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EMERGENCY CARE OF THE DIALYSIS PATIENTS

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ABSTRACT

End stage renal disease (ESRD) is one of the major health care burdens worldwide. Emergency staff are well aware of the frequent use of their services by dialysis patients. In this article we discuss the urgent and serious medical problems that bring the dialysis patient to the emergency department (ED), and the special considerations in the management of such patients in the acute care setting. The main medical problems in dialysis patients presenting to the emergency department are as follows: emergent acid-base and electrolyte disorders; fever; cardiovascular emergencies; dyspnea; angina/chest pain; anemia and emergencies related to access. In conclusion, hemodialysis (HD) and peritoneal dialysis (PD) patients frequently utilize ED services because of their proneness to a variety of emergency medical problems.

KEY WORDS: emergency care, treatment, dialysis, cardiography impedance

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INTRODUCTION

Kidney disease is classified based on the glomerular filtration rate (GFR). The National Kidney Foundation Kidney Disease Outcome Quality Initiative (KDOQI) Advisory Board published Clinical Practice Guidelines for Chronic Kidney Disease in 2002. These guidelines provided a definition for chronic kidney disease (CKD) and established a classification system based on the GFR. CKD is defined as either kidney damage or GFR $<$ 60 mL/min/1.73 m^2 for 3 months or longer [1]. Diabetes and hypertension are the two most common causes of CKD [2]. This article discusses the end stage renal disease (ESRD), as defined by a GFR of less than 15 mL/min/1.73 m^2 or treatment with dialysis. ESRD is one of the major health care burdens worldwide. Renal replacement therapy (RRT) consists of two basic modalities: kidney transplant (KTx) and dialysis. KTx is now recognized as the treatment of choice for patients with ESRD who would otherwise require dialysis. KTx is associated with possibly longer survival and quality of life [3]. According to the 2016 Annual Data Report of the United States Renal Data System, about 678,383 prevalent cases of ESRD are being treated by dialysis, with approximately 63% receiving hemodialysis (HD), about 7% on continuous ambulatory peritoneal dialysis (CAPD) while 30% had a functioning KTx [2].

HD is usually performed 3 times per week for 4–5 hours, blood is drawn out of and returned to the circulation through a arteriovenous fistula (AVF) or central venous catheters. The patient is scheduled for a specific appointment time and is usually dialyzed on a Monday-Wednesday-Friday or Tuesday-Thursday-Saturday schedule. The Kidney Disease Outcomes Quality Initiative guidelines recommend that the prevalence of central venous catheters should be below 10% in HD. Hemodialysis corrects the fluid overload and removes unwanted waste products. In CAPD, the peritoneum is used as the semipermeable membrane separating the peritoneal capillary blood from dialysate instilled into the peritoneal cavity through an implanted catheter (Tenckhoff catheter). CAPD is performed manually (generally 4 times a day) or, in automated peritoneal dialysis (APD), by a cycler machine during the night.

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Emergency staff are well aware of the frequent use of their services by dialysis patients. In this article we discuss the urgent and serious medical problems that bring the dialysis patient to the emergency department (ED), and the special considerations in the management of such patients in the acute care setting.

COMMON MEDICAL PROBLEMS IN DIALYSIS PATIENTS PRESENTING TO THE EMERGENCY DEPARTMENT

Emergent acid-base and electrolyte disorders in dialysis patients

Firstly, the nurse should make sure the sample is not hemolyzed. Hemolysis is a common cause of falsely diagnosing hyperkalemia. The hyperkalemic dialysis patient is usually asymptomatic. Common factors for hyperkalemia in HD patients are as follows: noncompliance with dietary potassium restriction; angiotensin-converting enzyme inhibitors; missed dialysis session; and severe metabolic acidosis. Generally, only when the serum potassium level exceeds 7.0 mEq/L, may generalized muscle weakness occur. Changes in ECG (peaked T waves, prolonged PR interval, disappearance of P waves and finally a sine wave [4]) are the best guide to the management of the hyperkalemia. In dialysis patients, like in general population, the serum potassium level can be treated effectively by the use of IV insulin and glucose. The onset of effects is about 20–30 minutes, and lasts for about 5 hours. The other immediate method is an IV infusion of 10 mL of 10% Calcium chloride solution (effects least 30–60 min). Another method is the use of oral or rectal sodium polystyrene sulfonate (effects is at least 12 hours, and lasts for at least 24 hours [5]. Patients should as soon as possible receive adequate dialysis e.g. continuous venovenous hemodiafiltration (CVVHDF) (Fig. 1).

Metabolic acidosis resulting from the interdialytic accumulation of hydrogen ions generated in the course of normal metabolism is common in HD patients. Correction of metabolic acidosis is one of the goals of effective dialysis. Despite the technical advances in dialysis therapy, pre-dialysis serum HCO3- remains lower (values between 19 and 24 mEq/L) than normal in most patients receiving HD. In HD patients, if respiratory compensation is intact, metabolic acidosis is generally asymptomatic. If necessary (pH < 7.15), intravenous sodium bicarbonate therapy should be given cautiously in patients with ESRD.

