Revisiting the basis of peri-operative fluid management in oral and maxillofacial surgery


Abstract: Oral and maxillofacial surgery involves a wide scope of operative procedures to correct abnormality in the head and neck region. The abnormality can be secondary to trauma, diseases, neoplasia and congenital anomalies, among others, and occasionally may involve medically compromised patients or requiring major reconstructive procedure to repair massive maxillofacial defect. All these patients are subjected to fluid and blood losses from the stress and injury induced from the operation. With progressive expansion of the scope in this specialty, more surgically extensive procedures such as craniofacial and maxillofacial reconstructive surgery are being performed. As such, it is necessary for every oral and maxillofacial surgeon to equip themselves with adequate knowledge in the peri-operative management of fluid and blood losses to optimize comprehensive patient care. This article aims to revisit important aspects of peri-operative fluid management in oral and maxillofacial surgery.

Key words: Fluids; Electrolytes; Perioperative management.

Introduction

Oral and maxillofacial surgery is a surgical specialty that specializes in treating structural abnormality secondary to injuries, defects and diseases in the head, neck and oral regions (1). Surgical procedures involved in this specialty can be categorized into minor or major and performed either under local anaesthesia with or without sedation or general anaesthesia.

Minor procedures include removal of impacted teeth, cyst enucleation, sinus lift, dental implantology and isolated trauma, among others. Major surgeries which routinely being performed under general anaesthesia includes oncology, craniofacial, panfacial trauma, orthognathic, cleft surgery and when indicated involve extensive reconstructive procedures. The various types of major surgeries involved in this field lead to potential long operating hours thus carrying the risk of intra and post-operative fluid and blood loss (2, 3).

As such, it is vital for every oral and maxillofacial surgeon to understand the physiology of body water and electrolyte to improve peri-operative fluid management ensuring optimum patient’s recovery and successful surgical outcome. This article aims to revisit important basic aspects of fluid management relevant to the field of oral and maxillofacial surgery.

Basic Physiology

Fluid management includes understanding the basis of fluid distribution within the human body which is related to the distribution of osmotic active substances (4). In patients undergoing surgery, the distribution, movement and loss of fluid includes body water and blood, together with intravenous (IV) fluid given during peri-operative period.

It is paramount for human body to maintain the intra and extracellular fluid balance for optimum cells function. This balanced condition is called homeostasis. In general, 50% to 70% of body weight consists of water. An average 75 kg adult male contains approximately 45 L of water and this amount is divided into intracellular and extracellular compartments. Two thirds of body water (~30 L) is in intracellular compartment and the remaining one third (~15 L) is in extracellular compartment. Extracellular compartment is further divided into interstitial (~12 L) and intravascular (~3 L) space which contains plasma volume (5). Other small amount of ‘transcellular’ fluids is considered ‘non-functional’ due to anatomical separation and not in dynamic equilibrium with interstitial and intravascular compartments. Transcellular fluids include cerebrospinal fluid, ocular fluid and gastrointestinal secretion (4). The summary of body fluid distribution is illustrated in Figure 1.
changes in electrolyte concentration, changes in volume or acid potential fluid maldistribution during the peri-operative period. As in any surgical specialty, the chief surgeon plays an important role in the overall management of the patient. As such, it is important for the surgeon and the surgical team to be aware of certain important conditions associated with potential fluid maldistribution during the peri-operative period.

In general, body fluid disturbance can be secondary to changes in electrolyte concentration, changes in volume or acid-base disturbance. Electrolytes balance is important as its concentration dictates the fluid composition in body compartments. Electrolytes can be divided into anions which include chloride (Cl\(^-\)), hydrogen bicarbonate (HCO\(_3\)-) and cations such as sodium (Na\(^+\)), potassium (K\(^+\)), magnesium (Mg\(^2+\)) and calcium (Ca\(^2+\)). As the kidneys are the major organs that involve in excreting excess water and regulating electrolytes balance, renal function test is the test of choice to detect any abnormality related to electrolytes concentration.

