Methods and Challenges for the Practical Application of Crit-Line™ Monitor Utilization in Patients on Hemodialysis

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Key Words

Intravascular blood volume measurement · Target weight assessments · Hemodialysis · Crit-Line™ monitor

Abstract

The Crit-Line™ monitor measures relative changes in intravascular blood volume during hemodialysis. The device is also used to monitor hematocrit and oxygen saturation. Using this device to decrease fluid volume has yielded inconsistent results on outcome measures such as hospitalization rates, erythropoietin utilization, and blood pressure reduction. Through a year-long deployment of the Crit-Line™ monitor, the Renal Research Institute (RRI) has shown that outcomes can be improved even in a busy dialysis clinic with attention to the details of how the device is utilized. In this paper, we are proposing areas of focus and methods that if properly implemented should yield improved clinical outcomes. Strong physician approval and enthusiasm coupled with clinical staff support have been shown to be vital to the success of this device in improving clinical outcomes. Even in this setting, inadequately and improperly trained staff have been identified as almost insurmountable impediments to adequate Crit-Line™ use. Our studies have shown that in facilities where staff turnover is high, procedures must be implemented to engage and train new

staff immediately upon their arrival on the dialysis floor. Other issues that may lead to improper use of the Crit-Line™ monitor include incorrect target weight assessments, failure of staff to properly monitor patients during the treatment, and the over dependency of saline administration for cramps.

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Introduction

Fluid overload is a cause of hypertension as well as cardiovascular morbidity and mortality in patients with end stage renal disease (ESRD) [1–3]. While volume reduction has been shown to reduce blood pressure, the ability to achieve normal fluid status has proven to be elusive for many patients [4, 5]. The challenge to clinicians is to avoid excessive volume reduction with its attendant hypotension and cramps yet target ultrafiltration rates that will reduce symptoms of fluid overload. In fact, calculating a target weight for fluid removal is extremely difficult and often subjective [6]. Recent papers have stressed the importance of quality initiatives that focus on fluid management [7, 8].

The Crit-Line™ (Fresenius Medical Care NA, Waltham, Mass., USA) monitor is a device cleared by the

United States Food and Drug Administration (FDA) that noninvasively measures hematocrit, calculated hemoglobin, oxygen saturation, and change in intravascular blood volume continuously during dialysis. Although the use of the Crit-Line™ has been shown to assist in the assessment of target weight [9, 10] and be associated with the decreased use of erythropoiesis stimulating agents (ESA) [11], studies on hospital admissions have been conflicting. In an earlier unblinded, randomized controlled trial, hospitalization rates were higher in the Crit-Line™ arm versus a conventional treatment group [12]. However, a more recent multicenter quality improvement study experienced a 50% reduction in hospitalization when compared to the situation before the implementation of Crit-Line [13].

In this paper, we detail methods and practical approaches to the application of the Crit-Line™ monitor in a quality improvement project being conducted at 18 clinics. We anticipate these approaches will yield improvements in key clinical outcome variables and avoid the pitfalls of other studies.

Methods

The Crit-Line™ monitor detects changes in intravascular blood volume during dialysis so that appropriate changes in ultrafiltration may be continually made during the treatment. The Renal Research Institute has deployed Crit-Line™ monitors over the past three years in 20 dialysis facilities as part of a quality improvement project. In these clinics, Crit-Line™ monitoring is ordered on almost every patient and every treatment but consistent use of the monitor has varied among the units. In the present paper, we discuss the practical problems associated with using the Crit-Line™ monitor in the dialysis unit and the practical solutions we have developed. Issues identified may also explain some of the conflicting results of previous studies.

Management Support

Physician Engagement

Physician approval and enthusiasm were vital for the successful deployment of Crit-Line™ monitors in the dialysis facilities. This active engagement by the nephrologists was transmitted to patients as well as to the clinical staff. In addition, it was agreed that sodium modeling be discontinued. Physicians frequently felt their intuition

was superior in directing ultrafiltration and dry weight determination despite Crit-Line evidence to the contrary. Some physicians were concerned that technicians relied too heavily on the monitor and failed to look at the patient. Other physicians ordered 'no Crit-Line™' when residual function was present or if the patient 'crashed' even occasionally. Finally, it was vital that the nephrologists knew the diagnosis of the varying blood volume patterns on the monitor and were ready to question technicians at any time. That being said, the nephrologist needed to understand that Crit-Line™ is a nurse-driven procedure. Physicians needed to be willing to accept suggestions from staff concerning ultrafiltration rates, time on dialysis, and treatment of cramps and hypotension.

