Sepsis has been defined as the systemic response to infection. Prompt and effective resuscitation, rational prescription of antibiotics and where appropriate, surgical debridement and drainage are the essentials in the treatment of severe infections. Anaesthesia with concurrent sepsis is risky, and involves consideration of possible organ dysfunctions—respiratory, cardiovascular, renal, and haematological—as well as ensuring that appropriate antibiotics are given after taking the necessary microbiological specimens. Because prompt attention needs to be paid to so many body systems, the place for a structured approach during anaesthesia for a septic patient was assessed.

**Objectives:** To examine the role of a previously described core algorithm “COVER ABCD–A SWIFT CHECK”, supplemented by a specific sub-algorithm for sepsis, in the management of sepsis occurring in association with anaesthesia.

**Methods:** The potential performance of this structured approach for each of the relevant incidents among the first 4000 reported to the Australian Incident Monitoring Study (AIMS) was compared with the actual management as reported by the anaesthetists involved.

**Results:** Sepsis was identified as the primary problem in 13 of the first 4000 reports (<1%) to AIMS. The incidents reported generally occurred in sick patients; 70% were ASA status III or worse. The COVER ABCD algorithm provided a diagnosis and corrective manoeuvre in only 15% (2/13) of reported incidents, and the sepsis sub-algorithm provided adequate therapeutic strategies in a further 38% (5/13) of the incidents. Eight cases required the use of additional sub-algorithms for desaturation (30%), cardiac arrest (15%), hypotension (8%), and aspiration (8%).

**Conclusion:** Sepsis involves a serious physiological stress upon multiple organ systems. The use of a structured approach involving a core algorithm and additional sub-algorithms as required provides a series of checklists that can successfully deal with the complex multiple and interrelating problems that these patients present.

**METHODS**

Of the first 4000 incidents reported to AIMS, those that made reference to sepsis were extracted and analysed for relevance, presenting features, type of surgery, cause, management, and outcome. The COVER ABCD–A SWIFT CHECK algorithm, as presented elsewhere in this set of articles, was applied to each relevant report to determine the stages at which the problem might have been diagnosed and to confirm that activating the COVER portion would have led to appropriate initial steps being taken.

As sepsis was not adequately dealt with by this algorithm, a specific sub-algorithm was developed for these problems (see fig 1), and its putative effectiveness was tested against the reports. How this was done is described elsewhere in this set of articles. The potential value of this structured approach...
(that is, the application of COVER ABCD–A SWIFT CHECK to the diagnosis and initial management of this problem, followed by the application of the sub-algorithm for sepsis) was assessed in the light of the AIMS reports by comparing its potential effectiveness for each incident with that of the actual management, as recorded in each report.

RESULTS
There were 36 reports that contained the word “sepsis”. Of these, 13 were associated with specific sepsis related events and were analysed for this study. The remaining 23 reports related to other incidents in which sepsis did not play a significant role.

Presenting features are shown in table 2, and features of the procedure and patient in table 3.

In summary, the incidents reported generally occurred in very sick patients; 69% were ASA status III or worse (table 1). Diabetic, immunocompromised, and intensive care patients undergoing procedures for urological, biliary, or cutaneous infections were represented. Cardiorespiratory compromise presenting as desaturation (77%), hypovolaemia (46%), and hypotension (30%) were the most common presentations (table 2). These incidents occurred most frequently at intubation (37%), following extubation, or in the immediate postoperative period (67%). Premature extubation requiring reintubation for respiratory failure was common (62%) and of these patients, the majority (75%) required postoperative ventilation in the intensive care unit. Volume resuscitation was used in 46%, and inotropic support in 40%.

The COVER ABCD algorithm and the sepsis sub-algorithm were sufficient for adequate management in just over half of the patients; however, eight cases required additional sub-algorithms for desaturation (30%), cardiac arrest (15%), hypotension (18%), and aspiration (8%).

DISCUSSION
This study analysed incidents from 4000 AIMS reports where sepsis or infection related incidents were identified during

**Table 1 Classification according the American Society of Anesthesiologists (ASA)**

<table>
<thead>
<tr>
<th>ASA status*</th>
<th>Definition</th>
<th>n (= 13)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Healthy patient</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>II</td>
<td>Mild systemic disease</td>
<td>3</td>
<td>23</td>
</tr>
<tr>
<td>III</td>
<td>Moderate systemic disease</td>
<td>6</td>
<td>46</td>
</tr>
<tr>
<td>IV</td>
<td>Severe systemic disease</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>V</td>
<td>Moribund patient</td>
<td>1</td>
<td>8</td>
</tr>
</tbody>
</table>

*38% (5/13) patients were emergencies.