Hyponatremia is one of the most common electrolyte deficiencies and is defined when plasma sodium (Na\(^+\)) is less than 135 mmol/L. Even though not all conditions are true hyponatremia, it is important to determine its cause by measuring patient’s urine sodium, plasma osmolality and urine osmolality. Other electrolyte imbalance conditions include hypernatremia, hyperkalaemia, hypokalaemia, hypercalcemia, hypocalcaemia, hypermagnesemia and hypomagnesemia. Hypernatremia can be due to common condition such as dehydration. Hyperkalaemia which can be life threatening may cause dysrhythmia. Severe hypocalcaemia is clinically manifested by peri-oral paraesthesia, carpopedal spasm or positive Chvostek’s sign. Each condition requires comprehensive assessment and specific management as untreated imbalances may lead to further deterioration in body function.

**Goal of fluid therapy**

Massive loss of blood, plasma or other extracellular fluid leads to hypovolemic state. It is important to remember that the goal of fluid therapy is to correct hypovolemia by restoring circulating blood volume thus maintaining tissue perfusion and oxygenation (7).

Peri-operative fluid therapy consist of 3 major components namely 1) maintenance 2) correction and 3) replacement. IV fluid maintenance is given based on normal daily requirement of water and electrolytes. IV fluid correction is given to correct any deficit of water and electrolytes which can be due to prolonged reduced oral intake, fasting, vomiting or diarrhoea. Blood and other body fluid losses due to bleeding or just by simple evaporation from surgical site during and after operation will be replaced by IV fluid replacement. However, blood loss primarily induces intravascular deficit which include blood components, hence need to be corrected with blood or blood products transfusion when necessary (5, 6).

**Fluid selection**

Similar as in any other surgical specialties, oral and maxillofacial surgical cases carry the risk of bleeding that may lead to hypovolemia. This risk is subjected to the extensiveness of the surgery thus requiring appropriate estimation which includes operating hours, the need of blood reserve and fluid management. Selecting either crystalloid or colloid solution to correct hypovolemia depends on the indication as both types of solution have their own advantages and disadvantages.

Ideally, the selected fluid should be safe, efficient for intravascular volume expansion, isotonic to plasma and have similar distribution of electrolytes without causing acid-base imbalance and other unwanted reactions (6).
Crystalloids

Crystalloid solution has low molecular weight and low oncotic pressure in comparison to colloid solution thus making crystalloid solution to remain only for a short duration in the intravascular compartment when given intravenously. Because only a quarter to one fifth of the crystalloid solution infused remains in the intravascular compartment, larger volume of crystalloid solution (almost 3 times to the amount of blood loss) is often needed to replace peri-operative blood loss (3:1 ratio). The high volume of IV crystalloid solution given during peri-operative period may cause tissue edema especially when administration is done rapidly (6).

Hypotremia is one of the commonest electrolyte abnormalities and may occur if body fluid losses are replaced by hypotonic fluid. Hypotonic fluids include dextrose 5% in water (D5W) which is commonly used alternately with normal saline in oral and maxillofacial surgery. It is worth to mention that the 25 g of dextrose in 500 ml of water in D5W solution can increase blood glucose by approximately 4.17 mmol/L (6). Hypertonic saline on the other hand is one of the IV fluids of choice during trauma resuscitation in severe hypovolemic shock especially when associated with head injury. However, it has the disadvantage of being an irritant to endothelial surface (7).

At the moment, isotonic crystalloid solutions remain the most commonly used solutions intra-operatively. Examples of isotonic crystalloid solutions are normal saline which contains sodium and chloride only (0.9% sodium chloride) and physiologic solution like lactated Ringer’s solution which also contains sodium chloride but with additional calcium, magnesium and lactate at concentration which resemble plasma content.

Reported side effects following administration of crystalloid solutions include altered acid-base status such as metabolic acidosis and hyperglycaemia from dextrose-containing crystalloid solutions (6).

Colloids

As colloids remain in the vascular compartment longer than crystalloids when given intravenously, the amount of infusion needed to restore haemodynamic ideally should be similar with blood volume deficit (1:1 ratio). Colloids maintain or raise the colloid oncotic pressure of blood and provide longer duration of plasma volume expansion in comparison to crystalloids (6).

Common colloid solutions are succinylated gelatine (gelofusine), albumin, hydroxyethyl starch and dextran. Colloids’ reported side effects include hypersensitivity, renal failure and haemodilution which may impair patient’s blood coagulation (7). Comparison of crystalloids and colloids (8) are summarized in Table 1.

