Review Article

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Intravenous fluid Considerations in the Resuscitation of a Head Injured Patient

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Abstract: Resuscitation of the head injured patients with shock poses a dilemma to the treating neurosurgeon. Whereas achieving hemodynamic stability is the objective in shock and in head injury, there is apprehension that aggressive fluid resuscitation may lead to aggravation of brain edema, especially if fluids used in resuscitation are hypoosmolar. Instituting cerebral decongestants such as mannitol, frusemide to treat raised intracranial pressure may cause hypotension due to obligatory diuresis. This review article examines the literature on the resuscitation of head injured patient and closely looks into the suitability of various intravenous fluids available today for this emergency situation.

Keywords: cerebral edema, colloids, crystalloids, head injury, intravenous fluids

INTRODUCTION

Damage suffered by the brain from traumatic injury is not complete at the time of impact but continues to evolve during the ensuing period and contributes significantly to the poor outcome. Hypotension singularly is a significant factor for this secondary damage[1,2]. In 717 patients of closed head injury in traumatic coma data bank, 35% had systolic pressure of less than 90mm of Hg and THIS was associated with 150% increase in mortality. Hypotension is poorly tolerated by injured brain. Because brain injury usually disrupts normal cerebral auto regulation, cerebral blood flow rises and falls with systolic blood pressure[3]. Hypotension on arrival in emergency, in the intensive care unit (ICU) and during surgery has been associated with increased mortality and poor outcome[4,5]. It is therefore pertinent to avoid hypotension and treat it promptly in head injured patient. However there is apprehension that intravenous fluids may worsen cerebral edema and thus increase intracranial pressure (ICP)[6]. In a recent prevalence survey of 3147 patients in 200 ICUs, it was found that fluid balance was the primary factor that influenced the outcome[7]. It therefore becomes important, what degree of resuscitation and what kind of fluids should he given to head injured patient during resuscitation so as not to exacerbate cerebral edema and increase ICP, thus improving their outcome.

Degree of Resuscitation

In patients having head injury and hypotension, there is dichotomy of the views on the degree of resuscitation and type of intravenous fluids. In patient without head injury a systolic blood pressure of 90 mm Hg (controlled hypertension) is considered adequate to reduce the chances of hemorrhage[8]. This may not be appropriate for a head injured patient, as it may not provide adequate cerebral perfusion pressure in the setting of impaired cerebral auto regulation and raised ICP. It is desirable that a cerebral perfusion pressure (CPP) of >70 mm of Hg is provided to the injured brain which is possible if mean arterial pressure of >90 mm of Hg is achieved. Thus the practice of controlled hypertension is not desirable in the setting of head injury[9].

At the same time aggressive fluid resuscitation may lead to cerebral edema formation and poor outcome. This is particularly so if hypo-osmolar fluids are used for resuscitation[1, 6,8]. Fluid restriction in the head injury which was in vogue in the past has been found to be harmful as hypotension is associated with devastating secondary ischaemic injury to traumatic brain[9, 10,11]. Therefore aim, in such a situation, should be to achieve euvolemia so as to ensure adequate substrate delivery (Oxygen & glucose) to the injured brain. Use of aggressive fluid resuscitation has shown good results and even CPP based management has been advocated by some[12, 13].

What kind of fluids?

What kind of fluids should be used in head injured patients? The answers are not straightforward. A fluid which maintains or auguments intravascular volume and doesn't increase cerebral edema is ideal and there are efforts towards that end. But let us have a look on the intravenous fluids that are available to us and generally used.

Crystalloids are generally used intravenous fluids for the resuscitation of hypovolemic patient. Ringer's lactate

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has been found to be good[14], but in the setting of head injury it is slightly hypo-osmolar with an osmolality of 270 mOsmol/L and thus may increase cerebral edema[1, 14]. Isotonic glucose (5% glucose) rapidly becomes hyposmolar after the utilization of glucose and will aggravate cerebral edema, thus raising 1CP[15]. It may also contribute to the deleterious effects of hyperglycemia in a severely head injured patient.

Isotonic saline is good choice for head injured patient as it has an osmolatity of 308 m Osmol/L and therefore very little potential for exacerbation of brain edema [1, 16, 17].