FURTHER CARE
Continue vigorous fluid resuscitation throughout
Continue the adrenaline infusion
If there is continuing instability → ICU

(1) Cardiorespiratory compromise presenting as desaturation – 77%, hypovolaemia – 46%, and hypotension – 30% were the commonest presentations. Postoperative respiratory failure was common – 62% of reported incidents: 31% requiring re-intubation.

(2) Sepsis was generally reported in high risk patients: 70% were ASA III or above
Diabetics
Intensive Care patients
Immunocompromised patients
Instrumental urological procedures
Instrumental enteric and biliary procedures
Orthopaedic infections

(3) Active infection/sepsis:
Urological sepsis
Gynaecological sepsis
Biliary sepsis
Pancreatitis
Abscesses
Cellulitis/fascitis

These notes comprise a reverse side of a page of the Crisis Management Manual.

SEPSIS

**SIGNS (1)**
Confusion/tachypnoea
Hypotension or tachycardia
Unexplained desaturation or hypercarbia
Spiking fever and rigors, or hypothermia
Unexplained metabolic acidosis
Oliguria
Elevated creatinine
Thrombocytopenia
Evidence of disseminated intravascular coagulopathy
Postoperative respiratory failure
Failure to reverse

**EMERGENCY MANAGEMENT (2)**
Complete COVER ABCD–A SWIFT CHECK
Call for help
100% oxygen
Bolus of crystalloid or colloid 10ml/kg IV
Consider placing an arterial line
Consider on adenrenaline infusion
Adrenaline: for easy adult doses, see (4) on page 71**
Titrate to achieve a mean blood pressure >70mmHg

Further management (3)
Consider placing a central venous line
Aim for a CVP of >8mmHg
Take samples for microscopy and culture of:
Blood, urine
Any other fluids (e.g. bile, pus, ascites, CSF)
Record any prior antibiotics
Give appropriate empirical antibiotics (seek advice if unsure)
Check haematology, coagulation status, biochemistry, blood gases
Place a urinary catheter


* Numbers in brackets refer to Notes in the right hand panel.
** Page references refer to Crisis Management Manual.
anaesthesia. Sepsis is the systemic response to infection and represents a continuum of illness severity from minor constitutional signs (fever, tachycardia, leucocytosis) to septic shock and multiple organ failure. The duration of this response is variable and may persist into the postoperative period. Initially, it represents an endogenous mediator driven response to increase the patient’s capacity to meet the metabolic demands imposed by the septic insult. This may manifest as an increase in cardiorespiratory drive in order to increase oxygen delivery. In the normal individual, this endogenous response is well tolerated. Associated cardiorespiratory comorbidities and reduced immunocompetence by diseases such as diabetes, malignancy, or by drugs may reduce the capacity of the patient to meet these increased metabolic demands. Certain infections such as gram negative reduce the capacity of the patient to meet increased metabolic demands and hypovolaemia that are hallmark of sepsis. The majority of reports pertained to infectious episodes that occurred in the immediate postoperative period, where premature extubation and postoperative cardiorespiratory failure might have exposed the limited reserve of the patient. These patients should be transferred to Intensive Care Unit (ICU). Volume replacement was used in 46% and inotropes in 40%.

The limited data from this study confirm that septic patients undergoing anaesthesia for procedures directed at the underlying septic problem are vulnerable to hypoxia and hypotension during the perioperative period. It is vital to eliminate any causes of desaturation or hypotension that are unrelated to the underlying septic problem. These are diagnosed and corrected by the COVER ABCD algorithm, and, if necessary, the desaturation, hypotension, and any other relevant sub-algorithms. When the cause of desaturation or hypotension remains obscure, sepsis or SIRS should be considered to be the mechanism. A “sepsis” sub-algorithm for anaesthesia (fig 1) is proposed in these circumstances. Unexpected desaturation during intubation and hypotension following induction of anaesthesia are manifestations of increased metabolic demands and hypovolaemia that are hallmarks of sepsis. The majority of reports pertained to incidents that occurred in the immediate postoperative period, where premature extubation and postoperative cardiorespiratory failure might have exposed the limited reserve of the patient. These patients should be transferred to an intensive care unit for postoperative ventilation and management.

In the control of sepsis, the use of a structured approach involving a core algorithm and any necessary sub-algorithm provides a series of checklists in what otherwise can become an overwhelmingly complex set of problems. This also ensures that an additional, unrelated problem is not compromising the patient.

