17.4 Assessing and preparing patients with medical

17.4 Assessing and preparing patients with medical conditions for major surgery 3860 Tom Abbott and Rupert Pearse

ESSENTIALS The assessment of patients before surgery is complex. However, since surgery is offered to increasing numbers of patients with mul- tiple comorbidities, the demand for comprehensive preoperative assessment is expected to increase. Perioperative medicine provides a patient-centred approach from preoperative assessment through to hospital discharge and beyond. Preoperative assessment serves to identify comorbidity that may require optimization before surgery, plan perioperative care, identify a need for a nonstandard anaesthetic technique, assess functional reserve, brief patients on the perioperative care pathway, and provide patients with an opportunity to have questions answered. Patients with active cardiac or respiratory conditions are among
those most likely to benefit from preoperative optimization. Smoking cessation reduces the incidence of postoperative pul- monary complications. During surgery, goal-directed haemo- dynamic therapy is used to optimize cardiovascular performance. It is unclear what practical steps can be taken to prevent illness in the immediate postoperative period, over and above increased vigilance. There are a variety of tools for preoperative assessment and rec- ognized approaches to

managing patients with existing chronic disease during the perioperative period, but the absence of robust evidence to favour any particular clinical approach is striking. Introduction Surgical treatments are now offered to more and more patients. This due to growing global population, increased healthcare cap- acity, and because improvements in surgical and anaesthetic care mean that patients considered too high-risk only a few years ago are now routinely offered surgery. The result is a shifting demo- graphic of the surgical population toward older patients with multiple comorbidities. Modern perioperative care therefore re- quires a robust and considered approach to each stage of a patient's journey and a multidisciplinary approach best termed periopera- tive medicine. Here, we review current approaches for assessing and preparing patients for surgery. Perioperative morbidity and mortality:
A global perspective An estimated 300 million surgical procedures are performed world- wide each year, which is greater than the worldwide prevalence of malaria (c.200 million cases). However, little is known about the global incidence of postoperative death and disability. Accepted es- timates of perioperative mortality in developed countries range be- tween 0.5 to 2.0% of surgical procedures, although one estimate was as high as 4% for noncardiac surgery. In contrast, data from small studies suggest the postoperative mortality rate may be as high as 5–10% in resource-poor countries. The most common causes of death within two days of surgery are cardiovascular in origin, fol- lowed by sepsis and multiorgan failure. Death is more common fol- lowing emergency compared to elective surgery. However, different population demographics and public health profiles make accurate comparisons between developing and developed countries complex. Nonfatal complications following surgical procedures are common. These range from wound pain and immobility to more serious conditions, including pneumonia, surgical site infection, myocardial infarction, acute kidney injury, and stroke. The presence of any postoperative complication is associated with reduced long- term survival. In developed countries, estimates of the proportion of patients with complications or adverse events following surgery vary between 3 to 20% of procedures (Table 17.4.1) with the incidence affected by patient factors, the nature of the surgical procedure, and the quality of the care the patient receives. The 'high-risk' surgical patient Epidemiological studies have described a high-risk group of patients that account for 80% of postoperative deaths, but represent only 15% of patients having major surgery. The characteristics of this high-risk group are not well defined, but the typical patient is older, with sig- nificant comorbid disease, and often undergoes emergency surgery. The risk of postoperative complications is influenced by multiple factors, which can be divided into two broad categories: procedure- related factors and patient-related factors. Procedure-related factors include surgical technique (e.g. open or laparoscopic), duration, 17.4 Assessing and preparing patients with medical conditions for major surgery Tom Abbott and Rupert Pearse

 and type of surgery, intraoperative complications (e.g. blood loss), procedure-specific postoperative complications (e.g. anastomotic leak after bowel resection), and—much less frequently—surgical or anaesthetic error. The influence of these factors is compounded by abnormal physiology during emergency procedures, resulting in worse outcomes. However, most postoperative complications are likely to occur, not as a direct result of the surgical procedure, but as a secondary consequence of indirect factors such as immobility, tissue inflammation, or hospital-acquired infection. Patient-related factors refer to an individual's state of general physical health or functional capacity. This is usually considered in the context of the ability to withstand the physiological stress as- sociated with surgery, such as elevated cardiac output or minute ventilation, fluid shifts between body compartments, the effects of mechanical

