Chapter 15

MANAGEMENT OF STABLE CASUALTIES

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INTRODUCTION

"While it is evident that the general principles of anesthesia are not affected by the circumstances of war, it is equally evident that it is our duty assiduously to seek those means in anesthesia which are especially suited to the exigencies of battle; and I hope to show that although men of the fighting services are of necessity exceptionally fit before an engagement, they may frequently be most urgently in need of the best attention known to anesthesia after the conflict."[1] Wesley Bourne's observations at the Annual Meeting of the Massachusetts Medical Society, May 22, 1941, remain pertinent to the conduct of anesthesia in current combat conditions.

It is self-evident that management of combat-related trauma remains the fundamental clinical activity of a military medical treatment facility. The overall quality of care of the severely injured patient in combat circumstances, who is by definition unstable, has always attracted considerable attention. In the last decade, significant advances in care have resulted in unexpected rates of survival.[2] Similarly, the anesthetic management of the stable casualty will of necessity require attention not merely to technique but also to external factors, including battle tempo and logistics, in order to ensure successful continuum of care.[3]

THE STABLE CASUALTY

Labelling a patient's condition as "stable" may be a potentially risky decision, especially for combat casualties presenting to a military medical treatment facility (MTF). The American Hospital Association advises that the term "stable" not be used, either as a condition or in combination with other conditions, because such statements are often inherently contradictory and misleading.[4] In the context of combat trauma-orientated MTFs, stability is largely denoted by physiological variables. While this approach remains useful, it must also include consideration of the mechanism of injury and the extent of energy transfer. These considerations will help the perioperative medical team maintain appropriate levels of vigilance with a stable patient. The concept of the "metastable" patient (one whose current stability is judged to have the potential to change rapidly) is useful in this regard, particularly in relation to preserving surgical situational awareness and in guiding anesthesia strategy for these patients.[5]

For the purposes of this text, the term "stable" refers to those patients whose condition is not expected to deteriorate in the next 24 hours. Surgery on stable patients will mostly be performed according to scheduled rather than emergency operating lists, and such patients may be:

- casualties requiring surgery for injuries that are not time-critical,
- casualties needing follow-up procedures for wound and injury care, or
- patients with disease non-battle-injury (DNBI) problems (eg, appendicitis).[6]

Consequently, stable casualties range from the minor DNBI patient to the complex polytrauma patient on whom damage control surgery has already been performed. Various observers including the authors have noted the rapidity with which apparently stable patients can deteriorate, either due to the consequences of surgery or because of injuries that have evolved or gone unrecognized.[7–9] Indeed, this situation necessitates that high and specific levels of clinical vigilance be maintained, which can normally be accomplished in a more comprehensive Role 3 MTF or combat support hospital, which would be better resourced than a forward surgical facility.[3] Therefore, anesthesia for stable military patients is likely to be undertaken in a field hospital, either Role 2 (enhanced) or Role 3 because these facilities are expected to possess the necessary resources for maintaining such clinical oversight.[10] Nonemergent surgery is rarely performed further forward than this. The contents of this chapter will also be relevant to the anesthesiologist working in a parent nation's domestic Role 4 hospital, who may be required to anesthetize battlefield casualties within days of their injury.

THE POPULATION AT RISK

The deployed military population is composed of predominantly young, fit, and prescreened individuals. Every effort is made to evacuate the seriously injured military patient to a suitable Role 4 (domestic) hospital as soon as possible, both for clinical benefit and to enhance operational agility in dealing with further casualties at the forward facility. Such evacuation reduces workload, supply consumption, and bed occupancy in the field hospital. Consequently, most of these patients will receive only emergency or damage control surgery at the field hospital, although weeks of follow-up and reconstructive procedures may await them at Role 4.

