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An Intravenous Fluid Primer for Physician Assistants in the Emergency Department

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Abstract

As more physician assistants (PAs) choose emergency medicine as a new career choice, it is imperative that their ongoing training after graduation continue so that they may learn the importance of knowing how to take care of critically ill patients. In many instances, whether it be PAs wanting a change of clinical practice, or newly minted ones wishing a future in Emergency Medicine (EM). All face a challenge of knowing when to utilize intravenous (IV) fluids using well documented and sound clinical knowledge. This article will give a brief look at the beginnings of IV therapy and summarize the physiology and some of the medical therapeutic aspects of their uses. It is in no way meant to be a stand-in for proper clinical instruction and ongoing medical training. However, it should strengthen the importance and benefits of continuing one's medical education to help achieve the best clinical outcomes for patients.

Keywords: intravenous fluids, physician assistant, emergency room, critical, physiologic, patient, outcome, learning, crystalloids, and colloids, best practice.

Introduction

Nature of the Problem

Resuscitation fluids are used freely and often by PAs in an emergency room (ER) setting. There is growing evidence that the wrong application, in various circumstances, of specific IV fluids can be detrimental to patient medical outcomes and contribute to medical errors.[1] The inherently fast-paced environment of the ER requires PAs to have clinical experience and access to immediate treatment modalities. There is little opportunity to reference standards of care to guide treatment while performing emergent care on critically ill patients.

It is apparent that there is a knowledge gap, which can, in some cases, hurt the clinical outcomes of our patients. When asking fundamental questions as to why specific fluids are chosen for treating emergent conditions, practicing PAs responses are, (a) that is what I have always done, (b) that is what my attending uses and (C) we never really learned IV infusion therapy in depth during PA school.

Discussion

In an article by Duggleby, it was noted that the use of IV fluids is typical in a hospital, but the choice of what to use may be given to the most junior and inexperienced members of a clinical team.[2] The article indicated that increased levels of morbidity and mortality could be connected to the inappropriate use of or failure to use IV fluids. Furthermore, they stated that most clinicians were unaware of the use of the National Institute for Health and Care Excellence (NICE) guidelines for IV use.[3]

Early Beginnings of IV Infusion Therapy

In 1831, during the cholera epidemic in Europe, Dr. W B O'Shaughnessy first put forth the theory of treating the effects of the disease-causing," universal stagnation of the venous

system, and rapid cessation of the arterialization of the blood.".[4] In vitro studies at the time show that venous blood can be arterialized by agitating in air or contact with heavily oxygenated solids or fluids. Leading to the idea of the intravenous injection of nitrate or chlorate of potash — salts which contained the greatest quantity of oxygen. He tested his theory and delivery technique on a stray dog and proved it was safe. In 1832, his findings, "Report on the Chemical Pathology of Malignant Cholera," [1]was published by the Central Board of Health. [5] Thomas Latta performed the first actual recorded use of the procedure, a physician in England in 1832.[6] He performed an IV infusion using warm water with salts on an elderly septic patient. The patient did improve dramatically but died when a surgeon stopped giving infusions while Dr. Latta was resting. From the 1800s onward, the primary fluid for patient volume expansion has been crystalloids. During that same period, physicians stressed that fluids for adequate rehydration of children with diarrhea must be as close to the same composition as body fluids to be useful.[7]

Physiology

There are physiologic issues associated with how we choose certain IV fluids to use. Many different disease processes can alter the distribution of fluids within critical patients presenting to an ER. Combining this with the number of fluids available and their protocols of use can make the correct choice of fluids difficult for the untrained clinician. Thus, choosing the correct one is crucial to the well-being of a critically ill patient.

To utilize IV fluids correctly, it is important one understands the physiology behind their use. In humans, water is distributed between intracellular and extracellular compartments. The extracellular compartment makes up plasma and interstitial compartments. This water moves easily through membranes between these compartments to achieve constant osmosis. It is the movement of a solvent across a semi-permeable membrane to an area of higher concentration.