ventilation, or inflammation associated with tissue in- jury. The resultant increase in cellular respiration increases the total body oxygen requirement. Inadequate functional capacity in one or more organ systems can manifest as an inability to adequately in- crease oxygen transport to the body tissues during surgery, which is thought to be causally associated with postoperative complications and death. Functional capacity is influenced by age, cardiorespira- tory fitness, and comorbidities, but cannot be reduced to a list of chronic diseases or measurement of any one variable. Inter-relation of functional reserve, comorbidity, and procedural factors is com- plex (Fig. 17.4.1). There is considerable overlap between functional reserve and comorbidity because physical illness affects cardio- respiratory fitness. For example, patients with congestive cardiac failure, or those receiving cytotoxic chemotherapy, often experience a reduction in exercise performance. Equally comorbid disease can directly influence a surgical procedure, mandating a specific surgical or anaesthetic technique. Preoperative assessment and risk stratification Ideally, the anaesthetic assessment will be performed days or weeks in advance of surgery to allow time for planning of perioperative care. However, in many healthcare systems, assessment on the morning of surgery is the routine. This often leaves clinical staff with the diffi- cult decision to either proceed with surgery or postpone surgery at the last minute to address the management of chronic disease. The preoperative assessment clinic, led by nurses and doctors, provides an opportunity to evaluate the patient in the days or weeks before a planned surgical procedure and formulate a definitive plan for peri- operative care. Preoperative assessment serves several purposes: • To identify comorbidity that may require optimization before surgery • To plan perioperative care • To identify a need for a nonstandard anaesthetic technique • To assess functional reserve • To brief patients on the perioperative care pathway and provide an opportunity to have questions answered A typical appointment involves a medical history and physical examination including: resting observations, height, and weight; blood tests such as routine haematology, biochemistry, and coagu- lation tests; urine analysis and electrocardiography. Further inves- tigations, for example, chest X-ray, spirometry, echocardiography, or exercise testing, or referral to a specialist, are performed on a case-by-case basis. Some centres use standard criteria to trigger a review by an anaesthetist or referral to other specialists such as a cardiologist. It seems intuitive that patients attending a preoperative assessment clinic are less likely to have their procedure postponed on the day of surgery. However, growing evidence suggests that at- tending a preoperative assessment clinic could also result in lower postoperative mortality, reduced hospital and high-dependency unit (HDU) length of stay, and fewer unplanned critical care unit admissions. Unfortunately, the provision of preoperative assessment clinics is not universal and 20% of patients undergoing high-risk surgery in the United Kingdom do not attend a preoperative assess- ment clinic. The global availability and use of preoperative assess- ment clinics is unknown. Opinion leaders suggest that all patients undergoing major surgery should be reviewed by an experienced anaesthetist in a preoperative Table 17.4.1 Approximate incidence of common postoperative complications following elective noncardiac surgery Complication Incidence (%) All complications 15% Infectious complications Sepsis 5% Superficial surgical site 3% Pneumonia 2% Urinary tract 2% Deep surgical site 1% Body cavity <1% Cardiovascular complications Myocardial injury 8% Myocardial infarction 3% Arrhythmia 3% Heart failure 2% Pulmonary embolism <1% Stroke <1% Cardiac arrest <1% Other complications Postoperative bleeding 3% Acute kidney injury 2% Acute respiratory distress syndrome <1% Gastrointestinal bleed <1% Procedure-related factors Functional reserve Co-morbidity Fig. 17.4.1 The three principle components of perioperative risk.