The field hospital, deployed on operations other than war such as disaster relief and peacekeeping operations, as well as during combat, can expect a significant number of locally born patients.[11] These may be civilians (both adults and children),[12] military allies, or detainees. An analysis was performed of the surgical workload of a NATO field hospital deployed to Kandahar, Afghanistan, over 5 months in 2006. Of 259 patients treated, 118 were Afghan soldiers or police, 60 were local civilians, and 10 were detainees.[13] Such patients can have poorly managed or untreated chronic disease, which will present an extra challenge to the anesthesiologist. There may also be entitled civilian contractors with undeclared chronic health problems that would have precluded their employment had they been divulged. Conditions such as hypertension, ischemic heart disease, diabetes mellitus, and malignancy have all been seen in this population during recent operations in Iraq and Afghanistan.[6] Civilian patients, in particular, form a significant proportion of the scheduled operating workload, since they may remain under the care of the field hospital for weeks while waiting for transfer to a suitable facility. During this time they can require multiple returns to the operating room for wound debridement and dressing changes.

SPECIAL CONSIDERATIONS IN THE STABLE CASUALTY

It is the stated intent of UK Role 3 MTFs to deliver healthcare at least to the standard of that provided at Role 4 civilian hospitals in the National Health Service in the United Kingdom. In the nonemergent patient, military anesthesiologists must consider the possible requirement to modify their approach to one much more in keeping with a civilian hospital setting. Patients should be fasting, and a well-documented anesthetic history and examination should be performed, which may uncover chronic health issues such as those mentioned above. However, unlike in elective civilian practice, the military anesthesiologist must be prepared to proceed with a medical history that may be fragmentary and inaccurate (especially for local national patients). Therefore, perioperative vigilance is vital to deal with unanticipated problems.

Informed consent for the proposed anesthetic technique should be obtained, following good-practice guidelines[14]:

- fully disclose serious or frequently occurring risks;
- discuss potential benefits and alternatives;
- avoid providing new information immediately prior to anesthesia induction, when possible;
- ensure the patient is able to understand, retain, and use the information provided;
- use a trained interpreter to facilitate communication, if necessary; and
- record the discussion in the clinical notes.

Two particular patient groups require further consideration: pediatric patients and detainees. Experience during recent operations indicates that all expeditionary MTFs will need to be able to manage pediatric patients with trauma, medical conditions, or both.[15] For pediatric patients, parental involvement in treatment decisions and their presence at induction of anesthesia is highly desirable, just as would occur in a Western civilian hospital. For detainees, there may well be security requirements. Security should be in keeping with the expeditionary force's ethical guidelines, and detainees should be provided the same information and treatment choices as any other patient.

COMMON OPERATIONS IN STABLE CASUALTIES

Nonemergent surgery forms a significant proportion of the operative workload of a deployed field hospital. In the previously mentioned analysis at a NATO field hospital in Afghanistan, of the 393 quantifiable procedures performed over a 5-month period, 166 were wound debridements. Dressing changes for trauma or burns were the second most common operations performed by general surgeons (15% of all their procedures). Other nonemergent procedures included drain and packing removal and skin grafting. DNBI patients encompassed 8% of the general surgical workload, including seven appendectomies. Seventeen patients returned to the operating room for further surgery (including one patient who required six separate operations).[13]

By their nature, the injuries of war often require multiple operations, particularly in those patients who have not been repatriated. Wounds are often highly contaminated at presentation and may require repeated dressing changes and debridement. Delayed primary closure of such wounds, if possible, is performed between day 4 and day 6, during the

