Irrigation of closed body spaces may lead to substantial perioperative fluid and electrolyte shifts. The transurethreal resection of prostate (TURP) syndrome is characterised by a spectrum of symptoms ranging from asymptomatic hyponatraemia, to electrocardiographic (ECG) changes, nausea, vomiting, convulsions, coma, and death. A similar syndrome has been described in women undergoing transcervical endometrial ablation (TCEA). The occurrence of this “water intoxication” syndrome is determined by a combination of operator, patient, and procedural factors. Asymptomatic hyponatraemia can occur in over 50% of TURPs, while clinically detectable TURP syndrome may become obvious in 2% of resections. As the consequences of this syndrome can be serious, prompt recognition and appropriate management are important.

The aim of this study was to identify all cases of water intoxication in the first 4000 incidents reported to the Australian Incident Monitoring Study (AIMS), create a management algorithm, and compare this with the actual management of the incidents described.

In 1993, a “core” crisis management algorithm, represented by the mnemonic COVER ABCD–A SWIFT CHECK (the AB precedes COVER for the non-intubated patient) was proposed as the basis for a systematic approach to any crisis during anaesthesia where it is not immediately obvious what should be done, or where actions taken have failed to remedy the situation. This was validated against the first 2000 incidents reported to the original AIMS. AIMS is an ongoing study which involves the voluntary, anonymous reporting of any unintended incident which reduced, or could have reduced the safety margin for a patient. It was concluded that if this algorithm had been correctly applied, a functional diagnosis would have been reached within 40–60 seconds in 99% of applicable incidents, and that the learned sequence of actions recommended by the COVER portion would have led to appropriate steps being taken to handle the 60% of problems relevant to this portion of the algorithm. However, this study also showed that the 40% of problems represented by the remainder of the algorithm, ABCD–A SWIFT CHECK, were not always promptly diagnosed or appropriately managed. It was decided that it would be useful for these remaining problems to develop a set of sub-algorithms in an easy to use crisis management manual. This study reports on the place of the COVER ABCD–A SWIFT CHECK algorithm in the diagnosis and initial management of water intoxication, provides an outline of a specific crisis management sub-algorithm for this problem during anaesthesia, and provides an indication of the potential value of using this structured approach.

METHODS

Of the first 4000 incidents reported to AIMS, those which made reference to water intoxication, glycine, irrigation, urology, endometrial surgery, hyponatraemia, low sodium, and TURP were extracted and analysed for relevance, presenting features, type of surgery, cause, management, and outcome.

The COVER ABCD–A SWIFT CHECK algorithm, described 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 water intoxication is not adequately dealt with by this algorithm, a specific sub-algorithm for this syndrome was developed (see figure) 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 the problem, followed by the application of the water intoxication sub-algorithm, was assessed in the light of AIMS reports by comparing its potential effectiveness for each incident with that of the actual management, as recorded in each report.

RESULTS
Ten incidents of water intoxication were identified. The majority had undergone transurethral procedures on either prostate (7) or bladder (1), all under spinal blockade. Two incidents involved TCEA, both of which were performed under general anaesthesia. The presenting features are shown in table 1.

When the COVER ABCD–A SWIFT CHECK algorithm was applied to each report, it was considered that the majority of cases (70%) would have been detected at the COVER portion of the algorithm. The actions recommended by the COVER portion (100% oxygen, turning off the vaporiser, and, if necessary, removing the patient from the anaesthetic machine, filter, and circuit) were all considered reasonable immediate steps. However diagnosis of the actual problem was only possible from COVER in two cases while the other eight required specific consideration. Effective treatment required a specific sub-algorithm (fig 1) in eight cases; one case required both hypotension and water intoxication sub-algorithms while the final case would have required the use of sub-algorithms for cardiac arrest, hypotension, and water intoxication.

<table>
<thead>
<tr>
<th>Presenting features of water intoxication/hyponatraemia*</th>
<th>General anaesthesia</th>
<th>Regional anaesthesia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confusion, seizure, sedation/drowsiness</td>
<td>N/A</td>
<td>6</td>
</tr>
<tr>
<td>Chest pain, ECG changes</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Hypotension</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Bronchospasm</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Desaturation</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

*Some patients presented with more than one symptom or sign.
†All endometrial ablations (n = 7) were performed under GA, and all TURP/bladder procedures (n = 8) were performed under RA.
‡There was one case each of hypertension and bradycardia in this subgroup.

NOTES:
10 reports of water intoxication were made, 8 involving male urological procedures and 2 involving endometrial ablation. The COVER algorithm deals poorly with this uncommon event and requires a simple specific management algorithm.

