

CORRESPONDENCE

*al.*¹ McFarlane and Lee studied 30 patients with a mean weight of approximately 60 kg who were undergoing surgery that lasted approximately 200 min; therefore, the mean volume of fluid administered would be approximately 3 l, which cannot be considered "unusually large." Unfortunately, neither the title of this article nor the key words include the terms "randomized comparison," "acidosis," or "hyperchloremia," which may explain why the article was neglected. The report is completely substantiated by the subsequent article by Scheingraber *et al.*,¹ although the acidosis caused by the administration of the saline solution was less severe because the dose of saline was less. In addition, McFarlane and Lee² reported that the plasma chloride values had returned to normal after 24 h.

I agree wholeheartedly with the editorial comment³ that the Stewart approach to acid-base balance contributes greatly to understanding these phenomena, and that current thinking is often muddled, as shown by a recent survey⁴ and the subsequent correspondence.⁵ Much of this debate, regardless of whether it acknowledges previous studies, fails to properly address the potential harm from hyperchloremia. Some argue that hyperchloremia is harmful,⁶ whereas others, including the authors of the editorial, consider that hyperchloremia is not harmful,² but cite no supporting evidence. If hyperchloremia has important adverse effects, why have they not yet become apparent? A recent volunteer study suggests that subjective mental changes can occur more readily after sodium chloride administration.⁷ A prospective randomized study of clinical outcome may be justified because it is outcome rather than surrogate measures, such as biochemical values, that are of clinical importance.

Anesthesiology
2000; 92:625-6
© 2000 American Society of Anesthesiologists, Inc
Lippincott Williams & Wilkins, Inc.

Avoiding Iatrogenic Hyperchloremic Acidosis—Call for a New Crystalloid Fluid

To the Editor:—Scheingraber *et al.*¹ have provided further evidence that hyperchloremia causes acidosis and draw attention to this clinical problem. However, the authors suggest that iatrogenic hyperchloremic acidosis may be benign. This may be true in relatively healthy patients subjected to limited hyperchloremic insults, because the hyperchloremia is corrected by the subsequent chloruresis. The concern is the effect of more severe hyperchloremia secondary to aggressive fluid resuscitation in acutely ill patients undergoing major trauma surgery, burn debridements, vascular surgery, and liver transplantation. In vascular surgery, lactic and carbonic acid load from the distal segment may be superimposed on the iatrogenic hyperchloremic acidosis at the time of unclamping the aorta.

Animal studies suggest that hyperchloremia causes renal vasoconstriction^{2,3} and its affect on other organ functions are not known.

It is a matter of concern that hyperchloremia may be playing a contributory if not a major role in the pathogenesis of renal insufficiency or failure that may be frequently seen in patients requiring massive resuscitation. Until the safety of hyperchloremic acidosis is established, it seems prudent to avoid 0.9% saline during massive

G. B. Drummond, M.B., Ch.B., F.R.C.A.
Department of Anaesthetics
Royal Infirmary
Edinburgh, Scotland

References

1. Scheingraber S, Rehm M, Schmisch C, Finsterer U: Rapid saline infusion produces hyperchloremic acidosis in patients undergoing gynecologic surgery. *ANESTHESIOLOGY* 1999; 90:1265-70
2. McFarlane C, Lee A: A comparison of Plasmalyte 148 and 0.9% saline for intra-operative fluid replacement. *Anaesthesia* 1994; 49:779-81
3. Prough DS, Bidani A: Hyperchloremic metabolic acidosis is a predictable consequence of intraoperative infusion of 0.9% saline. *ANESTHESIOLOGY* 1999; 90:1247-9
4. White SA, Goldhill DR: Is Hartmann's the solution? *Anaesthesia* 1997; 52:422-7
5. Drummond GB: Is Hartmann's the solution? (correspondence) *Anaesthesia* 1997; 52: 918-9
6. Russo MA: Dilutional acidosis: A nonentity? *ANESTHESIOLOGY* 1997; 87:1010-1
7. Williams EL, Hildebrand KL, McCormick SA, Bedel MJ: The effect of intravenous lactated Ringer's solution versus 0.9% sodium chloride solution on serum osmolality in human volunteers. *Anesth Analg* 1999; 88:999-1003

(Accepted for publication September 23, 1999.)

resuscitation. This avoidance may be more easily said than done; one consequence of massive resuscitation is increasing hyperkalemia caused by the use of blood products. The hyperkalemia is of special concern if the patient is already in renal failure. Substituting 0.9% saline by the commercially available normochloremic fluids such as lactated Ringer's injection, Normosol (Abbott), and Plasma-Lyte (Baxter) is likely to compound the problem of hyperkalemia, because these fluids contain potassium. This situation is best exemplified by the case report where a patient undergoing bilateral nephrectomy for polycystic kidney disease required 20 l normal saline, along with blood products.⁴

One means of avoiding hyperchloremia and hyperkalemia is to use a fluid with the following composition: Na⁺ = 140 mEq/l, Cl⁻ = 100 mEq/l, and lactate or bicarbonate = 40 mEq/l. Currently, the only way one can get such normochloremic- and potassium-free fluid is to have the hospital pharmacy prepare it on request from the physician.

