THE YEAR IN ANAESTHESIA AND CRITICAL CARE

VOLUME 1
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Foreword

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It is difficult to overestimate the importance of Continuing Medical Education and Professional Development (CEPD) for practising clinicians, and the major advances which continue to be made in anaesthesia and critical care must occupy a key role in this. It is all too easy for us, with the ever-increasing workload and demands of complex patient care, to feel we have no time to update our knowledge and skills, preferring to employ techniques with which we are familiar, supported by the sound clinical knowledge and judgment which we have acquired over many years. However, the development of anaesthetic techniques, equipment and pharmacology does not stand still. Equally, the sophistication of diagnostic techniques for our patients means that we are much better informed than in the past. In some ways, the more we know, the more difficult it is to make a balanced judgment on the optimal care of a patient. Yet how much more informative it is to know the actual gradient across a stenosed aortic valve than simply a judgment made on clinical signs. The demands made of anaesthetists both in theatre, in pain management and in the intensive care unit mean that being able to find sufficient time to attend CEPD meetings, particularly outside one’s own local environment let alone overseas, is increasingly difficult and therefore, for many of us, there is limited opportunity to concentrate and learn in an undisturbed way. Importantly, we need to hear the views of experts in their chosen field and, inevitably, we rely to a great extent on information supplied in academic journals and textbooks together, increasingly, from the Internet.

Unless one has an enormous amount of time and a range of journals available, it is often difficult to obtain a balanced view about new areas of anaesthesia and critical care. What we really need is an expert to assess the current topic in question and to produce an objective commentary and judgment on the various papers that have been written during recent months. The Year in Anaesthesia and Critical Care is, for me, a new concept of book-based CEPD, which concentrates on extracting information from a number of recent papers and assessing it in a meaningful and readable way. New books appear on a regular basis but most are either orientated towards examinations and assessment processes during training, or are expert textbooks in a particular field of either anaesthesia or critical care. Few are aimed at CEPD for established career grade clinical anaesthetists, but this, with its new innovative format and concept, is such a book.

No book of this nature should attempt to be comprehensive, and what the contributors have done is to select four key areas of recent development, namely perioperative care, anaesthetic pharmacology, new technologies in anaesthesia, and critical care. Individual key subjects are dealt with in more detail within these four sections, and organised in...
each case by an editor who provides an excellent and objective editorial section at the beginning, including a brief overview of the subject, a summary of the papers, individual comment and references. The subject areas are reviewed by experts in the field who concentrate on a number of key publications that have occurred during the past year, looking at the key findings and recommendations of each and then coordinating these to provide more detailed response and comment. The reader is thus able to have expert opinion and comment at two levels both for the individual detailed subject area and more generally in the field which is the subject of the section of the book. Laid out as it is, in sections and subsections each with comprehensive headings, it is both easy to read and concentrate upon. Importantly, one only needs to read a small section at a time to gain relevant information, and interruptions do not disturb one’s flow of thought and learning unduly.

There is no doubt that the opportunity to concentrate on specific topical areas rather than the need to be comprehensive in terms of subject content makes for a much more readable and interesting publication. Even at the level of studying for examinations, key comment and essays from experts do much to help one’s understanding of a subject and the research and scientific basis behind new developments and techniques. This selective approach is exemplified in all parts of the book. The section on perioperative care, for example, concentrates on perioperative blood and intravenous fluid therapy and protecting the heart in coincidental surgical operations, together with one review specifically related to cardiac surgery. For clinical anaesthetists wishing to read material to increase their knowledge, this combination has all the right ingredients. It develops themes about which they already know a considerable amount but wish to be updated, leading them through new ideas and techniques. Finally, it provides a detailed look at a more specialist area of work which would be of interest even if they were not acutely involved with it. The second section on anaesthetic pharmacology follows a similar theme identifying clinical aspects of basic pharmacology, leading into discussions on some of the newer hypnotics and analgesics which will undoubtedly alter clinical practice in the future. Finally, it provides an update on the influence of pharmacogenetics on anaesthesia, a topic which is becoming increasingly important for us.