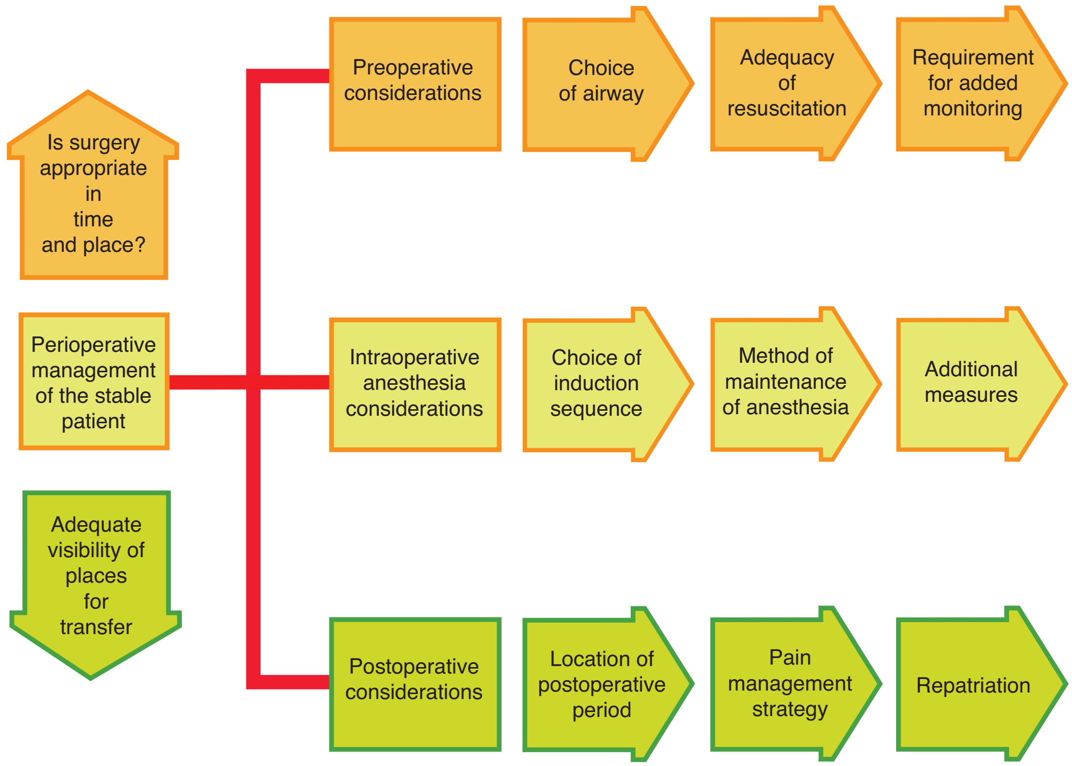

Figure 15-1. Perioperative considerations in a stable trauma patient.

fibroblastic phase of healing when postinjury swelling has diminished.[16] When this is not possible, split skin grafting may be used. Re-look laparotomies are also performed, especially in the presence of laparostomy, as the clinical picture demands, or in the light of radiological findings.

The potential for blood loss with such operations cannot be overemphasized. It is prudent to ensure that blood is available and that large-bore intravenous access is in position prior to commencing the procedure. Equally, the assurance of the stability of imaging, hematological, and biochemical variables will further inform the decision to re-operate. Early visibility of plans to evacuate a given patient elsewhere within the theater of operations or indeed outside it will assist in formulating rational perioperative management plans. Figure 15-1 outlines the major perioperative considerations in a stable patient.

CHOICE OF ANESTHETIC TECHNIQUE

Choice of anesthetic technique is usually dictated by patient presentation and personal preference. The deployed military anesthetist must also take account of the resources available as well as the tactical and strategic contexts. This section explores the potential advantages and disadvantages of each technique in the stable war surgery patient.

Clinical reassessment of the stable patient together with the results of appropriate investigations will normally precede the anesthetic. Whichever technique is selected, optimization of analgesia in the stabilized, nonemergent war surgery patient is highly desirable. Humane considerations apart, pain associated with repeated procedures may increase the care burden in an environment where resources are not unlimited. Furthermore, acute uncontrolled pain has deleterious effects not only on the patient but also on family members and medical staff.[17] A causal link to the appearance of chronic pain problems following combat injury remains to be fully elucidated, although the benefits of timely and effective interventions do appear to reduce longer-term consumption of analgesics.[18]

Intraoperative monitoring will normally be expected to conform to the standards of care provided at a Role 4 hospital.[19,20] Depending on individual national doctrinal stance and equipment scaling, appropriate advanced monitoring modalities such as thromboelastometry and intracranial pressure monitoring are applicable to anesthesia for stable patients receiving intensive care in order to maintain their continued recovery.