Table 1. Crystalloids versus colloids (8)

<table>
<thead>
<tr>
<th></th>
<th>Crystalloids</th>
<th>Colloids</th>
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<tbody>
<tr>
<td>Intravascular persistence</td>
<td>Poor</td>
<td>Good</td>
</tr>
<tr>
<td>Hemodynamic stabilization</td>
<td>Transient</td>
<td>Prolonged</td>
</tr>
<tr>
<td>Required infusion volume</td>
<td>Large</td>
<td>Moderate</td>
</tr>
<tr>
<td>Risk of tissue edema</td>
<td>Obvious</td>
<td>Insignificant</td>
</tr>
<tr>
<td>Enhancement of capillary</td>
<td>Poor</td>
<td>Good</td>
</tr>
<tr>
<td>Risk of anaphylaxis</td>
<td>-</td>
<td>Low to moderate</td>
</tr>
<tr>
<td>Colloid oncotic pressure</td>
<td>Reduced</td>
<td>Maintained</td>
</tr>
<tr>
<td>Cost</td>
<td>Inexpensive</td>
<td>More expensive</td>
</tr>
</tbody>
</table>

Blood products

Apart from crystalloids and colloids, blood products are also important and they can be categorized into whole blood, packed red cells, platelets, fresh frozen plasma, cryoprecipitate and albumin, among others. And in the case of replacing acute blood loss, peri-operative blood transfusion with either whole blood or packed red cells is not always the ideal therapy due to its associated risks which include blood incompatibility and infection (9). Some studies show that intra-operative blood transfusion is associated with a higher risk of mortality and morbidity in surgical patients with severe anaemia (10, 11). As such, the decision for blood transfusion would require comprehensive clinical assessment, investigative analysis and must only be indicated according to strict transfusion guideline.

Fluid calculation for maintenance and deficit

In general, amount of IV fluid need to be given for maintenance and correction of fluid deficit can be calculated using the 4:2:1 Hollday and Segar formula. This formula calculates IV fluid requirement based on patient’s body weight. The first 10 kg body weight requires a rate of 4 ml/kg/h, the next 10 kg requires 2 ml/kg/h and the remainder of body weight requires 1 ml/kg/h. The total volume obtained is the IV fluid maintenance rate per hour (12).

The fluid deficit due to fasting prior to surgery can be estimated by using the same rate obtained from the formula, multiply by the fasting hours to get the total volume of fluid for correction. Half of the total volume of fluid for correction will be given during the first hour of surgery, one quarter in the second hour and the last one quarter in the third hour (13). Nevertheless, other than weight, it is important to remember that fluid therapy can also be affected by age and other conditions such as fever and hyperventilation. A general formula to calculate peri-operative fluid requirements is illustrated in Figure 2.

![Figure 2. General formula for the calculation of peri-operative fluid requirement](image-url)
Peri-operative assessment

Pre-operative

Comprehensive pre-operative patient assessment is paramount to ensure patient is at optimum condition prior to surgery. Complete medical history is essential and important medical co-morbidities must not be missed. Patient’s condition which includes hydration status and level of plasma electrolytes needs to be ascertained once the patient is admitted to the ward. The American Society of Anesthesiologists (ASA) classification is a universal system in categorizing patients into 6 categories according to their overall health and fitness prior to surgery.

History of recent illness must not be underestimated. Conditions like hypermetabolism, hyperventilation and fever increase insensible water loss. Clinical findings relevant to fluid imbalance must be taken seriously as it can be fatal and may contribute to other morbidity. Skin turgor, mucosal condition, peripheral pulses characteristics, capillary refill time and urine output are some of the clinical assessment that can be done pre-operatively.

Patient with chronic illness such as oral cancer may present with history of loss of appetite and progressive weight loss. As such, dehydration may be a common finding amongst this group of patients. Dehydration is defined as a clinical condition of an abnormal reduction of one or more of the fluid compartments. Patient with complicated medical history such as long standing diabetes mellitus and hypertension may also have heart or renal failure which classically presented with pedal edema. Edema is defined as a clinical condition with an abnormal fluid accumulation of interstitial or tissue fluid. Patient with heart or renal failure can present with fluid overload pre-operatively which need cautious peri-operative fluid management. Multidisciplinary management is often necessary for this group of patients to reduce morbidity and mortality.