The section on new technology in anaesthesia and critical care is designed to take clinicians away from their current techniques, to show them what new developments have occurred and why these might be beneficial both for the quality of patient care and importantly for patient safety. This section then leads on to new equipment which few of us have had the opportunity of using. Although many of us are probably content to use our tried and tested techniques for central venous access and regional anaesthesia, if one talks to trainees, the vast majority find the use of ultrasound and Seldinger techniques second nature, and cannot imagine why we do not routinely use them in the same way. A book like this has the opportunity to discuss the advantages and disadvantages of new developments at length, and to try and reason through recent research and publications which inform the choice of technique. At present, there is considerable emphasis on the need to monitor depth of anaesthesia. Yet informed judgment is undoubtedly necessary if we are to avoid simply purchasing vast numbers of monitors in response to external demands and pressures. It is for this reason as much as anything else that, as anaesthetists, we need to develop our thoughts and reasoning logically. We are very fortunate to have this undertaken for us in such a readable and understandable way.
Although the last section contains a very valuable editorial on the issues surrounding critical care outreach and allows us to take a balanced view on its value in different hospitals, other articles in this section deal with a variety of other problems in intensive care medicine. Critical care outreach is again something about which one needs to make an informed judgment, before being pressurised to institute it, particularly if one feels that the decision to set up such a scheme is based upon little hard evidence and rather more on a perceived need because of a shortfall in ward-based care.

Review articles are an excellent way of keeping up to date and enhancing one’s knowledge. Inevitably, they concentrate on specific topics and contain much of the authors’ own opinions rather than looking at the variety of views from others and allowing the reader to exercise their own judgment. This book allows objective discussion and comment to be made about all the articles written around a certain subject by others. It then allows the reader to make a balanced judgment based upon the recommendations made. For continuous education to have an impact on one’s opinion and clinical practice, one must be allowed to judge for oneself and not simply feel spoon-fed by others’ opinions. The innovative format of this book, and the ease with which one can read and concentrate on it, makes it an ideal opportunity to enhance one’s education in anaesthesia and critical care. The breadth of subjects covered will, I am sure, have widespread appeal.
Part I
Perioperative care
Perioperative care
HANS-JOACHIM PRIEBE

Introduction
Numerous aspects of management comprise perioperative care. This brief overview will concentrate on four broad topic areas: perioperative intravenous fluid therapy, perioperative blood transfusion therapy, off-pump coronary artery bypass surgery and perioperative cardiac protection.

Perioperative intravenous fluid therapy

Type of fluid
Even after decades of ongoing controversy, the debate on crystalloids versus colloids is still not settled. The debate is enlarged by the debate over the optimal type of crystalloid. Crystalloid administration may be associated with considerable adverse effects and these effects may differ considerably between different crystalloids.

Metabolic effects
Resuscitation with large volumes of high-concentration chloride solutions causes hyperchloraemic, non-anion gap metabolic acidosis. This type of acidosis may adversely affect urination, renal and gastric perfusion and function, pulmonary artery pressure and post-operative wellbeing [1]. Lack of awareness of this condition may result in the erroneous diagnosis and treatment of presumed anion gap or respiratory acidosis.

Immunological effects
Different intravenous fluids have variable effects on immune function. This may be of considerable clinical relevance because trauma and surgery activate the immune system, which, in turn, may aggravate post-traumatic cell injury and organ dysfunction. It must be of concern that isotonic crystalloids (in particular lactated Ringer’s solution) can cause immune activation and cellular injury [2]. The effect of hypertonic saline is less pronounced and plasma and albumin seem to be void of immuneactivating activity. Lactated Ringer’s and hydroxyethyl starch solutions may even cause acute lung apoptosis [3].

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The clinical relevance of these findings needs to be determined. Crystalloid solutions are being developed that not only possess volume-expanding but also antiinflammatory characteristics [4].