Clinical Staff Support

Clinic managers and various senior managers were highly supportive and involved. Direction of the installation of Crit-Line™ was not delegated to junior staff members. The unit staff was taught to recognize the basics of monitor patterns and to be prepared to ask questions and discuss patterns with the medical staff. The clinic manager and senior management were taught to investigate problem units when the monitor was not being used as prescribed and to question whether overall ultrafiltration targets were achieved.

Staff Training

Staff not trained or poorly trained may be an obstacle to adequate Crit-Line™ use. As an integrated part of the dialysis process, Crit-Line™ was taught as part of the basic orientation class for nurses and technicians. It was determined that less than two hours in the classroom is an adequate basic period for learning. A paper copy of 'take away' points to be memorized has been useful to clinic staff. Memorization of basic monitor patterns and related errors may be more important than discussions of physiology. Individual case studies and calculations were avoided during initial training. 'On the floor' training by a preceptor was aimed at to start the same week as classroom training or later depending on staff ability and comfort. Individual case studies were presented as necessary in follow-up training.

Staff Turnover

Although a dialysis unit with Crit-Line™ may be functioning well, sudden changes in staff due to illness, resignations, and other causes may result in an influx of new staff that may have dialysis experience but no Crit-

Line™ experience. We have found it is necessary to have personnel who can quickly train new staff. A preceptor system has been helpful so that a new technician can be supervised by a trained technician who is following nearby patients and who has passed a competency test. An experienced technician may be a preceptor for a registered nurse or another technician. All trained and tested technicians and nurses may act as preceptors for new staff. A 'fluid manager' similar to an 'anemia manager' for ESA dosing has been suggested but may not be desirable. We have found that an experienced Crit-Line™ staff member should be present on every shift, every day to act as a preceptor for untrained staff. Ideally, everyone was responsible for everyone else. As with other areas of dialysis, we recommended that technicians be permitted increased levels of responsibility for both increasing and reducing ultrafiltration goals within allowable limits. Increasing technician responsibility increases technician interest.

Incorrect Target Weights Setting UF Goals

All dialysis procedures start with the staff using the physician-ordered, target weight and setting the ultrafiltration goal to achieve that weight. Therefore, the success of the entire run depended on a correct target weight. The patient's target weight was continually challenged to detect unrecognized fluid retention. It was emphasized that the ultrafiltration goal not be set too low because of a target weight being set too high at the beginning of the run. The most important ultrafiltration interventions are posted on each dialysis machine to remind staff of what to do.

Target Weight

The importance of frequently challenging the target weight was explained to the patients. In addition, the staff was taught to tactfully but firmly approach the physician for frequent changes. There is a misconception that Crit-Line™ use will make the dialysis completely symptom free. Patient complaints may increase during periods of challenge to the target weight and the physician may want to make the patient more comfortable and therefore set the target weight too high.

Other Issues

Integrating Crit-Line™ with Clinical Observation

The Crit-Line™ monitor allows placement of an arrow sign on the screen so that staff can see the change that oc-

curs after an intervention is made. Observing the location of the arrow enables staff coverage during breaks. The covering technician then knows what ultrafiltration changes are being attempted. We have taught the staff to avoid interventions based solely on the Crit-Line™ monitor. We have emphasized to the staff to look at the patient before making any changes and that increases in ultrafiltration rates should be attempted only when the patient is alert. After determining that the patient is alert, the technicians have been trained to look at the trend of the blood pressure from the beginning of the treatment rather than the blood pressure reading only at the particular moment that intervention is contemplated. It is important to emphasize that cramps, hypotension, or 'crashing' on a given treatment does not mean that they will occur on future treatments or at the same ultrafiltration rate which led to symptoms previously. A possible explanation of the Reddan et al. [12], findings that hospitalizations and mortality were higher with Crit-Line™ is that staff may have tended to reduce ultrafiltration rates with the idea of preventing symptoms such as cramps more than they otherwise would have had before Crit-Line™ use was initiated.

Treating Cramps

A complication that arises out of dialysis is muscle cramps. These often occur when an increase in ultrafiltration rate is attempted. When treating cramps, we have learned that it is important to avoid being aggressive with the use of saline. Cramps often occur toward the end of dialysis, a time at which sodium retention from saline administration is more likely to occur than at the beginning of the treatment. Staff were encouraged to change the position of the extremity or affected area as soon as cramps occurred and decrease the ultrafiltration rate, usually to 300 ml per hour. At that point, staff were taught to wait 2–3 min observing the Crit-Line™ monitor for refill without administering saline. If no refill occurs and the cramps have not begun to improve, 100 cc of saline may be given, but 5 min should elapse before a second dose of saline is given. If a patient has cramps frequently, it should be understood by both the physicians and staff that the cramps are not necessarily a reason to raise the dry weight. With recurrent cramps on consecutive treatments, staff were taught to increase the ultrafiltration goal only by 50–100 ml every 30 min rather than the 200 ml goal, which is the goal we used frequently with Crit-Line™. If the patient refuses an increase in ultrafiltration, it may be desirable to negotiate for 'just a little bit' of increased ultrafiltration or a decrease in dialysate