Occasionally, maxillofacial patients with severe upper airway discrepancy such as in syndromic craniosynostosis and Treacher Collins syndrome can be presented with tracheostomy which has been in place during infancy. Oncology cases which require major jaw reconstruction can also be indicated for tracheostomy as the airway needs to be protected. Patients with tracheostomy have higher risk of insensible water loss (14).

Intra-operative

Intra-operatively, ongoing blood loss must be monitored closely. Apart from estimation from blood volume in suction canisters and soaked gauzes; haemodynamic parameters, urine output, peripheral pulses characteristics capillary refill time and colour of mucosa and skin may reflect the degree of intra-operative blood and fluid losses. Invasive monitoring which includes blood pressure monitoring via arterial line, central venous pressure, pulmonary capillary wedge pressure and transesophageal echocardiogram can also be used to ascertain patient’s fluid volume status. Point of care device which can measure haemoglobin concentration like HemoCue™ is also available to guide intra-operative blood transfusion (15). Whenever indicated, significant blood loss should be replaced by blood transfusion following the appropriate guideline.

Blood loss can also be estimated preoperatively via anticipated operating hours. When long operation is indicated, blood should be reserved for possible transfusion. Placement of urinary catheter is often necessary for lengthy maxillofacial procedure to measure urine output which is one of the parameters of adequate organ perfusion.

In maxillofacial surgery, the site of operation may also contribute to the degree of bleeding. A bimaxillary orthognathic surgery carries more risk of longer operating time and blood loss in comparison to single jaw orthognathic surgery.

Intra-operative bleeding must be controlled via local measures such as the use of direct pressure, local hemostatic agents, electrocautery, vessel ligation and bone wax when the source can be identified. Pharmacological measure such as intra-operative tranexamic acid and other methods such as hypotensive anaesthesia and reverse Trendelenburg position can also be used to reduce bleeding (16, 17).

Post-operative

Post-operative haemoglobin level should be checked especially when there is significant blood loss. Blood transfusion is often indicated for symptomatic patient with hemoglobin less than 10 g/dL and when hemoglobin level is lower at 7 to 8 g/dL (18). Nevertheless, higher threshold for blood transfusion is widely practiced nowadays. Blood transfusion is not necessary even when Hb is at 6 g/dL if patient is asymptomatic and has no comorbidities such as ischemic heart disease (18, 19).

Patients at risk of fluid loss and dehydration need to be closely monitored after the surgery. Certain clinical presentations and complaints may indicate fluid deficit and inadequate organ perfusion. The signs and symptoms of fluid deficit or dehydration in surgical patients are summarized in Table 2.

Table 2. Signs and symptoms of fluid deficit

<table>
<thead>
<tr>
<th>Central Nervous</th>
<th>Cardio-vascular</th>
<th>Respiratory</th>
<th>Gastro-intestinal</th>
<th>Skin</th>
<th>Metabolic System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sleepiness</td>
<td>Apathy</td>
<td>Reduced or lost reflexes</td>
<td>Coma</td>
<td></td>
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<tr>
<td>Tachycardia</td>
<td>Orthostatic Hypotension</td>
<td>Dyspnea</td>
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<td></td>
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</tr>
<tr>
<td>Anorexia</td>
<td>Nausea</td>
<td>Vomiting</td>
<td></td>
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<tr>
<td>Ileus</td>
<td>Dryness</td>
<td>Reduced turgor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduced</td>
<td>Temperature</td>
<td>Reduced urine output</td>
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</table>

The success of fluid therapy in general, can be assessed by the improvement of these signs and symptoms indicating adequate organ perfusion.

Fluid input and output documentation is necessary for objective evaluation of fluid status. Normal haemodynamic parameters and urine output (≥0.5 ml/kg/hr) are indicators of restored normal circulation (13).

Conclusion

Patients undergoing major oral and maxillofacial surgical procedures are at risk of significant peri-operative fluid and blood loss. Peri-operative fluid and electrolytes imbalance should be corrected and managed wisely based on sound understanding of body water and electrolytes physiology and also peri-operative fluid and blood management to ensure optimum patient’s recovery and successful surgical outcome.

References

2. Akinbami BO, Onajin-Obembe B. Assessment of intraoperative blood loss during oral and maxillofacial


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