



## Review Article

## Basic concept of fluid electrolyte balance in trauma patient

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## ABSTRACT

Adequate Fluid and electrolyte balance in trauma patients is a task with complex decisions that are often complicated by coagulopathy and blood loss. An adequate volume of blood in the circulation is essential to maintain cerebral perfusion and vital function of the heart, kidneys, lungs, and other organs. Acute blood loss has been identified as one of the major causes of preventable deaths on arrival at hospital. The aim of fluid resuscitation should be to restore critical organ perfusion. This review discusses the availability of various options of Intravenous fluids and their co-relation with body's demand in fluid management of trauma patients.

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## 1. Introduction

Fluid resuscitation in patients after trauma is ongoing challenge, reviewed and debated constantly, results in recommendations changing for the use of various fluids such as crystalloids, colloids, packed red blood cells, fresh whole blood and clotting factors.<sup>1</sup> Other difficulties, such as availability of resources, impact the practitioners' choice of fluid. The best fluid available does not always matches to the appropriate fluid for the patient, especially where long transfers and no blood availability are concerned.<sup>2</sup> These decisions and management strategies appear relevant for further discussion and research, as this fluid resuscitation attempts to provide adequate organ perfusion and oxygen delivery in a system compromised by the physiological consequences of injury. Achieving balance in the resuscitation period is challenging, particularly the volume administered. Administration of more fluid is not always correct.<sup>3</sup> Much of the literature on fluid resuscitation focuses on critically ill patients with sepsis, or elective perioperative patients.<sup>4,5</sup> To improve care

of comprehensive patient, oral and maxillofacial surgeons require a sound knowledge of the basic principles of fluid management and use a sound strategy for blood product usage. For this, one should know detail knowledge about pattern of loss of body fluids due to trauma.<sup>6,7</sup>

## 1.1. Circulation and haemorrhage control

An adequate volume of blood in the circulation is essential to maintain cerebral perfusion and vital function of the heart, kidneys, lungs, and other organs. Acute blood loss resulting in hypovolemic shock is responsible for 30% to 40% of trauma deaths, up to half of which occur in the pre-hospital period.<sup>8</sup> Acute blood loss has been identified as one of the major causes of preventable deaths on arrival at hospital.<sup>9</sup> Early mortality in the resuscitation room is caused by continued haemorrhage, coagulopathy, and incomplete resuscitation. Most injured patients who are in shock are suffering from hypovolemia, but there are also other forms of shock, such as cardiogenic, neurogenic, and septic shock. In addition, cardiac tamponade and tension pneumothorax reduce venous return to the heart and may produce shock. Neurogenic shock results from extensive

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injury to the central nervous system or spinal cord, which causes peripheral vasodilatation, and patients may present with shock from both hypovolemia and vasodilatation. Septic shock is unusual but must be considered in patients whose retrieval from the scene of trauma has been significantly delayed by many hours or days.

## 2. Pathophysiology of Shock

Shock is defined as “an abnormality of the circulatory system that results in inadequate organ perfusion and tissue oxygenation.”<sup>10</sup> Left unchecked, it leads to the “lethal triad” of metabolic acidosis, hypothermia, and coagulopathy, resulting in end-organ dysfunction.<sup>11</sup> Metabolic acidosis is caused by inadequate tissue perfusion and oxygenation and the anaerobic glycolysis that results in lactic acid production. The acidosis leads to coagulation factor and platelet dysfunction, combined with coagulation factor consumption, resulting in a profound coagulopathy.

## 3. Recognition of Shock

Hypotension after injury must be considered to be hypovolemic shock until proved otherwise. Once airway and breathing have been stabilized, rapid evaluation of the patient’s circulatory system is essential to identify the severity of the problem, prevent further blood loss, and resuscitate the patient.

There are several signs of shock:

### 3.1. Tachycardia

Palpate a central pulse, either carotid or femoral. Check for rate, regularity, and quality. A slow, full, regular pulse indicates relative normovolemia, whereas a rapid, thready pulse (caused by catecholamine release) indicates hypovolemia. An irregular pulse may be a warning of impending cardiac dysfunction. Inability to palpate a central pulse mandates immediate resuscitation.

### 3.2. Skin colour

Cold, ashen-grey, diaphoretic (sweaty) skin indicates exsanguinated extremities and therefore likely hypovolemia.