Sodium-potassium pumps on the cell membranes pump sodium out of and potassium into cells thus keeping the intracellular concentration lower than the extracellular concentration to ensure equilibrium.[8] However, this process can be compromised in the event of injury or infection to a person. Think trauma or sepsis.

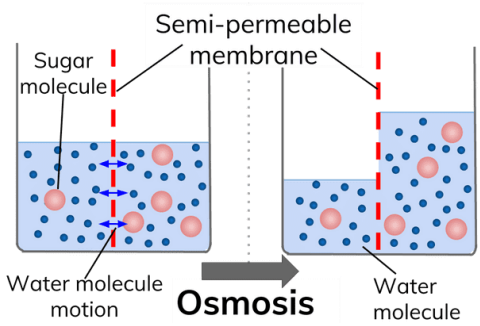

Diagram 1. Osmosis (Seneca, 2018)

IV fluids are divided into mainly two solutions:[9]

1. Colloids are large molecular chemical structures that cannot escape the vascular system nor diffuse across the cellular membrane. Some examples would be Gelofusin and Voluven.
2. Crystalloids are solutions of small molecules in water that can escape the bodies vascular system by diffusing across cellular membranes. Their ability to move smoothly into the bodies interstitial spaces has made them very beneficial for use in fluid resuscitation.[10] Examples would be lactated ringer (LR), normal saline (NS) and Dextrose 5%. Many proponents of crystalloids use them in IV resuscitation as they are inexpensive, readily available, can be stored at room temperature, and have an established use as a first-line treatment for fluid resuscitation.[11]

IV Fluid Therapy Choice

Crystalloid solutions that contain the same concentration of electrolytes as that of the body's plasma are considered *isotonic* fluids.[12] In the ER they are effectively used to treat both shock and sepsis.[13] However, when giving these solutions to replace large amounts of body fluid loss, and thus reduce hypovolemia, one must monitor the patient very carefully. Large quantities of crystalloids such as Lactated Ringers (LR) infused over a short amount of time can cause cerebral edema which can lead to death. Subsequently, Normal Saline (NS) given in large amounts can cause hypernatremia and hyperchloremia. It also can decrease kidney function and reduce urine output, while at the same time producing metabolic acidosis.[14] A study reported by the International Journal of Contemporary Medical Research in 2017, postulated that LR is superior to NS for initial fluid resuscitation.[15] There were no significant differences found in the length of stay or clinical outcomes of patients with the use of either as an initial resuscitation fluid.

The timing of fluid therapy can be more of a critical concern than how much to give. Is has been documented that treating critically ill patients emergently with IV fluid resuscitation within the first six hours of presentation, can improve clinical outcomes better than those patients that have resuscitation fluids delayed. The objective of this aggressive treatment is to reverse circulatory shock and restore intravascular and circulatory volume, thus increasing cardiac output. It has the effect of helping to restore oxygen levels and tissue perfusion.

Sepsis and septic shock are critical medical issues that must be rapidly aggressively treated in the initial stages. Early goal-directed therapy consists of aggressive fluid replacement which improves survival in these patients. However, there has been concern that this may cause fluid overload, and affect the clinical outcome with individual patients. There was a study done

to review this issue, and its findings reported in the SHOCK medical journal in 2015.[16] It studied 405 patients admitted and treated with aggressive IV fluid infusions to treat septic shock. The subjects were all treated at a tertiary teaching hospital. The studies premise was that patients treated for septic shock with large volumes of fluids, would be subject to volume overload and affect clinical outcomes. Although not conclusive, this study indicated that in some cases where fluid infusions are used to treat septic shock, treatment outcomes might be worse. The study indicated that more clinical trials would be needed to find these thresholds where volume overload occurs.

Ongoing IV fluid therapy can be challenging to maintain. Once a clinician has achieved the primary goal of stabilizing a patient with initial fluid resuscitation, fluid maintenance needs to be adjusted to maintain clinical stability.[17] There may be pre-existing deficits of fluids from unforeseen areas such as renal failure, surgical drains, and fistulas that must be monitored and corrected for fluid loss. Cardiac and cerebrovascular disease may cause volume overload and difficulties in maintaining electrolyte balances. It is essential to understand where these fluids get distributed compartmentally. Thus, fluid knowledge and how it is distributed can help the clinician make better treatment choices in what and when to use them.