Clearly, further studies are needed to better understand the pathophysiology of hyperchloremic metabolic acidosis in acutely ill patients. We think that until such data are available, the conservative and logical approach should be to avoid iatrogenic hyperchloremia. This is more

CORRESPONDENCE

easily achieved if a fluid that is more normal than "normal" saline becomes commercially available.

Pema Dorje, M.D.
Assistant Professor
pemdor@umich.edu
Gaury Adhikary, M.D.
Assistant Professor
Department of Anesthesiology
University of Michigan Medical Center
Ann Arbor, Michigan 48109-0048
Deepak K. Tempe, M.D.
Professor of Anaesthesiology
G. B. Pant Hospital
New Delhi, India

Anesthesiology
2000; 92:626
© 2000 American Society of Anesthesiologists, Inc.
Lippincott Williams & Wilkins, Inc.

In Reply:—We are grateful to have the opportunity to respond to the thoughtful comments by Drs. Story *et al.*, Drummond, and Dorje *et al.* We entirely agree with Story *et al.* that the Stewart approach¹ provides a fundamental insight into acid-base equilibrium, and that in many cases this approach better explains the causes for metabolic pH changes than the Henderson-Hasselbalch² approach. Nevertheless, the Henderson-Hasselbalch equation is still correct, and most clinicians work well with this equation, despite the fact that the equation does not reflect the whole background of acid-base homeostasis. Consequently, it seemed appropriate to present a well-balanced discussion of our results in the light of the "traditional" Henderson-Hasselbalch approach and the "modern" Stewart approach.

We respond to the letter by Dr. Drummond by stating that we did not claim to be the first to evaluate acid-base changes under large saline infusions. However, probably because of unfortunately chosen key words, we did not come across the report by McFarlane and Lee while preparing our manuscript.³

The question asked by Dorje *et al.* whether artificial hyperchloremia has any important adverse effects cannot be answered with our data. Perioperative hyperchloremia seems to be benign in patients with normal renal function; however, we agree that for critically ill patients, especially those with acute or chronic renal failure, more "physiologic" crystalloid solutions would be advantageous. The proposal of Dorje *et al.* ($\text{Na}^+ = 140$ mM, $\text{Cl}^- = 100$ mM, and lactate or bicarbonate = 40 mM) would probably lead to an ongoing metabolic alkalosis in case of 40 mM bicarbonate content. Our experience with substitutes containing lactate suggests that these solutions will cause a slight but continuous increase in serum lactate

Anesthesiology
2000; 92:626-7
© 2000 American Society of Anesthesiologists, Inc.
Lippincott Williams & Wilkins, Inc.

In Reply:—We appreciate the comments of Drummond¹ and Story *et al.*² Both letters address issues that clarify the report by Scheingraber *et al.*³

First, Drummond¹ appropriately calls additional attention to the

References

1. Scheingraber S, Rehm M, Sehmisch C, Finsterer U: Rapid Saline Infusion Produces Hyperchloremic Acidosis in Patients Undergoing Gynecologic Procedures. *ANESTHESIOLOGY* 1999; 90:1265-70
2. Wilcox CS: Regulation of renal blood flow by plasma chloride. *J Clin Invest* 1983; 71:726-35
3. Wilcox CS: Release of renin and angiotensin II into plasma and lymph during hyperchloremia. *Am J Physiol* 1987; 253:F734-41
4. Mathes DD, Morel RC, Rohr MS: Dilutional Acidosis: Is it a real clinical entity? *ANESTHESIOLOGY* 1997; 86:501-3

(Accepted for publication September 23, 1999.)

concentration. Unfortunately, this artificial increase in serum lactate concentration will lead to loss of an essential routine monitoring for inadequate tissue oxygenation. In summary, we conclude that the ideal electrolyte composition of crystalloids has not yet been found, and further investigations in this field are necessary.

Udilo Finsterer, M.D.
Professor of Anesthesiology
jfreeden@ana.med.uni-muenchen.de
Stefan Scheingraber, M.D.
Staff Anesthesiologist
Markus Rehm, M.D.
Staff Anesthesiologist
Clinic of Anesthesiology
Ludwig-Maximilians University
Marchioninstr 15
Munich D-81377, Germany

References

1. Stewart PA: Modern quantitative acid-base chemistry. *Can J Physiol Pharmacol* 1983; 61:1444-61
2. Siggaard-Andersen O: *The Acid-Base Status of the Blood*. 4th Edition. Baltimore: Williams and Wilkins, 1976
3. McFarlane C, Lee A: A comparison of plasmalyte 148 and 0.9% saline for intraoperative fluid replacement. *Anaesthesia* 1994; 49:779-81

(Accepted for publication September 23, 1999.)

important study by his colleagues at the Royal Infirmary in Edinburgh.⁴ Both McFarlane and Lee⁴ and Scheingraber *et al.*³ conducted randomized clinical trials comparing 0.9% saline balanced salt solutions. The two studies differ in that McFarlane and Lee⁴ enrolled patients under-