### 3.3. Level of consciousness

When circulating volume is reduced, cerebral perfusion may be impaired, resulting in hypoxia.

This can cause confusion, aggression, drowsiness, or coma.

### 3.4. Respiratory rate

Tachypnea indicates oxygen insufficiency and may be a result of hypovolemia.

## 3.5. Urine output

In a catheterized patient, the urine output may give a good indication of circulating volume. Because healthy elderly patients have a limited ability to increase their heart rate in response to blood loss, tachycardia, usually an early sign of volume depletion, may not reflect the true volume loss in these patients. Also, their blood pressure may have little correlation with cardiac output. Use of  $\beta$ -blockers and other drugs may further prevent tachycardia. Therefore, great care is required in assessing the “shock” state of the elderly. Children, on the other hand, have enormous reserve of physiological function, and this may enable relatively normal physiological parameters despite significant blood loss. However, when deterioration does occur, it can be precipitous.<sup>12</sup>

## 4. Haemorrhage

Haemorrhage is an acute loss of circulating blood volume. The blood volume in a normal 70-kg adult is approximately 7% of the body weight (i.e., about 5 L). Classes of haemorrhage based on percentage of acute blood volume loss and the associated anticipated clinical signs have been described. Volume replacement should be directed by the response to initial therapy rather than by relying solely on the initial classification. It is dangerous to wait until the trauma patient fits the precise physiological classification of shock before initiating aggressive volume restoration. Fluid resuscitation must be initiated when early signs and symptoms of blood loss are apparent, not when the blood pressure is falling or absent.

### 4.1. Class I haemorrhage

Up to 15% blood volume loss (up to 750 mL). This is the equivalent of donating 1 unit of blood. Minimal tachycardia may be seen. No measurable changes occur in blood pressure, pulse pressure, or respiratory rate. For healthy individuals, this amount does not require replacement; blood volume is restored within 24 hours.

### 4.2. Class II haemorrhage

15% to 30% blood volume loss. In a 70-kg man, this represents 750 to 1500 mL of blood. Clinical symptoms include tachycardia, tachypnea, and a decrease in pulse pressure, which makes the pulse less palpable. The latter sign is mainly related to a rise in the diastolic component due to increased circulating catecholamine, which cause constriction in the peripheral venous circulation. Despite the significant blood loss and cardiovascular changes, urine output is only mildly affected (i.e., it is usually 20 to 30 mL/h) in the adult. Some of these patients may eventually require a blood transfusion, but they may be stabilized initially with crystalloid solution.

### 4.3. Class III haemorrhage

30% to 40% blood volume loss. This is approximately 2000 mL in an adult and can be devastating. Patients present with the classic signs of inadequate perfusion, including marked tachycardia and tachypnea, changes in mental status, and a measurable fall in systolic pressure. This is the least amount of blood loss that consistently causes a drop in systolic blood pressure. Patients almost always require transfusion.

### 4.4. Class IV haemorrhage

Greater than 40% blood volume loss. This amount of blood loss is immediately life-threatening. Signs include marked tachycardia, a significant fall in systolic blood pressure, and a narrow pulse pressure. Urine output is negligible, and mental status is markedly depressed. The skin is cold and pale. These patients require rapid transfusion and immediate surgical intervention. Loss of more than 50% of a patient's blood volume results in loss of consciousness, pulse, and blood pressure. It is important to remember that, whereas loss of up to 30% of blood volume produces tachycardia and reduced pulse pressure, the blood pressure may remain within normal limits. There is a consistent fall in the systolic blood pressure only after more than 30% of the blood volume has been lost.<sup>13</sup>

## 5. Fluid Replacement

In a patient with shock and hypotension, the aim of fluid resuscitation should be to restore critical organ perfusion. In an adult trauma patient, 2 L of warmed isotonic crystalloid, preferably Ringer's lactate, should be given and the response assessed. In children, 20 mL/kg should be infused as the initial bolus. (Table 1)

There are three types of patient response:

### 5.1. Responder

The vital signs return toward normal. These patients have probably lost less than 20% of their circulating volume and are probably not still actively bleeding.