Volatile Gas Anesthesia

An intravenous induction sequence followed by volatile gas anesthesia (VGA) continues to be widely accepted as a safe and practicable choice in the deployed setting. Details of this well-understood technique will not be discussed here; however, it is worth noting that all volatile agents produce dose-dependent depression of myocardial contractility, with the newer agents (desflurane, isoflurane, and sevoflurane) maintaining cardiac output better than older agents. Although there is no absolute contraindication to any volatile agent, nitrous oxide should be avoided to limit bowel and closed-space gas accumulation in the presence of potential pneumothorax, pneumocephalus, and bowel trauma[21] (its availability on deployment is likely to be limited anyway). Concerns have arisen regarding low-flow VGA using sevoflurane, which has been demonstrated to produce nephrotoxic compound A in rats. However, a study in humans was unable to reproduce this effect.[22]

Regional Anesthesia and Neuraxial Anesthesia

Regional anesthesia (RA) and neuraxial anesthesia may be used alone or in combination with general anesthesia or conscious sedation. The physician's imperative to "first, do no harm" is particularly applicable when considering the deployment of these techniques. The military anesthetist should be confident that the casualty does not have coagulopathy of trauma shock. Thromboelastometry, where available, may reveal clinically significant platelet dysfunction in the presence of apparently normal laboratory clotting tests.[23] Sterility should certainly be ensured and adequate postoperative monitoring and care must be available, particularly when in-dwelling catheters are used.

Limb injury has been highly prevalent in war surgery patients during the conflicts in Iraq and Afghanistan.[24,25] Peripheral nerve blockade has many advantages in this patient group, including providing excellent pain relief while reducing the use (and side effects) of traditional opioid-based analgesia. Recent developments in advanced RA techniques and continuous peripheral nerve blockade have been driven by an improved understanding of pain in war casualties and improvements in ultrasound technology. Pioneering initiatives such as the Military Advanced Regional Anesthesia and Analgesia program in the US military have expanded the use of RA to provide pain management not only intraoperatively but during repatriation and well into the postoperative period.[26]

A persisting concern with peripheral nerve blockade is its potential to mask acute compartment syndrome (ACS). This concern has not been borne out in a study of over 100 battlefield casualties, of whom only two developed a delayed ACS requiring fasciotomy as a late presentation (rather than a missed primary presentation) after evacuation to Role 4. A policy of performing fasciotomies prior to prolonged aeromedical transfer when there is a significant chance of developing ACS is recommended, and RA should remain a valid technique.[27] RA techniques have been well-recognized as useful in austere circumstances[28,29] and are discussed in Chapter 22, Regional Anesthesia and Coagulopathy.

Surgeon Rear Admiral G. Gordon-Taylor, a veteran of both world wars, famously pronounced, "for the abdominal wounds of war spinal anesthesia is certain euthanasia."[30] Most modern day military anesthesiologists would probably agree with this statement as applied to patients in the resuscitation phase. In the stable patient, however, neuraxial anesthesia has been successfully employed.[31] Epidural anesthesia, as a particularly effective technique in circumstances where even an anesthetist is unavailable, has been described.[32] Recent operational experiences with epidural anesthesia have largely been in the anesthetic management of stable casualties with bilateral lower limb injuries.

Conscious Sedation

Conscious sedation is commonly employed as an adjunct to analgesia (either systemic or local anesthesia/regional block) to make unpleasant procedures more acceptable. The patients necessarily fall into the stable category, and procedures frequently requiring sedation in the field hospital include repeat dressing changes, drain removal, and dental operations.

The term "sedation" can mean different things to different clinicians (anesthesiologists and surgeons in particular). It has been defined as:

> A technique in which the use of a drug or drugs produces a state of depression of the central nervous system enabling treatment to be carried out, but during which verbal contact with the patient is maintained throughout the period of sedation. The drugs and techniques used to provide conscious sedation . . . should carry a margin of safety wide enough to render loss of consciousness unlikely.[33]

Some clinicians describe a state of "deep sedation." However, a patient who is unresponsive to verbal and physical stimuli may be unable to maintain a clear airway,[34] and such a state should be regarded as general anesthesia. It is also worth remembering that more deaths occur under sedation than under general anesthesia.[35]