Section 17 Critical care medicine 3862 assessment clinic. This provides an opportunity to evaluate the risk of postoperative morbidity or mortality. Risk estimates can be used to identify patients who are likely to require enhanced perioperative care, to determine whether a patient requires critical care immedi- ately following surgery, and to provide patients with important de- tail during the informed consent process. The optimal approach to estimating the risk of perioperative morbidity or mortality remains uncertain. Potential methods include risk stratification scores or in- dices, objective assessment of functional capacity through exercise, and plasma biomarkers. Similar approaches are used in audit and re- search to adjust for individual patient risk factors and facilitate com- parisons between different patients or institutions. However, the most commonly used risk-adjustment models use a combination of preoperative and intraoperative factors, which limit their use for risk prediction before surgery. Risk stratification tools Clinical prediction rules are ubiquitous to medical practice and comprise main five types: scoring systems, prediction models, nomograms, decision trees, and neural networks. The underlying principle is to identify factors associated with a particular outcome and to calculate the probability of that outcome occurring given the presence of one or more predictors. Scoring systems tend to feature a concise group of predictors, weighted according to their association with the outcome measure. The total score indicates a risk category, but does not provide an absolute measure of risk. More complex risk prediction models feature a larger number of variables and often provide a numerical estimate of risk. However, due to the amount of information required, the latter can be cumbersome to use.
A variety of surgical scoring systems and risk prediction models are available for general and specific surgical populations and out- come measures. However, most of these have only been validated in single-centre studies or in specific patient groups. Four preoperative risk stratification tools have been validated in multiple centres: the American Society of Anesthesiologists' Physical Status Score (ASA- PS), the Surgical Risk Score, the Surgical Risk Scale, and the Charlson Comorbidity Index. ASA-PS is a simple and commonly used risk assessment tool, whereby a patient is placed into one of five groups according the presence and severity of comorbid disease. However, it has been criticized due to reportedly low inter-rater reliability. The Surgical Risk Scale is favoured because it is concise, easy to use, and comprises only preoperative variables. It is a composite score de- rived from the ASA-PS, urgency of surgery and the grade of surgery according to the British United Provident Association (BUPA) clas- sification (Table 17.4.2). However, it has only a moderate predictive accuracy. While it is simple is to use and could be easily integrated into clinical practice, it has been criticized for including ASA-PS, which requires a subjective assessment by the clinician. The Charlson Comorbidity Index, which is more objective, has a poor predictive accuracy. The Revised Cardiac Risk Index is one of the best models for predicting postoperative cardiac complications. It consists of six components: high-risk type of surgery, history of ischaemic heart disease, history of congestive cardiac failure, history of cerebrovas- cular disease, preoperative insulin usage, and preoperative serum creatinine levels of more than 2.0 mg/dl (>177 µmol/litre). Other risk stratification models used for risk-adjustment have a higher predictive accuracy, for example, the P-POSSUM. However, these models use intraoperative and postoperative variables, so they do not have a preoperative application. Despite their utility, preopera- tive risk stratification tools are not widely used. Assessing functional capacity For many years, anaesthetists and surgeons have subjectively as- sessed their patients' functional capacity to provide an indication of cardiorespiratory reserve. There are also more objective methods to evaluate functional capacity. Metabolic equivalents (METs) provide a semi-quantitative measure of exercise tolerance. One MET repre- sents resting oxygen consumption of c.3.5 ml/kg/min when sitting. Nomograms and tables provide a list of day-to-day activities with corresponding average