### 5.2. Transient responder

The vital signs initially improve but then deteriorate. These patients are still actively bleeding from either an open wound or, more likely, an occult site. They require transfusion with blood, identification of the source of continued bleeding, and probably surgery to stop it.

### 5.3. Non-responders

The vital signs do not improve. This implies that the blood loss is continuing at a rate at least equal to the rate of fluid replacement. The history, mechanism of injury, and physical findings will help identify the problem, and a central venous

line should be inserted to exclude other potential causes such as neurogenic shock, tension pneumothorax, or cardiac tamponade.<sup>14</sup>

## 6. Crystalloid versus Colloid

According to ATLS (Advanced trauma Life Support), if a patient needs colloid—that is, an agent that replaces intravascular loss and remains intravascular, thereby increasing circulating volume—blood should be given, because it is the only agent in general use that improves oxygen-carrying capacity.<sup>15</sup>

Crystalloids such as Ringer's lactate are isotonic electrolyte solutions that pass freely between the intravascular and interstitial spaces; therefore, a three to four times greater volume is needed to produce a hemodynamic effect similar to that of colloids. Crystalloids also dilute clotting factors, and unless the patient is adequately warmed, they are more likely to cause hypothermia. Crystalloids are cheap and safe; however, in cases of severe uncontrolled haemorrhagic shock, damage control resuscitation must be considered. Colloids are typically iso-oncotic and can be used to replace blood loss on a 1:1 volume basis; however, they do not directly improve the oxygen-carrying capacity. Polygelatins such as Hemaccel and Gelofusine are reasonably cheap, carry a relatively low anaphylactic risk, and have an intravascular half-life of 6 to 8 hours. Care must be taken not to overload the patient with fluid if blood transfusion is necessary later. Hetastarch is more expensive; it has a longer half-life (about 12 hours) but still carries a relatively low anaphylactic risk. However, in a systematic review comparing the mortality rates after fluid resuscitation with colloid or crystalloid solutions in critically ill patients, resuscitation with colloids was associated with an increased absolute risk of mortality. The authors stated that this finding “does not support the continued use of colloids for volume replacement in critically ill patients.”<sup>16</sup>

## 7. Hypertonic Saline and Synthetic Fluids

A number of studies have suggested that early infusion of a limited volume (approximately 250 mL) of 7.5% hypertonic saline with 6% dextran 70 may be beneficial in patients with severe trauma and continuing haemorrhage, especially in the pre-hospital setting.<sup>17</sup> The hypertonic fluid osmotically draws fluid into the circulation, reducing viscosity; for this reason, it may also have a greater benefit than mannitol in reducing cerebral edema in head-injured patients.<sup>18</sup> Because restoration of oxygenation to the tissues is essential to prevent metabolic acidosis and organ failure, new (fluorocarbon-based) synthetic fluids with oxygen-carrying capacity continue to be produced. Fluosol-DA20 was available in the United States in 1989 but had to be withdrawn due to limited success and side effects. More