### Key messages

- Sepsis was identified as the primary problem in 13 of the first 4000 incidents reported to AIMS.
- Seventy per cent of the patients were graded ASA III or worse; one patient was moribund.
- The commonest performed procedures were urological, enteric, biliary, and cutaneous/orthopaedic.
- Thirty eight per cent of the patients were diabetic. Eight per cent were immunosuppressed.
- Commonest presenting incidents in the series were: desaturation (77%); postoperative respiratory failure (62%); hypovolaemia (46%); hypotension (31%).
- Seventy five per cent required postoperative ventilation in the ICU. Volume replacement was used in 46% and inotropes in 40%.
- The COVER ABCD core algorithm and the sepsis sub-algorithm were adequate for the management of just over half the patients. However additional sub-algorithms were required for eight cases, namely desaturation (30%), hypotension (18%), cardiac arrest (15%), and aspiration (8%).

### Acknowledgements

The authors would like to thank all the anaesthetists in Australia and New Zealand who contributed to the 4000 incident reports upon which this and the other 24 papers in the Crisis Management Series are based. The coordinators of the project also thank Liz Brown for preparing the draft of the original Crisis Management Manual; Loretta Smyth for typing; Monika Bullock, RN, for earlier coding and classifying of data; Dr Charles Bradfield for the electronic version of the algorithms; Dr Klee Benveniste for literature research; Drs Klee Benveniste, Michal Kluger, John Williamson, and Andrew Paix for editing and checking manuscripts.

### Authors’ affiliations

| J A Myburgh, Associate Professor, University of New South Wales, Director of Research, Department of Intensive Care Medicine, The St. George Hospital, Sydney, Australia |
| M J Chapman, Senior Staff Specialist, Intensive Care Unit, Royal Adelaide Hospital and University of Adelaide, Adelaide, South Australia, Australia |
| S M Szekely, Senior Staff Specialist, Department of Anaesthesia and Intensive Care, Royal Adelaide Hospital and University of Adelaide, Adelaide, South Australia, Australia |
| G A Osborne, Senior Staff Specialist, Department of Anaesthesia and Intensive Care, Royal Adelaide Hospital and University of Adelaide, Adelaide, South Australia, Australia |

The study was coordinated by the Australian Patient Safety Foundation, GPO Box 400, Adelaide, South Australia, 5001, Australia.

### Table 2

<table>
<thead>
<tr>
<th>Classification of reports according to presenting incident*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presenting feature*</td>
</tr>
<tr>
<td>Desaturation†</td>
</tr>
<tr>
<td>Postoperative respiratory failure‡</td>
</tr>
<tr>
<td>Hypovolaemia</td>
</tr>
<tr>
<td>Hypertension</td>
</tr>
<tr>
<td>Reintubation§</td>
</tr>
<tr>
<td>Hypercapnia</td>
</tr>
<tr>
<td>Fever, rigours</td>
</tr>
</tbody>
</table>

*There was more than one presenting feature in many of the reports. †Desaturation occurred at induction, intraoperatively and post-extubation in three, two, and five cases respectively. ‡Six patients required transfer to ICU, two patients recovered. §Three recovered and one patient required transfer to ICU.

### Table 3

<table>
<thead>
<tr>
<th>Classification of reports according to procedure performed and patient features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedure</td>
</tr>
<tr>
<td>Urological</td>
</tr>
<tr>
<td>Enteric</td>
</tr>
<tr>
<td>Biliary</td>
</tr>
<tr>
<td>Cutaneous/orthopaedic infections</td>
</tr>
<tr>
<td>Patients</td>
</tr>
<tr>
<td>Diabetic patients</td>
</tr>
<tr>
<td>Intensive care patients</td>
</tr>
<tr>
<td>Immunosuppressed patients</td>
</tr>
</tbody>
</table>
REFERENCES

Crisis management during anaesthesia: sepsis

J A Myburgh, M J Chapman, S M Szekely and G A Osborne

*Qual Saf Health Care* 2005 14: e22
doi: 10.1136/qshc.2002.004234

Updated information and services can be found at:
http://qualitysafety.bmj.com/content/14/3/e22

These include:

**References**
This article cites 10 articles, 5 of which you can access for free at:
http://qualitysafety.bmj.com/content/14/3/e22#BIBL

**Email alerting service**
Receive free email alerts when new articles cite this article. Sign up in the box at the top right corner of the online article.

**Topic Collections**
Articles on similar topics can be found in the following collections

QSHC Crisis management in anaesthesia (26)

**Notes**

To request permissions go to:
http://group.bmj.com/group/rights-licensing/permissions

To order reprints go to:
http://journals.bmj.com/cgi/reprintform

To subscribe to BMJ go to:
http://group.bmj.com/subscribe/