METS, which allow the clinician to estimate functional capacity. A more reliable method is to use a patient ques- tionnaire, for example, the Duke Activity Status Index (DASI), which is a set of 12 standardized questions relating to a range of activity levels. The total score correlates with maximal oxygen consump- tion measured during exercise testing in surgical and nonsurgical cohorts. However, the ability of the index to predict postoperative mortality or morbidity is still being evaluated. Perhaps the most robust method for assessing functional cap- acity is cardiopulmonary exercise testing (CPET). Most commonly a cycle ergometer operating an incremental ramp protocol is used, whereby the workload increases along a fixed gradient according to predicted exercise tolerance. The aim is for the patient to reach peak exertion within 8–12 minutes. Noninvasive haemodynamic and gas exchange measurements are recorded continuously, which allows multiple parameters, with variable predictive accuracies, to be de- rived. The two most widely used cardiopulmonary exercise testing- derived variables are peak oxygen consumption (VO2peak) and Table 17.4.2 Surgical Risk Scale, incorporating American Society of Anesthesiologists' Physical Status Score (ASA-PS) Category Description/Example surgery Score Urgency of surgery Elective Routine booked nonurgent case 1 Scheduled Booked admission 2 Urgent Case requiring treatment within 24–48 hours of admission 3 Emergency Case requiring immediate treatment 4 Grade of surgery Minor Removal of sebaceous cyst, skin lesion, oesophagogastric duodenoscopy 1 Intermediate Unilateral varicose vein, unilateral hernia repair, colonoscopy 2 Major Appendicectomy, open cholecystectomy 3 Major plus Gastrectomy, colectomy 4 Complex major Carotid endartarectomy, AAA repair, limb salvage, anterior resection, oesophagectomy 5 ASA-PS I No systemic disease 1 II Mild systemic disease 2 III Systemic disease affecting activity 3 IV Serious disease but not moribund 4 V Moribund, unlikely to survive 5 AAA, abdominal aortic aneurysm.

17.4 Assessing and preparing patients 3863 oxygen consumption at the anaerobic threshold (VO2AT), the point where the metabolism switches from predominantly aerobic res- piration to predominantly anaerobic respiration (Fig. 17.4.2). Most evidence supporting preoperative cardiopulmonary exercise testing comes from single-centre studies of restricted cohorts of surgical patients. In only a handful of the studies were clinicians blinded to the result of the cardiopulmonary exercise testing, adding fur- ther potential for bias. Growing evidence suggests that VO2peak may be the best cardiopulmonary exercise testing-derived predictor of surgical outcome. However, VO2AT is probably the most commonly used. Cardiopulmonary exercise testing is becoming increasingly popular as an objective method of preoperative assessment in some countries. In the United Kingdom, approximately half of hospitals have access to it. Biochemical markers of risk Biochemical markers are a core feature of modern medical practice. Familiar examples include creatinine as a marker of renal function and cardiac troponin as a marker of cardiac injury. In the context of surgery, biochemical markers are used before, during, and after pro- cedures to identify and categorize disease, track clinical progress and response to treatment, and to aid prognostication. However, there is growing interest in their use to predict short- and long-term surgical outcomes. Current evidence is mainly restricted to morbidity and mortality associated with perioperative cardiac and renal disease and features a limited number of candidate molecules. Brain natriuretic peptide (BNP) is most commonly used to aid diagnosis and prognosis in patients with heart failure, but it is be- coming increasingly clear that increased preoperative BNP is as- sociated with postoperative mortality and nonfatal myocardial infarction. When combined with the Revised Cardiac Risk Index, preoperative BNP improves the accuracy of risk prediction com- pared with the risk index alone. Other candidate biochemical markers are cardiac troponin

and cystatin-c. Troponin is elevated before 10% of cardiac surgical procedures and may be associated with postoperative cardiac complications, although this has not been widely studied in patients undergoing noncardiac surgery. Preoperative cystatin-c may be associated with kidney injury after surgery, but needs further investigation. One in ten patients experience myocardial injury after non- cardiac surgery, defined by a transient increase in serum troponin concentration. This is associated with mortality, the risk of which increases with the magnitude of troponin release. Most cases of postoperative myocardial injury are asymptomatic and there is increasing awareness that traditional tests of myocardial ischaemia and infarction do not identify the bulk of these. Postoperative brain natriuretic peptide and C-reactive protein are both associated with mortality and adverse cardiac events. Gas exchange AT 0:00 2:00 4:00 6:00 8:00 10:00 12:00 Time (min) 14:00 16:00 Increasing workload VO2 and VCO2 18:00 20:00 22:00 Slope (ml/min / W) = 10.0 Fig. 17.4.2 Gas exchange during a cardiopulmonary exercise test. Blue line—VO2, red line—VCO2. The anaerobic threshold (AT) is indicated.