temperature on each run. If there is refill of the vascular space at the time of reducing the ultrafiltration, it is clear that the patient has additional fluid. Even without immediate refill, the cramps may be treated by some combination of: (1) lengthening the treatment time, (2) reducing the blood pressure medications, or (3) reducing the dialysate temperature 0.5 to 1.0 degree on future runs.

Evaluation of Success

Periodically an end-of-treatment refill test is done to determine the effectiveness of target weight challenges [4]. This procedure is accomplished by turning the ultrafiltration goal to minimal level for 10–15 min. A positive test is a hematocrit reduction of 0.5% (dilution), and it can be concluded that the patient is refilling the vascular

space and has more fluid to remove. However, a negative test does not eliminate the possibility that the patient has more fluid to remove.

Conclusion

Increasingly, fluid overload is recognized as an urgent subject requiring more attention in chronic dialysis. When used with adequate physician approval and thorough staff training, the Crit-Line™ monitor should greatly facilitate comfortable and adequate fluid removal.

Disclosure Statement

Dr. Zabetakis and Mr. Artemyev are employees of Fresenius Medical Care and Dr. Balter is a consultant at Fresenius Medical Care.

References

- 1 Kalantar-Zadeh K, Regidor DL, Kovesdy CP, Van Wyck D, Bunnapradist S, Horwich TB, Fonarow GC: Fluid retention is associated with cardiovascular mortality in patients undergoing long-term hemodialysis. *Circulation* 2009;119:671–679.
- 2 Agarwal R: Hypervolemia is associated with increased mortality among hemodialysis patients. *Hypertension* 2010;56:512–517.
- 3 Chazot C, Wabel P, Chamney P, Moissl U, Wieskotten S, Wizemann V: Importance of normohydration for the long-term survival of haemodialysis patients. *Nephrol Dial Transplant* 2012;27:2404–2410.
- 4 Rodriguez HJ, Domenici R, Diroll A, Goykhman I: Assessment of dry weight by monitoring changes in blood volume during hemodialysis using Crit-Line. *Kidney Int* 2005;68:854–861.
- 5 Antlanger M, Hecking M, Haidinger M, Wertzowa J, Kovarik JJ, Paul G, Eigner M, Bonderman D, Hörl WH, Säemann MD: Fluid overload in hemodialysis patients: a cross-sectional study to determine its association with cardiac biomarkers and nutritional status. *BMC Nephrol* 2013;14:266.
- 6 Sinha AD: Why assistive technology is needed for probing of dry weight. *Blood Purif* 2011;31:197–202.
- 7 Parker TF 3rd, Straube BM, Nissenson A, Hakim RM, Steinman TI, Glasscock RJ: Dialysis at a Crossroads – Part II: a call for action. *Clin J Am Soc Nephrol* 2012;7:1026–1032.
- 8 Weiner DE, Brunelli SM, Hunt A, Schiller B, Glasscock R, Maddux FW, Johnson D, Parker T, Nissenson A: Improving Clinical Outcomes Among Hemodialysis Patients: A Proposal for a ‘Volume First’ Approach From the Chief Medical Officers of US Dialysis Providers. *Am J Kidney Dis* 2014;64:685–695. DOI: 10.1053/j.ajkd.2014.07.003.
- 9 Sinha AD, Light RP, Agarwal R: Relative plasma volume monitoring during hemodialysis: the assessment of dry weight. *Hypertension* 2010;55:305–311.
- 10 Rodriguez HJ, Domenici R, et al: Assessment of dry weight by monitoring changes in blood volume during hemodialysis using Crit-Line™. *Kidney Int* 2005;68:854–861.
- 11 Sibbel SP, Ficociello LH, et al: Effects of Crit-Line™ monitor use on patient outcomes and epoetin alfa dosing following onset of hemodialysis: a propensity score-matched study. *Blood Purif* 2014;37:249–257.
- 12 Reddan DN, Szczech LA, et al: Intradialytic blood volume monitoring in ambulatory hemodialysis patients: a randomized trial. *J Am Soc Nephrol* 2005;16:2162–2169.
- 13 Parker TF 3rd, Hakim R, et al: A quality initiative. Reducing rates of hospitalizations by objectively monitoring volume removal. *Nephrol News Issues* 2013;27:30–32.