Conscious sedation may be produced with small doses of anesthetic agents such as intravenous midazolam and propofol. Inhalational sedation with 50:50 nitrous oxide: oxygen mixtures is widely practiced in dentistry but may not be available or appropriate in the field hospital for reasons already mentioned. Caution is advised with drug combinations, particularly for doctors without anesthetic training. However, the experience of the authors is that an IV bolus of midazolam (2 mg) combined with small incremental IV doses of ketamine (20 mg) for adult patients undergoing potentially painful dressing changes is safe, well tolerated, and provides an effective analgesia. Successful and safe use of similar techniques have been described in austere circumstances.[36,37]

Minimal monitoring for conscious sedation consists of a pulse oximeter and, most importantly, a suitably trained individual present throughout the procedure with designated responsibility for patient safety. Blood pressure and electrocardiograph monitoring are not necessary unless cardiovascular problems are anticipated. Oxygen therapy should be available, and facilities for resuscitation should be immediately at hand.[34]

After sedation, patients should be cared for in a designated recovery area with properly trained nursing staff. In the case of military patients who have undergone minor procedures, at least 24 hours of light duties should be prescribed before they are allowed to drive, handle a weapon, operate heavy machinery, or resume a decision-making role.

Total Intravenous Anesthesia

Historically, the synergy that exists between military conflicts and medicine is well recognized. Indeed, the origins of the military use of intravenous anesthesia can possibly be traced to the 17th century following the English Civil War.[38] There is also considerable evidence of the use of intravenous ether and barbiturates in the military setting, culminating in the well-publicized use of thiopentone. Over the last 3 decades, ketamine has emerged as an important constituent of the anesthesia sequence, particularly in austere circumstances.

Concurrent and possibly serendipitous events in modern anesthesia, such as the introduction of propofol and the laryngeal mask airway, together with an improved understanding of compartment-based pharmacokinetics, have undoubtedly positively influenced anesthesia management of the stable patient. Manual infusion regimes, both simple and complex, have been recommended and used in total intravenous anesthesia (TIVA) practice. In recent years, the use of population pharmacokinetics to guide the development of devices that can deliver target-controlled infusions (TCI) has been a significant development in TIVA. The introduction of remifentanil, a potent opioid with ultra-short context-sensitive half-time, was equally felicitous, given that the synergy between it and propofol could be exploited clinically. A recent review discusses military applications of TIVA/TCI in greater detail together with suggested regimes.[39]

However, understandable reservations remain about the use of TIVA/TCI techniques during the acute phase of damage control resuscitation and related surgery. These concerns mostly relate to the unquantifiable changes in compartmental volumes that inevitably occur in the presence of major hemorrhagic injury.[40] These changes would, in turn, make it less prudent to place implicit reliance on the conventional pharmacokinetic models currently used in TIVA/TCI practice. Nonetheless, there is considerable benefit to be had in using these techniques in the stable patient, despite the inevitable technological burden associated with sophisticated syringe pumps. These benefits include:

- decreased recovery time with rapid return of cognitive function, thus lessening nursing burden;
- the possibility of seamless transition between sedation and analgesia in the stable but ventilated patient;
- abolition of pollution hazards to healthcare personnel, a concern of particular relevance in military MTFs that are unlikely to have active scavenging of waste gases; and
- the ability to quantify desired sedoanalgesia targets in a given patient in the context of repeat surgical procedures or lengthy patient transfers.

The introduction of "open" TCI pumps has removed the requirement to use custom-made prefilled syringes. Current levels of sophistication of these infusion devices permit administration of remifentanil by TCI. It is incumbent upon the user to be familiar with the critical assumptions employed by the pharmacokinetic models used in such devices.[41] An important example is the difference in the volume of the central compartment between the Marsh and the Schnider models for propofol.[42] While an extensive discussion of these models is beyond the scope of this chapter, it should be noted that dosing strategies for the individual patient require not only the use of the appropriate pharmacokinetic model but also clinical "calibration" by observation of clinical endpoints. Similarly, the use of either plasma or effect-site (brain) targets for propofol administration must be guided by the clinical suitability and levels of fitness of the individual patient. The benefits of effect-site targeting for remifentanil administration remain to be fully established.