Section 17 Critical care medicine 3864 Perioperative medicine: managing the high-risk surgical patient The supposition that most postoperative complications arise either during surgery or in the immediate postoperative period seems intuitive. Anaesthesia, mechanical ventilation, and surgical ma- nipulation are physiologically abnormal, hence it is not surprising that postoperative complications occur. Patients undergoing high-risk procedures or those with existing medical conditions are obvious candidates for perioperative interventions aimed at improving outcomes after surgery. The goal of perioperative medi- cine is to facilitate surgery and minimize associated morbidity and mortality—this has considerations before, during, and after sur- gery (Fig. 17.4.3). Before surgery Patients with active cardiac or respiratory conditions are among those most likely to benefit from preoperative optimization (Fig. 17.4.4). Suspected cardiac failure or valvular disease can be investigated with echocardiography. Hypertension is often treated if the systolic or diastolic pressures are greater than 180 mm Hg or 110 mm Hg, respectively. New guidelines suggest that patients referred for elective surgery should have a blood pressure of less than 160/100 mm Hg recorded in primary care. Gradual reduc- tion in blood pressure before surgery is preferable to rapid control using intravenous agents. Some patients with unstable coronary artery disease may require procedural intervention before sur- gery. However, prophylactic preoperative revascularization may not reduce postoperative cardiac events but will delay surgery. Pharmacotherapy to reduce postoperative cardiac events is also controversial. Until recently, perioperative blockers were recom- mended for patients with cardiovascular risk factors. However, while β-blockade reduces rates of postoperative myocardial infarc- tion, it increases the risk of stroke, hypotension, and death. These agents are now only recommended for patients at intermediate or high-risk of myocardial ischaemia and when prescribed should be started far enough in advance of planned surgery to allow safety and tolerability to be assessed prior to surgery. Other negatively chronotropic agents like ivabradine may represent an alternative, but this has yet to be investigated. Patients undergoing vascular surgery may benefit from risk factor modification with statins. Similarly, patients taking aspirin often continue to do so, when the risk of cardiovascular complications if aspirin is withheld out- weighs the risk of bleeding if aspirin is continued. In this respect, patients with coronary artery stents require special consideration. Patients with existing respiratory disease are at increased risk of postoperative pulmonary complications and may benefit from en- hanced perioperative care. This is particularly important for patients with chronic obstructive pulmonary disease (COPD), poorly con- trolled chronic respiratory conditions, or obesity-related disease such as obstructive sleep apnoea. The mainstay

of preoperative manage- ment is optimization of existing treatments and considering a lower threshold for postponing surgery in the event of an exacerbation. In addition, several preoperative respiratory interventions are gaining widespread support. Smoking cessation reduces the incidence of postoperative pulmonary complications, although the optimum duration of abstinence before surgery is unclear. Respiratory physio- therapy in the immediate postoperative period is widely adopted as prophylaxis against respiratory complications, and physio- therapy before surgery may provide added benefit. Similarly, there is growing evidence that increasing preoperative fitness through ex- ercise training can improve surgical outcomes, but more research is needed to better to define the optimum target population and exer- cise regimen. During surgery It is widely accepted that tissue oxygenation may become im- paired during surgery due to the effects of tissue injury, inflam- mation, and the sympathetic response to surgical stimulation. Many clinicians use intraoperative goal-directed haemodynamic Before surgery During surgery After surgery Home Risk assessment Procedure-related factors Functional capacity Co-morbidity Biomarkers Optimization Optimising existing treatments Starting new treatment where appropriate Consider goal-directed therapy Surveillance Consider screening for asymptomatic disease Reduce long-term harm Routine follow-up Identify perioperative complications Fig. 17.4.3 Flow diagram of the perioperative care pathway.