**Haematological effects**

In general, non-protein colloids are associated with impaired haemostasis, platelet dysfunction and increased bleeding, while albumin and gelatins have the least effect [5]. The effect of hydroxyethyl starch on coagulation is clearly dependent on the type of preparation, as defined by concentration (low 3%, medium 6% and high 10%), the degree of substitution of hydroxyethyl starch residues per mole of glucose (low 0.4, medium 0.5 and high 0.62–0.7), mean molecular weight (low 70 kDa, medium 130–260 kDa and high >450 kDa) and the ratio of C2:C6 hydroxyethylation [6, 7].

**Conclusion**

It is highly unlikely that there will ever be an intravenous fluid that ‘fits all’. Only knowledge of the kinetics of fluid therapy, of the physico-chemical and pharmacokinetic characteristics of the fluids and of the pathophysiology of the underlying disease entity requiring fluid resuscitation will enable an appropriate choice and monitoring of volume replacement.

**Volume of fluid administration**

**The past**

It is still common practice to administer large volumes of fluid during elective surgical procedures [8]. This practice is based on the paradigm upheld for many decades that surgical patients require high intra-operative fluid volumes, irrespective of specific haemodynamic measurements [9]. This paradigm seemed to be supported by the principle of ‘goal-directed’ therapy, which improved outcome in high-risk surgical patients [10] and in patients with severe sepsis and septic shock [11] by ‘optimizing’ cardiac output.

However, data from studies involving patients with sepsis, shock and trauma cannot automatically be extrapolated to patients undergoing elective surgical procedures (and vice versa). Furthermore, most studies of goal-directed therapy have examined the effect of fluid therapy strategy in combination with inotropic support and the results of these studies have not been unanimous. Studies on goal-directed therapy looking at the influence of fluid administration alone have shown differences in the amount of perioperatively administered fluid between groups that were of questionable clinical relevance [12–15], which makes interpretation of the findings difficult. The most extensive recent trial on goal-directed therapy in major surgery not only failed to demonstrate benefit of such an approach, but pointed out some serious disadvantages [15].

The strategy of replacing blood loss by crystalloids at a 3:1 ratio is still common practice. Interestingly, the Saline versus Albumin Fluid Evaluation (SAFE) Study reported a mere 1.4:1 ratio of administered crystalloid:colloid [16]. This finding is consistent with the possibility that the accepted practice of replacing blood loss with
crystalloids at a 3:1 ratio leads to clinically relevant acute over-transfusion with crystalloids.

**The present**

In contrast to what is commonly practised, there is now mounting evidence that the extracellular fluid shift (‘third spacing’) is less than previously assumed, that excess fluid can be detrimental and that excess perioperative fluid administration may worsen and fluid restriction may improve the perioperative outcome [17, 18]. Thus, evidence suggests that careful perioperative fluid restriction may be indicated in selected patient populations undergoing selected elective surgical procedures. A decrease in perioperative urine output may often be a reflection of the perioperative stress response rather than of inadequate fluid therapy.

**Timing of volume administration**

The timing of volume of fluid resuscitation has recently received increasing attention. Inadequate fluid resuscitation (identified as being the most common management deficiency in trauma deaths) must be carefully weighed against increasing evidence that overly aggressive fluid replacement adversely affects the outcome in trauma patients [19, 20].

**Perioperative blood transfusion therapy**

Although red blood cell transfusion increases oxygen-carrying capacity, a liberal transfusion strategy is usually not associated with improved outcome. This would suggest that either anaemia is beneficial or transfusion is detrimental. The beneficial effects of anaemia per se are difficult to postulate. On the other hand, the detrimental effects of transfusion leading to increased morbidity and mortality are well defined: infection, haemolytic reaction, contamination, allergic-anaphylactic reactions, transfusion-related lung injury [21] intravascular volume-related pulmonary oedema and immunomodulation.