**Table 1:**

<b>Solution</b>	<b>Composition (per 100 ml)</b>	<b>Indications</b>
Dextrose and normal saline (DNS)	Dextrose anhydrous 5% wv Sodium chloride 0.9% Water injection qs	<ul style="list-style-type: none"> <li>• To increase total fluid volume</li> <li>• To correct the hypoglycaemia</li> <li>• Used as a media for administration of drugs</li> </ul>
Lactated Ringer's (Hartmann's solution )	Lactic acid 0.24ml Sodium hydroxide 0.115 g Dilute hydrochloric acid in sufficient quantity Sodium chloride 0.6g Potassium chloride 0.04g Calcium chloride 0.027 Water for injection qs	<ul style="list-style-type: none"> <li>• To replace the body fluids</li> <li>• To buffer acidosis</li> <li>• In shock and other hypo perfusion states</li> </ul>
Dextrose 5%	Dextrose anhydrous 5%w/v Water for injection qs	<ul style="list-style-type: none"> <li>• To increase total volume</li> <li>• For hydration</li> <li>• To prevent hyperosmolar state</li> <li>• To maintain adequate renal tubular flow (to facilitate water secretion)</li> </ul>
Dextrose 10%	Dextrose anhydrous 10%w/v Water for injection qs	<ul style="list-style-type: none"> <li>• For prevention and correction of hypoglycaemia</li> </ul>
Dextrose 25%	Dextrose anhydrous 25%w/v Water for injection qs	<ul style="list-style-type: none"> <li>• For prevention and correction of hypoglycaemia</li> </ul>
Dextrose 50%	Dextrose anhydrous 50%w/v Water for injection qs	<ul style="list-style-type: none"> <li>• For prevention and correction of hypoglycaemia</li> </ul>
Isolyte M (maintenance solution with 5% dextrose injection)	Dextrose anhydrous 5.0g Sodium chloride 91.00mg Potassium chloride 0.15 g Sodium acetate 0.28 g Sodium metabisulfite 21.0mg Dibasic potassium phosphate 0.13g Water for injection qs	<ul style="list-style-type: none"> <li>• Used as IV maintenance therapy</li> </ul>
Isolyte E (extracellular replacement solution with 5% dextrose injection )	Dextrose anhydrous 5.0g Sodium acetate 0.64g Sodium chloride 0.50g Potassium chloride 0.075g Calcium chloride 0.052g Sodium metabisulfite 0.020g Magnesium chloride 0.031g Water for injection qs	<ul style="list-style-type: none"> <li>• In Burns</li> <li>• Fasciitis</li> <li>• Peritonitis</li> </ul>
Isolyte P (with dextrose)	Hydrous Dextrose USP 5 g; Sodium Acetate Trihydrate USP 0.32 g Potassium Chloride USP 0.13 g; Magnesium Chloride Hexahydrate USP 0.031g Dibasic Potassium Phosphate USP 0.026 g; Water for Injection USP qs	<ul style="list-style-type: none"> <li>• Source of electrolytes</li> <li>• Calories</li> <li>• Water for hydration</li> <li>• An alkalizing agent</li> </ul>
Mannitol (solution of mannitol in water or normal saline)	Mannitol (inert form of sugar mannose) 20%	<ul style="list-style-type: none"> <li>• To raise intravascular volume</li> <li>• To reduce interstitial and intracellular edema</li> <li>• To promote osmotic diuresis</li> </ul>
Haemacel (3.5% of infusion solution)	Polymer of gelatine derived polypeptides 3.5g Water for injection	<ul style="list-style-type: none"> <li>• To increase intravascular volume</li> <li>• For interstitial and intracellular edema reduction</li> <li>• To promote osmotic diuresis</li> <li>• To expand plasma volume (1.5L blood loss can be replaced with haemacel)</li> </ul>

recently, trial results with Polyheme were not as promising as hoped. Given limited blood supplies, limited shelf life of blood, and the risks of cross-infection, a synthetic, sterile alternative would have a valuable role. Researchers are also looking at potential roles for stem cells, dendrimers, and placental umbilical cord blood.

## 8. Blood Replacement

Acute blood loss can be replaced either with fresh whole blood or by dividing the blood up into a number of separate components (e.g., packed red cells, platelets, fresh-frozen plasma), which allows greater use of a limited resource. Because of the significant cross-infection risks, transfusion of fresh whole blood is not used in a civilian setting nor as a primary treatment in the military. Initially, packed red blood cells may be given; if more than 4 units are required, fresh frozen plasma, which contains clotting factors, must also be introduced to prevent development of a coagulopathy. Work has also been carried out on the use of recombinant factor VIIa, which initiates coagulation in conjunction with tissue factor; it has been used in isolated clinical settings with some benefit.<sup>19</sup> In some circumstances, such as uncontaminated blood loss into the chest or abdominal cavity, it may be possible to retrieve the patient's own blood with a cell saver and auto transfuse it back. The blood needs to be sterilely collected, anticoagulated, and retransfused.

## 9. Conclusion

Understanding the basic mechanism and the fluid and electrolyte physiology is an essential tool for successful fluid management in emergency as well as in maintenance phase. Appropriate fluid therapy is important to protect organ functioning. Suitable early fluid resuscitation in the patients of trauma is a challenging task. Appropriate care should be taken in the selection of both the type and volume for the perfusion and oxygen delivery, avoiding the adverse effects seen when giving insufficient or excessive. Thorough knowledge of the physiological consequences and differences of particular type of trauma is necessary for all doctors taking care for trauma patients.

## 10. Source of Funding

None.

## 11. Conflict of Interest

None.

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