 therapy to optimize cardiovascular performance, thus improving cellular respiration and tissue oxygenation with the aim of improving perioperative outcome. The most common method of achieving this is with intravenous fluid therapy and inotropic agents guided by cardiac output monitoring. Meta-data sug- gest that goal-directed therapy might be associated with lower rates of postoperative complication, but further evidence from multicentre trials is needed. After surgery The genesis and mechanism of most postoperative complications are poorly understood. Major surgery triggers a systemic inflam- matory response similar to that which follows sepsis or major trauma, although it is usually less severe. New evidence suggests that surgery can suppress the immune response for several days, indicating a period of potentially increased vulnerability to noso- comial infection. Furthermore, most postoperative myocardial in- jury, detected by raised cardiac troponins, occurs in the first 24 hours after surgery. However, it is unclear what practical steps can be taken to prevent illness in the immediate postoperative period, over and above increased vigilance. In the case of myocardial in- jury, routine troponin sampling is a potential surveillance option, but little is known about the aetiology of postoperative myocardial injury and myocardial infarction, and there are no proven treat- ment strategies. Further research is needed to define the clinical approach to prevention and treatment of postoperative cardiac complications. It is also possible that extending intraoperative treatment strat- egies, for example, goal-directed therapy and high intensity nursing, into the early postoperative period may improve patients' outcomes. This already occurs in some centres operating postanaesthesia care units for patients that are not transferred to the critical care unit immediately after surgery. Given the clear association between postoperative morbidity and subsequent mortality, enhanced sur- veillance of patients for postoperative complications after hospital discharge may be prudent. However, there is no defined protocol or pathway for postoperative surveillance over and above existing sur- gical outpatient follow-up. FURTHER READING Abbott, et al. (2017). Frequency of surgical treatment and related hos- pital procedures in the UK: a national ecological study using hos- pital episode statistics. Br J Anaesth, 119, 249–57. Fleisher LA, et al. (2014). 2014 ACC/AHA guideline on perioperative cardiovascular evaluation and management of patients undergoing General haemodynamic measures 1. 5% dextrose at 1

ml/kg/hr 2. Transfuse blood to maintain haemoglobin >8 g/dl 3. Clinician retains discretion to adjust therapy if concerned about risks of hypovolaemia or fluid overload 4. Mean arterial pressure 60–100 mmHg; SpO2 ≥ 94%; core temperature 37°C; heart rate <100 bpm Administering fluid to a stroke volume end point 1. 250 ml colloid boluses to achieve a maximal value of stroke volume [Note: Start dopexamine after first fluid challenge –see below] 2. Fluid challenges should not be continued in patients who are not fluid responsive in terms of a stroke volume increase 3. Fluid responsiveness is defined as a stroke volume increase ≥10% 4. If stroke volume decreases further fluid challenge(s) are indicated 5. Persistent stroke volume responsiveness suggests continued fluid loss Dopexamine

1. Start dopexamine infusion at fixed rate of 0.5 µg/kg/min after first colloid fluid challenge
2. Halve dose if heart rate rises to the greater of: (a) >120% of baseline value, or (b) >100 bpm for more than 30 minutes.
3. Stop dopexamine if tachycardia persists Example intraoperative optimization algorithm (OPTIMISE Trial) Fig. 17.4.4 Intraoperative goal-directed therapy algorithm from the OPTIMISE Trial.

Section 17 Critical care medicine 3866 noncardiac surgery: a report of the American College of Cardiology/ American Heart Association Task Force on Practice Guidelines. Circulation, 130, e278–333. International Surgical Outcomes Study Group (2016). Global pa- tient outcomes after elective surgery: prospective cohort study in 27 low-, middle- and high-income countries. Br J Anaesth, 117, 601–9. Khuri SF, et al. (2005). Determinants of long-term survival after major surgery and the adverse effect of postoperative complications. Ann Surg, 242, 326–41; discussion 41–3. Moonesinghe SR, et al. (2013). Risk stratification tools for predicting morbidity and mortality in adult patients undergoing major sur- gery: qualitative systematic review. Anesthesiology, 119, 959–81. National Institute for Health and Care Excellence (NICE) (2003). Preoperative Tests: The Use of Routine Preoperative Tests for Elective Surgery. Clinical guideline [CG3]. http://guidance.nice. org.uk/cg3 The Royal College of Anaesthetists (2015). Perioperative Medicine: The Pathway to Better Surgical Care. http://www.rcoa.ac.uk/perioperati vemedicine

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