**Transfusion trigger**

Uncertainty remains as to the appropriate haemoglobin (Hb) concentration that should trigger a blood transfusion. Despite evidence that a restrictive transfusion strategy (Hb 7.0–9.0 g/dl) lowers in-hospital mortality and reduces blood transfusions without adversely affecting the outcome in patients without cardiac disease [22], transfusion practice in the care of critically ill patients seems to have changed little during the past 10 years. Worldwide, the mean pre-transfusion Hb concentrations have consistently remained around 8.5 g/dl [23, 24]. Only patients with acute coronary syndromes may benefit from a more liberal transfusion strategy [25–27].
Immunomodulation

Transfusion-related immune modulation is receiving continued and increasing attention. It is postulated that transfused allogeneic leucocytes trigger the immune response, possibly resulting in more frequent infections, earlier development of malignancies and even increased mortality [28, 29]. Evidence does in fact suggest that universal leukoreduction may improve outcome [30] and, in particular, decrease post-transfusion non-haemolytic fever [31–34].

However, a recent meta-analysis of ten randomized trials did not demonstrate statistically significant benefits from leukoreduction [35]. Leukoreduction was only associated with a 40% reduction in post-operative infections if the analysis was restricted to those patients who actually received blood transfusions. Although the scientific proof for the benefit of leukoreduction is still pending, based on existing evidence universal adoption of this practice has been recommended [28].

Storage lesion

The clinical relevance of the blood ‘storage lesion’ possibly associated with the transfusion of ‘old’ blood continues to be debated. A blood storage lesion describes the reduced erythrocyte deformability caused by changes in the erythrocyte membrane due to storage-induced depletion of 2,3 diphosphoglycerol and adenosine triphosphate (ATP). Such erythrocyte defect may impair tissue oxygenation via impaired capillary blood flow and oxygen unloading from Hb.

The findings of two recent trials are controversial. One showed a trend towards a worse outcome in patients who received relatively old blood (mean age of blood 21 days) [24]. The other did not show adverse effects of transfusion of stored, leukodepleted red cells to anaemic, critically ill patients on gastric tonometry and global indices of oxygen delivery [36]. The issue remains far from being settled [37].

Off-pump coronary artery bypass surgery

Who benefits?

Considerable progress has been made during the past years in the technique of coronary artery bypass graft (CABG) surgery without cardiopulmonary bypass (off-pump CABG or off-pump coronary artery bypass [OPCAB] surgery). The advance in the technique of OPCAB surgery is driven by the considerable risk of post-operative cognitive dysfunction and stroke associated with on-pump CABG in high-risk patients on the one hand and concern with poor long-term graft patency possibly associated with OPCAB on the other. Thus, a reduced incidence of post-operative cognitive dysfunction and stroke, combined with a comparable quality of revascularization surgery will be the ultimate criteria by which to judge the benefit of OBCAB over on-pump surgery [38].

Despite considerable effort and progress in this area, it may be somewhat disappointing that several recent randomized clinical trials comparing OPCAB to on-pump CABG surgery failed to document clear advantages of one technique over the other [39–42]. Although OPCAB caused less myocardial damage than on-pump CABG and was
as safe, the graft patency rates were lower at 3 months post-operatively, which may adversely influence the long-term outcome [39]. There were no advantages of OPCAB over on-pump C ABG in terms of morbidity (transfusion requirements, perioperative myocardial infarction, stroke, new atrial fibrillation and sternal wound infection), length of hospitalization and mortality [40, 41].

A very recently published meta-analysis of 37 randomized trials involving 3369 patients confirmed the lack of difference between on-pump and off-pump CABG surgery in primary outcomes (mortality, myocardial infarction, stroke, renal dysfunction, requirement for an intra-aortic balloon pump, wound infection, rethoracotomy and reintervention) at 30 days and mortality at 2 years post-operatively [43]. Data on graft patency and post-operative cognitive function were inconclusive. Only selected short-term and mid-term clinical (atrial fibrillation, requirement for transfusion and inotropic support, respiratory infections, ventilatory support and length of stay in the intensive care unit and hospital) and resource outcomes favoured OPCAB surgery.

