents for CO_2 and O_2 (Ve/VCO_2 and Ve/VO_2) and anaerobic threshold. VO_{2max}, $Ve/VCO_2$and anaerobic threshold have been shown to identify high-risk surgical patients, hence they are used more commonly for risk stratification purposes including selection of patients for postoperative ICU care, including vascular and thoracic surgery [27–29]. Further studies are required to fully define the role of CPET in risk stratification prior to surgery [30▪▪].

Biomarkers

Biomarkers have also been used for risk stratification and prediction of postoperative morbidity and mortality and may be markers of organ dysfunction. Cardiac troponins (Tn), natriuretic peptides [e.g. brain natriuretic peptide (BNP) and its precursors], markers of renal dysfunction [e.g. neutrophil gelatinase-associated lipocalin (NGAL)] and inflammatory markers [e.g. high sensitivity C-reactive protein (hsCRP)] have all been investigated with this purpose. Tn and BNP have both been investigated as means of stratifying preoperative risk and both have been demonstrated to predict cardiovascular risk and mortality following noncardiac surgery. The predictive value is significantly improved whenever used in combination with clinical data from the LCRI scoring system [31,32].

Approaches to preoperative risk assessment

The approach to preoperative risk assessment is driven by time available and the nature of surgery. In elective surgery, thorough assessment and optimisation of chronic health conditions by specialist or perioperative medicine teams is advised. Increasingly, combinations of assessment methods, for example, CPET with epidemiological data and scoring systems are used to give an individualised prediction of risk and identify those who would benefit from postoperative critical care [33]. For emergency patients, assessment is limited by the urgency of surgery. Patients with chronic health conditions and severe physiological disturbance, undergoing even relatively modest surgery, may be at high risk of death and complications. Here scoring systems form the mainstay of assessment.

POSTOPERATIVE ICU UTILISATION AND PATIENT OUTCOME

Recent international comparison studies have suggested that patterns of ICU admission after surgery are not consistent [4▪,34], and value of routine admission is uncertain and may be nuanced. Those discharged to a ward setting may have delayed or unrecognised deterioration leading to morbidity or death. This is the so-called FtR rate, that is, the in-hospital death rate from postoperative

complications [6], and in a recent global study this figure was approximately 3% [4▪].

Studies of structure and process at both regional and institutional level suggest variations in mortality, complications and FtR after high-risk surgery [6]. In some studies, increased provision and utilisation of ICU beds do seem to be associated with overall benefit [7,8▪,35▪▪]. However, not all evidence shows an inverse relationship between ICU beds and mortality. A study using Medicare data of over 130 000 patients in North America, explored the association between mortality, duration of hospital admission and costs with ICU admission in patients of age over 65 years having one of five elective major surgical procedures. The key findings of this study were a wide variation in ICU admission practices; admission of large numbers of low-risk patients having major surgery to ICU beds; no associated reduction in mortality associated with ICU admission; and in certain low risk procedures, increased length of stay and costs [36].

Early large epidemiological studies that stratified standard and high-risk groups, based on risk of death from surgical procedure alone, suggested a small high-risk subgroup of patients accounting for a high proportion of all postoperative deaths. In these studies, a key finding was that that only a small proportion of those who died were admitted directly to ICU after surgery [5]. A recent large national study used a combination of surgical procedure, comorbidity and other patient level factors to construct a multivariable model to define levels of perioperative risk. This study did not identify a survival benefit associated with direct ICU admission following surgery for all patients, but only with those in the very highest risk groups [37▪▪]. Another large prospective international observational study of 44 000 patients undergoing elective surgery in 474 hospitals from 27 countries also found no association between ICU utilisation and mortality [38▪▪].

Nonrandomised and observational studies must be interpreted with caution. Confounding and bias may arise from inclusion of patients undergoing elective surgery only, variations in local ICU admission policy and nonstandard definition of an ICU bed. However, it is increasingly difficult to find a clear signal that routine ICU admission confers advantage to patients undergoing major elective surgery: benefits are more evident only in the sickest patients or those undergoing emergency surgery [39]. Patients who require ventilation, inotropic therapy and renal replacement therapy after surgery clearly do require ICU admission, yet few elective surgical patients require such levels of postoperative organ support, even amongst the highest risk groups. Although high-risk patients are admitted routinely to ICU for a few days postoperatively, many life-threatening complications occur later. Also, routine unnecessary ICU admission may not be beneficial, and might even be harmful. Risks of ICU admission include delayed mobilisation, exposure to sedation, delirium and hospital-acquired infection. These can delay recovery and prolong hospitalisation.