1. CNS symptoms appear early but are not specific, therefore a high index of suspicion is required.
2. Circulatory overload may manifest early as desaturation during general anaesthesia.
3. ECG changes in the history position is useful as it enables ST segment analysis.
4. Over rapid correction, especially with hypertonic saline, has been implicated in causing neurological problems such as central pontine myelinolysis.

These notes comprise a reverse side of a page of the Crisis Management Manual.17.

WATER INTOXICATION

SIGNS
In the awake patient – CNS symptoms (1)*
  - Drowsiness and confusion
  - Nausea and vomiting
  - Coma
  - Convulsions
In the anaesthetised patient – CVS symptoms (2)
  - Circulatory overload
  - ECG changes
  - Delayed emergence from anaesthesia

PRECEPITATING FACTORS
High risk procedures: closed cavity irrigation/prolonged operating time
Anaesthesia: administering large volumes of hypotonic fluids.

EMERGENCY MANAGEMENT
Inform surgeon
CEase irrigation/surgery
Increase FiO₂, monitor blood gases
URGENT, Na⁺, K⁺, Osmolality (blood)
If symptomatic:
  - 0.9% saline and frusemide 0.5–1.0 mg/kg IV
  - mannitol 0.25 g/kg may be considered if not hypervolaemic
If severe CNS depression/convulsions:
  - hypertonic saline (3) anticonvulsants

FURTHER CARE
Continue ECG/Spo₂ monitoring
Attention to fluid balance
Monitor electrolytes, asmolarity, blood gases
Mild symptoms – fluid restriction may suffice
Consider central venous line or pulmonary artery catheter
Consider HDU/ICU admission


* Numbers in brackets refer to Notes in the right hand panel.

Figure 1 Water intoxication.
The sub-algorithm (shown in fig 1, left hand panel) was estimated to be as effective as the actual management in seven cases; in the remaining three cases, earlier consideration and action may have improved outcome. In one incident there was a delay in diagnosis and the operation continued despite symptoms of confusion, nausea, vomiting, and chest pain. In another case pre-existing hyponatraemia (129 mmol/l) was left uncorrected, and this considerably worsened following a lengthy cystoscopy (98 mmol/l) and finally a protracted (three hour) resection led to increasing drowsiness and hypertension. The attending anaesthetist did not realise the significance of these signs until a relief consultant took over the case.

There was minor morbidity in three cases, with major morbidity in seven. There were no deaths. Half of all the patients with water intoxication were admitted to intensive care or high dependency units. The management of these cases is summarised in table 2. Presenting blood pressure was variable; hypotension in three cases, hypertension in one; normotension in three, and un unstated in three.

**DISCUSSION**

The small number of reports analysed for this survey limits the conclusions that can be drawn. A significant proportion of presenting features of water intoxication appear to be neurological signs; these were poorly managed using the COVER ABCD algorithm and hence a specific sub-algorithm needed to be developed. The majority of cases of water intoxication present with neurological signs in awake patients or with cardiovascular signs in patients under general anaesthesia. Although the term “water intoxication” is used, it is appreciated that the signs and symptoms may be related to fluid overload, hyponatraemia, glycine, or ammonia toxicity.1 It was judged that correct use of the sub-algorithm for water intoxication, once the possibility was considered, would have confirmed the diagnosis in all cases, by checking the serum sodium and osmolality, and would have led to definitive management in eight of 10 reports. The remaining two incidents also required a sub-algorithm for hypotension. Some general conclusions may be drawn from this small study.

**Precipitating factors**

The surgical procedures that predispose patients to water intoxication are chiefly transurethral resection of the prostate and endometrial ablation.

**Clinical features**

Under spinal anaesthesia, neurological signs appear early and include nausea, vomiting, confusion, and irritability. A high index of suspicion is needed when a patient’s neurological condition changes intraoperatively during one of these procedures. Further sedation should be avoided and the diagnosis of metabolic derangement considered; serum sodium and osmolality should be checked.

The earliest signs under general anaesthesia appear to be cardiorespiratory, including desaturating and ECG changes. These are well recognised as indicative of potential intraoperative problems in TURP.12 Full ECG monitoring therefore is advocated with lead positionning (for example, CMS) that enables ST segment analysis. In addition, oximetry should be mandatory for all patients.