In contrast, most non-randomized trials (including large database observational studies) found significant differences in mortality, neurological, pulmonary, renal and bleeding complications usually in favour of the off-pump approach [44–47]. Particularly in subsets of patients considered to be at high risk for perfusion, off-pump surgery showed clear benefits [48, 49]. Whereas in most randomized studies high-risk patients were excluded and the procedure-related risk was low for both procedures [43], the non-randomized trials contained relatively more high-risk patients in the on-pump groups than either the on- or off-pump groups in the randomized trials. Obviously, excluding high-risk patients from the randomized studies will make it more difficult for off-pump surgery to demonstrate superiority. Furthermore, in the randomized trials the mean age was only 63 years, the aggregate risk of stroke was only 1% (which is much lower than the usually reported rate of 2–3%), graft patency was not analysed quantitatively and the follow-up time was limited to 2 years.

Thus, the final verdict is not out yet. However, it is likely that different surgical approaches are indicated in different patient populations in order to optimize the short- and long-term outcomes [50]. Current evidence would suggest that, in good-risk patients, it is not worth compromising optimal revascularization for the purpose of performing surgery without cardiopulmonary bypass [51]. In contrast, patients with a risk of aortic cannulation or previous stroke and elderly patients may frequently benefit from the off-pump approach.

**Intra-operative management**

The success of OPCAB surgery will largely depend on optimal positioning of the heart in order to expose the target coronary vessel, on maximal reduction in local cardiac wall motion to perform the distal anastomosis and on techniques directed at minimizing myocardial injury during temporal occlusion of the target coronary artery necessary for visualizing the site of the distal anastomosis.

Lifting and rotating the heart and use of cardiac wall stabilization devices during OPCAB may impair cardiovascular performance, frequently requiring intravenous administration of fluid and inotropic support and the Trendelenburg position. Displacement of the heart, fixation of the cardiac wall and temporary occlusion of the
target coronary vessel contribute to impaired coronary blood flow and subsequent regional myocardial ischaemia, which, in turn, worsens haemodynamic instability |52|.

With this much interference of routine surgery with cardiovascular performance, it is to be expected that, like the surgical, the anaesthetic management for OPCAB surgery is more demanding than that for on-pump CABG. Anticipation and intimate knowledge of the aetiology of the side effects associated with OPCAB-typical surgical interventions, close cooperation with the surgeon, preventive rather than therapeutic measures for counteracting the surgery-induced impairment in cardiovascular performance and, foremost, a highly skilled surgeon, are likely to affect outcomes more than a particular anaesthetic technique or drug.

Perioperative cardiac protection

The perioperative period induces large, unpredictable and unphysiological alterations in coronary plaque morphology, function and progression and may trigger a mismatch of myocardial oxygen supply and demand |53|. With many and diverse factors involved, it is highly unlikely that one single intervention will successfully improve cardiac outcomes following non-cardiac surgery. A multifactorial, step wise approach is indicated.

Two principal strategies have been employed in an attempt to reduce the incidence of perioperative ischaemic cardiac events and complications: pre-operative coronary revascularization, and pharmacological treatment.

Pre-operative coronary revascularization

Controversy remains as to the appropriate management of patients identified preoperatively as having relevant but correctable coronary artery disease (CAD). The effectiveness of pre-operative coronary revascularization in this population continues to be debated. Proponents of ‘prophylactic’ coronary revascularization in selected patients argue that it improves both perioperative as well as long-term outcomes |54|. Opponents of this approach point out that the morbidity and mortality of percutaneous coronary intervention and CABG surgery in high-risk elderly vascular patients are substantial and outweigh any benefit, that recovery from such major morbidity substantially delays and even prevents the surgery for which the intervention was undertaken, that it does not differentiate between young and old age and between patients with symptomatic CAD and those with CAD discovered by cardiac stress testing only, that only survivors of coronary revascularization are included in the various reports and, most importantly, that no prospective randomized trial exists that demonstrates the effectiveness of pre-operative coronary revascularization in improving the short- and long-term cardiac outcomes and mortality in high-risk patients undergoing high-risk surgery.

Pre-operative percutaneous intervention

Patients who have recently been subjected to coronary stenting run a high risk of suffering a perioperative myocardial infarction and serious bleeding (summarized in |53|). If a (bare metal) coronary stent is placed, elective non-cardiac surgery should, therefore,