In a recent study of outcome after noncardiac surgery in Europe, ICU bed provision and rate of admission did not correlate with overall mortality, and countries with the lowest mortality rates after surgery also had the lowest rates of ICU admission [36]. This may be explained by increased use of alternatives to ICU admission for types of high-risk elective surgery in some of the best performing European countries and prompts us to consider what elements of ICU care are required when caring for high-risk postoperative patients. Patients recovering from major elective noncardiac surgery require prompt and effective treatment of pain, hypothermia, mild cardio-respiratory compromise, and fluid imbalance, with early mobilisation and enteral nutrition whenever possible. The advantageous elements of ICU care in this setting may in fact be better access to high quality nursing care, which is known to improve patient safety and reduce complications [40]. This can be delivered in less intensive environments such as PACUs, HDUs or specialist wards. Patients still require prompt identification of clinical deterioration, but this can be delivered with enhanced monitoring, early warning systems and rapid referral to critical care outreach teams.

In cardiac surgery, where patients with severe cardiac comorbidity undergo major surgery, the use of fast track interventions have been established for many years and appear to be safe, shortening duration of ICU care without increasing complications in low-risk and moderate-risk patients. Extending this model to types of major noncardiac surgery using speciality wards, specialist HDUs or fast track units may confer similar benefits while avoiding some of the disadvantages of ICU admission. These areas would have appropriate levels of nursing staff with expertise in managing specific types of major surgery, delivering protocolised care. Patients developing complications can be identified and referred early for critical care expertise, available either through timely review or by outreach teams. Direct admission to ICU would continue to be recommended for patients having emergency surgery, where inadequate preoperative assessment or optimisation was not possible, in the presence of severe physiological derangement or comorbidity, or where surgery was particularly complex, for

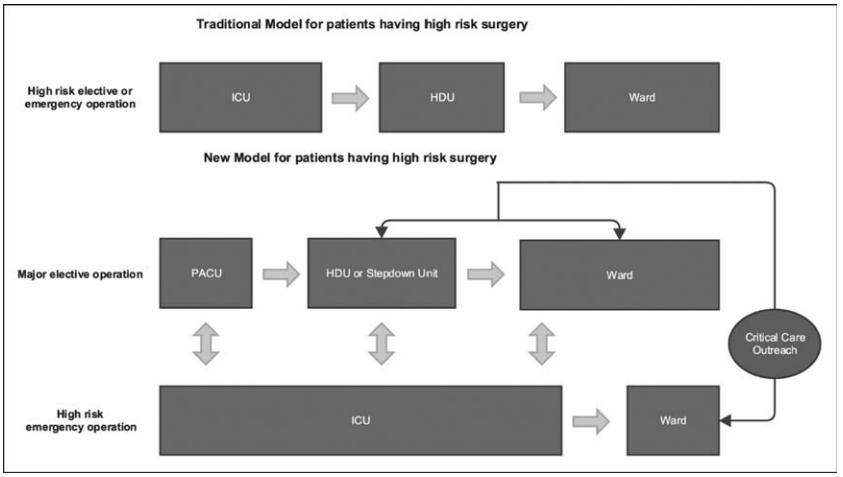

FIGURE 1. Old and new models for postoperative care after high-risk surgery.

example, redo surgery. An advantage of this approach is that ICU beds would be increasingly available for those who require them urgently. Old and new models for postoperative care are described in Fig. 1.

CONCLUSION

Identifying those most at risk of death and complications following surgery and preventing them is the major challenge of perioperative care in the coming decades [41▪▪]. Future studies may use combinations of epidemiological data, functional assessment, biomarkers and clinical data to provide a detailed assessment of risk prior to surgery.

The benefits of direct ICU admission after many types of major elective noncardiac surgery are unclear. Moreover, differences in definition, structure and delivery of postoperative care make comparative studies difficult. Increasing use of specialist HDUs, PACUs or similar may allow delivery of some of the important elements of ICU after major uncomplicated elective surgery while avoiding some of its undesirable effects.

Early identification of those deteriorating or developing complications allows early involvement of critical care outreach or similar expertise. It will also allow diversion of ICU service to those most likely to benefit: those having complex surgery, comorbid patients or those with deranged physiology undergoing high-risk emergency surgery. Future research should focus on how postoperative care can best be structured to provide optimum care to patients within available resources. Incidence of complications or FtR may provide useful metrics in future research.

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Conflicts of interest

M.A.G. is a NHS Research Scotland (NRS) Clinician.

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- ▪ of special interest
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