However the amount of crystalloids required is 3 times the amount of loss (3:1 rule) to amount for interstitial fluid deficit. But since these fluids are cheap and easily available and amongst them isotonic saline is good choice[1, 18].

Hypertonic saline of late has been found to be effective fluid for the resuscitation of traumatic brain injury both in experimental and clinical studies[8, 19, 20, 21]. Because if its higher osmolality (514 mOsmol/L) it withdraws fluid from the tissues and increases intravascular volume and may help in preventing brain edema and rise in ICP by creating a favorable gradient for free water from extra vascular to the intravascular compartment[22,23,24]. It is also known to improve cardiac output, thus increasing systolic arterial pressure resulting in better perfusion of the brain [23]. Due to its vasodilator effect it also improves microcirculation. It is also known to have modulatory effect on the immune trauma response, which may also be contributory to the better outcome with hypertonic saline[26].

Hypertonic saline has been used as single bolus therapy and as continuous as well as in various concentrations (from 1.8-7.5%) with good out come[27, 28]. However 3% saline is commonly available and thus can be easily used. Despite its good qualities for resuscitation of head injury patient certain concern remains with hypernatremia, hyperosmalality and its related renal failure[28, 29]. Therefore a close monitoring of serum sodium, osmolality and renal functions is mandatory. It should be seen that serum sodium does not rise beyond 155 mEq/L and serum osmolality does not exceed 320 mOsmol though even higher values have also been reported without adverse effects[19, 24,27,29]. Central pontine demyelination, which has been reported with rapid correction of hyponatremia[30], has not been reported with hypertonic saline resuscitation in head injured patients[19, 24,27,29], yet this still remains a serious concern.

Colloids don't move out of intra vascular compartment due large size of their molecule, thus look appealing for resuscitation of head injured patient as they will help in stabilization of systolic blood pressure by with drawing fluid into the intravascular compartment and at the same time will not aggravate cerebral edema[18, 31]. Volume required is also small (1:1 equal to amount of loss). But they are 40-80 times costlier than crystalloids. In addition have some potential adverse effects such as allergic reactions, anti coagulation side effects[18,32]. These are less likely with hydroxyl starch than dextan[33]. Despite theoretically appearing superiority of colloids limited available scientific data provide no definitive conclusions. A meta-analysis of several studies suggests rather a slightly lower mortality with crystalloids[34].

Recently albumen has also been looked into as a resuscitation fluid for head injury patients in SAFE study (saline versus Albumen fluid evaluation). It is supposed to draw fluid into intravascular compartment like colloids. However it did not show any benefit and was rather found to increase mortality even when its cost is prohibitive.[35]

Blood has been ideal substitute for blood loss, however it takes some time for its availability. It is a well-known fact that blood loss upto 20% of blood volume can be treated with crystalloids and colloids but a loss of 30% or more requires blood replacement. A blood loss of 40% more is life threatening and requires immediate transfusion [36]. Hemoglobin of less than 10 gm% also lowers oxygen carrying capacity of the blood and thus will impairs substrate delivery (oxygen) to the brain. Therefore a blood loss of more than 20% of blood volume should be corrected to improve oxygen delivery to brain[37].

CONCLUSIONS

In the era of molecular medicine when we have started looking at neurochemical and cellular mediators of secondary brain damage it is more pertinent that have closer look in the fluid resuscitation of a head injured patient as this can easily contribute in lessening the mortality and morbidity to some extent. Use of 5% glucose is contraindicated and even ringer lactate is not good being relatively hyposmolar1[1,14,15]. Isotonic saline is usually recommended but may not take care of raised 1CP[16,17,18]. Concomitant use of cerebral decongestants such as mannitol may be counter productive due to its diuretic effects which may worsen hypotension[38,39,40]. Colloids and even albumen though theoretically seem appealing but have not demonstrated better out come[34]. Hypertonic saline seems ideal as it restores normovolemia, decreases cerebral edema and lowers ICP[22, 23,24]. Experimental studies & recent clinical studies do show promise on its efficacy and safety for resuscitation of head injured patients [8,19,20,21]. However better designed double blind randomized studies are needed

to recommended its routine use for the treatment of raised intracranial pressure in head injury[41].

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