It should also be noted that current TCI systems are "open-loop" systems in that they deliver drug effect based on pharmacokinetic modelling derived from population studies. Although the model-derived predictions of plasma and effect-site concentrations do not necessarily reflect actual tissue concentrations, the authors suggest that clinical dose-response behavior in a given patient is more informative than knowledge of precise tissue concentrations. Such an individualized approach can also allay concerns about the ability of computer-driven models to cope with intra-individual and inter-individual differences in drug handling and clinical behavior. An understanding of this concept coupled with a fuller appreciation of compartmental distribution has led to widespread acceptance of TCI technology.

However, in the United States, the Food and Drug Administration has yet to endorse it for a variety of reasons, especially because these algorithm-based devices require drug approval rather than device approval. These regulatory hurdles have prevented adoption of TCI into mainstream anesthesia practice in the United States.[43,44] However, US military interest in the technique[45] has included formation of the Triservice Research Group Initiative on TIVA (TARGIT) in an effort to increase the use of this technique on the battlefield.[45] Training in TIVA has also been identified as an essential requirement for graduating US anesthesia residents, together with achieving an understanding of the usefulness of TIVA in the combat situation.[46]

Future directions for TCI may include an examination of "closed-loop" systems that incorporate depth of anesthesia (DoA) monitoring to provide biofeedback. Even such systems are likely to encounter significant regulatory hurdles and challenges before translation into routine clinical practice occurs.[47]

MONITORING DEPTH OF ANESTHESIA

The availability of a monitoring system that quantifies brain activity under anesthesia and sedation may increasingly need to be considered even in the context of relatively austere field conditions. Such a capability could provide a window into the effect site of interest—the brain—thus permitting differentiation of two critical anesthetic effects: hypnosis and analgesia. While a discussion of the various monitors is beyond the scope of this chapter, the uses of auditory-evoked potentials, spectral entropy, and a bispectral index have been widely examined, with the latter technology generating the most literature. Although the extensive literature on DoA monitoring has largely been focused on mitigating concerns about awareness under anesthesia, such monitoring may also have a role in determining the quality of anesthesia.[48]

Given the likely turbulent nature of the trauma resuscitative process, such monitoring could add a further layer of reassurance to patient management. It is still unclear whether the various commercially available modalities have sufficient sensitivity and specificity to provide an unimpeachable biological signal. Bruhn et al discuss these important aspects in greater detail.[49] While the debate continues about the ability of such monitoring to meaningfully integrate data derived from both spontaneous and evoked cerebral activity under anesthesia,[50] it has also revealed the need to examine whether excessively deep anesthesia has distant consequences. Monk et al ignited this issue by their prospective observational study in which they hypothesized that, in addition to recognized factors such as comorbidity, excessively deep anesthesia may well have an adverse impact on 1-year mortality.[51] Significantly, the study quantified DoA with the assistance of a bispectral index monitor to derive cumulative deep hypnotic time. The study has generated considerable debate, some of which questioned the need for DoA monitoring,[52] and has also focused attention on the need to reexamine the quality of delivered anesthesia. Improved anesthesia quality may provide longer-term benefits for the stable patient, in addition to the logistical advantages to the MTF of rapid recovery and diminished clinical burden.

CONCLUSION

Medical facilities in support of expeditionary military activity or disaster relief operations are likely to be austere but increasingly rely on highly developed protocol- and team-based working, supplemented by appropriate medical resources, to deliver high quality healthcare. Trauma remains a significant part of the workload of such MTFs.[53] It is incumbent on the part of such establishments to arrange for robust and enduring processes for the continuing care of the stable and the stabilized patient. When such care involves surgery, optimal perioperative management of such patients, particularly in the areas of anesthesia, analgesia, fluids management, and timely transfer will not only enhance the effectiveness of the MTF but also inform the management of the less stable patient.

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