**Management**

Avoidance of excessive resection time, irrigation fluid pressure, and administration of hypotonic fluids may prevent many cases of water intoxication. Immediate cessation of the procedure is warranted in all cases where this problem arises. Continuation may lead to a worsening of the clinical situation and potential complications. If the symptoms are mild, blood should be taken for urgent electrolyte and osmolality measurement. Often no further active treatment is required. If patients have neurological signs or exhibit signs of fluid overload, consideration needs to be given to the use of a diuretic (for example, frusemide), and fluid restriction. Mannitol has been found to be more effective than frusemide in the treatment of TURP syndrome as reflected in higher serum sodium and less need for postoperative fluid volume loading.13 However, in patients who are already fluid overloaded, mannitol may precipitate an initial worsening of this situation; in these, frusemide should be used.14 Normalisation of oxygenation and cardiovascular parameters should be sought. As the TURP patients are in an older age group, acute changes in intravascular fluid shifts may warrant invasive arterial and central venous or pulmonary artery pressure monitoring. Avoidance of hypotonic solutions and administration of isotonic saline is recommended. Hypertonic saline may occasionally be warranted, especially when the serum sodium falls below 120 mmol/l. Its use is required only in those cases where there is severe, acute neurological deterioration (for example, convulsions and coma); however, overly rapid correction, especially with preexisting hyponatraemia, has been implicated in causing neurological problems such as central pontine myelinolysis.15 As half of these patients required ICU or HDU admission, consideration should be given to admission of these patients to the appropriate ward following the procedure.

The mainstays of treatment of water intoxication include awareness of the problem in high risk patient groups, intraoperative electrolyte and blood gas monitoring and early cessation of surgery if the complication is considered. Marker techniques such as ethanol added to irrigation fluid have

<p>| Table 2: Management of water intoxication/hyponatraemia/glycine intoxication |
|-----------------------------|-----------------------------|-----------------------------|-----------------------------|</p>
<table>
<thead>
<tr>
<th>Case</th>
<th>Anaesthetic</th>
<th>Case</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>GA</td>
<td>TCEA</td>
<td>CVP line, frusemide</td>
</tr>
<tr>
<td>2</td>
<td>SP</td>
<td>TURP</td>
<td>Frusemide; normal saline</td>
</tr>
<tr>
<td>3</td>
<td>SP</td>
<td>TURP</td>
<td>Frusemide; normal saline</td>
</tr>
<tr>
<td>4</td>
<td>SP</td>
<td>TURP</td>
<td>CPR; adrenaline; atropine</td>
</tr>
<tr>
<td>5</td>
<td>SP</td>
<td>TURP</td>
<td>Hypertonic saline; hydrocortisone</td>
</tr>
<tr>
<td>6</td>
<td>SP</td>
<td>BNI</td>
<td>Frusemide; GTN patch</td>
</tr>
<tr>
<td>7</td>
<td>SP</td>
<td>TURP</td>
<td>Frusemide; hypertonic saline; CVP line</td>
</tr>
<tr>
<td>8</td>
<td>SP</td>
<td>TURP</td>
<td>IPPV (convulsion)</td>
</tr>
<tr>
<td>9</td>
<td>SP</td>
<td>TURP</td>
<td>IPPV (pulmonary oedema); frusemide</td>
</tr>
<tr>
<td>10</td>
<td>GA</td>
<td>TCEA</td>
<td>Frusemide</td>
</tr>
</tbody>
</table>

GA, general anaesthesia; SP, spinal anaesthesia; TCEA, endometrial ablation; TURP, transurethral resection of prostate; BNI, bladder neck incision; CVP, central venous pressure; CPR, cardiopulmonary resuscitation; GTN, glyceryl trinitrate; IPPV, intermittent positive pressure ventilation.
Key messages

- There were 10 reports of water intoxication identified from the first 4000 reports to the Australian Incident Monitoring Study (AIMS).
- Eight cases were associated with transurethral procedures under spinal anaesthesia. Two cases were associated with transcervical endometrial ablation (TCEA).
- The lowest recorded serum sodium level was 99 mmol/l, during a TCEA.
- There were no deaths but there was major morbidity in seven cases.
- The commonest presenting signs in the awake patient were developing mental confusion, sedation, drowsiness, and seizure. The earliest signs under general anaesthesia appear to be cardiorespiratory (for example, desaturation, ECG changes). Presenting blood pressure was variable. Electrocardiographic and pulse oxymetry monitoring are considered mandatory.
- The commonest management strategies reported involved administration of frusemide, normal saline, and IPPV.
- Half the patients required ICU or HDU admission postoperatively, indicating the need for admission to the appropriate ward following these procedures.
- Risk situations during transurethral or TCEA procedures include prolonged surgical time and excessive pressures using hypotonic irrigation fluids.
- The combined, correct application of the core algorithm and the specific sub-algorithm was considered likely to have improved the outcome for three of the patients.

ACKNOWLEDGEMENTS

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