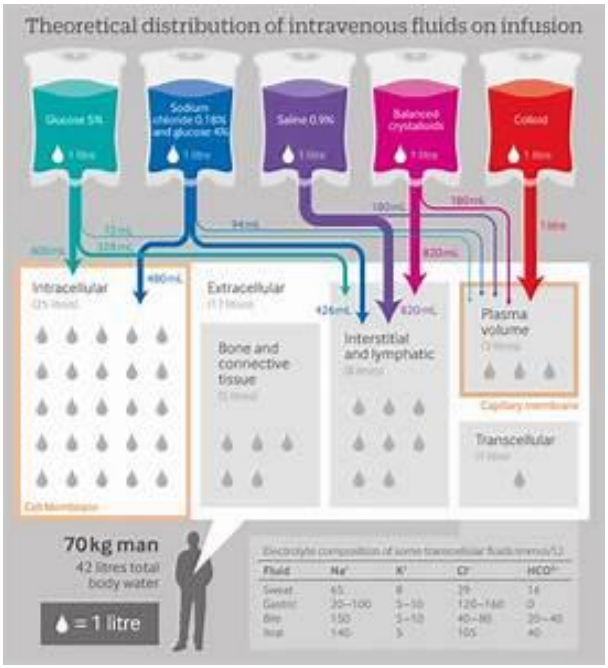

Diagram 2. Distribution of IV Fluids (bmj, 2015)

Some parameters can be a useful guide during rapid IV infusion and maintenance therapy. Serum sodium concentrations and changes in body weight are two ways to maintain water placement and continuing appropriate IV therapy. Furthermore, repeat testing for electrolyte disorders such as hyponatremia, hypokalemia, and metabolic alkalosis and acidosis should be part of a monitoring regimen of any patient receiving fluid infusions to head off any complications from these.

So how is one to choose which to use and when?

The '5Rs' of fluid resuscitation presents an excellent guide to follow for PAs in the ER clinical setting and to highlight and understand the importance of the correct usage of IV fluid therapy.[18]

1. Reassessment of the patient as to fluid needs and routes of administration must be done on an ongoing basis.

2. Redistribution and loss of fluids from the circulatory system must be watched closely.

3. Replacement of fluids and maintaining proper electrolyte, hydration and potassium balance is paramount.

4. Routine maintenance of fluids is essential for patients at risk from various types of fluid loss. Monitor closely.

5. Resuscitation. Employ best practice clinical decision making to determine the correct choice of fluid requirements of critically ill patients to ensure the best medical outcome

Conclusion

PAs whether just graduating or having practiced for years, have the opportunity, unlike most other medical professions to move freely from one area of medicine to another with little need for further training or showing competence in other areas of practice.

Our curriculum in PA school provides us, for the most part with a well-structured and balanced, albeit somewhat hurried education in the myriad aspects of clinical medicine. The basic principles of the importance of maintaining electrolyte balance in patients and IV infusion resuscitation get briefly memorized for testing and certification purposes, and then just as quickly forgotten.

There are more PAs than ever being utilized in hospital medicine as a field of practice.[19] Hospitals are trying to meet their increasing patient care loads by rapidly hiring them. Therefore, many PAs who have never practiced in an ER setting are finding themselves in a fast-paced, stressful, high patient volume and acuity environment, with not even a rudimentary knowledge of IV infusion therapy. Any clinical teaching of IV fluid resuscitation in the ER should at least include some basic understanding of the physiology behind IV fluid resuscitation when to use them, and their effects on patients. There are a high percentage of new grads and long-practicing PAs in all fields with very little, or no experience in their use in EM. It is vital

that PAs have increased in-depth knowledge of why what, and how to use IV fluid infusion therapy to ensure better patient outcomes.

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