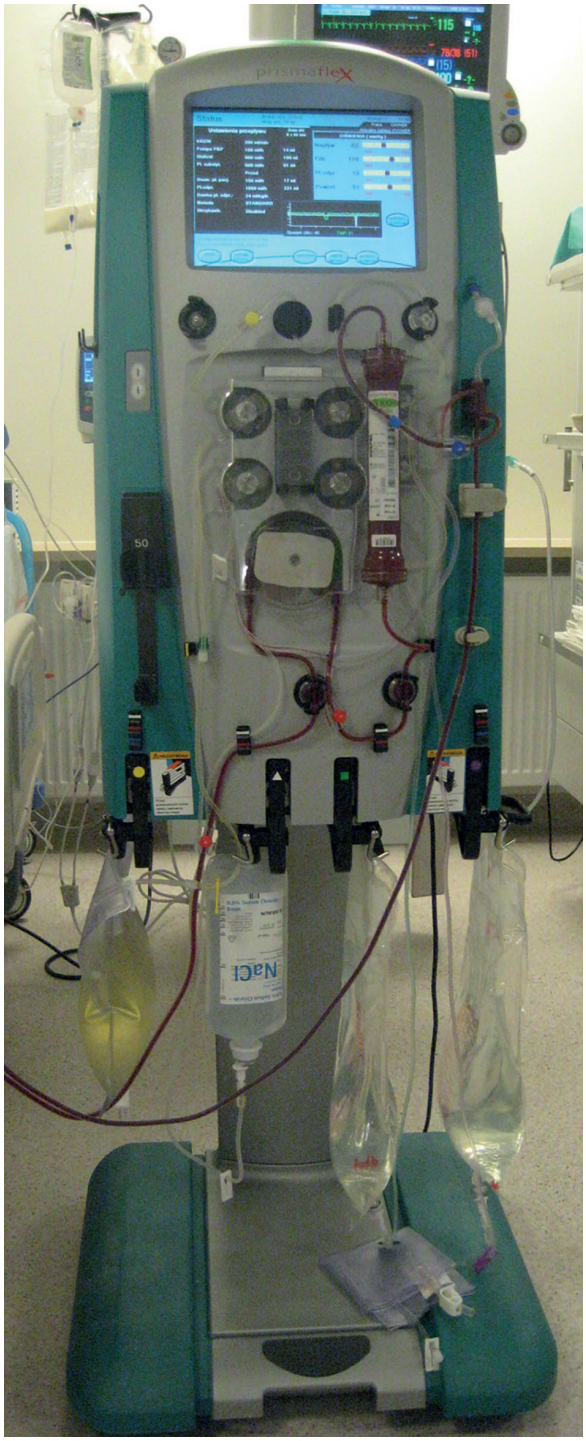

FIGURE 1. Continuous venovenous hemodiafiltration (CVVHDF) in Emergency Department Settings

Although hypocalcemia (ionized calcium less than 4.2 mg/dL) and hyperphosphatemia (serum phosphorus concentration greater than 5 mg/dL) is common in dialysis patients, it is usually asymptomatic. Mild hypermagnesemia (2.2–5 mEq/L) includes progressive flaccid muscle weakness and areflexia. Severe hypermagnesemia (> 5 mEq/L) in-

clude bradycardia, heart blocks, decreased level of consciousness, hypotension and cardiac arrest. This disorder can be countered with intravenous calcium gluconate (5–10 ml of 10% solution) [6].

Hypokalemia, hypophosphatemia, and hypomagnesemia are uncommon in patients with ESRD.

Fever in the dialysis patients

Any cause of fever in the general population may also occur in the dialysis patient. However, certain causes of fever are more common in dialysis patients and should be given special consideration. The most common cause of fever in HD patients is access-related infection, especially with central venous catheters. Infectious complications are a major source of morbidity and mortality in HD and PD patients. Investigations should include a complete blood count and chest X-ray. Febrile HD patients with suspected access infection should be hospitalized. Opportunistic infections occur frequently in such patients. Empiric systemic antibiotics should cover Gram-positive and -negative microorganisms, while the final regimen should be based on culture results. According to US data, the microorganisms most frequently isolated during catheter-related bacteremia are *Staphylococcus aureus* and *Staphylococcus epidermidis*. According to Allon [7], the recommended initial antibiotic therapy in HD patients is Vancomycin 15 mg/kg IV combined with gentamicin 1 to 2 mg/kg IV or a third generation cephalosporin 1 g IV. The most common cause of fever in PD patients is peritonitis. In PD patients, any changes to the color or transparency of the dialysate fluid is an indication of infection. Other typically symptoms are tenderness, diffuse abdominal pain, nausea or vomiting, diarrhea or constipation, while hyperactive or diminished bowel sounds are commonly present. Every PD patient with suspected access infection should be hospitalized. Current guidelines recommend intraperitoneal (IP) antibiotics over IV antibiotics. According to Piraino et al. [8], the recommended initial antibiotic therapy is Vancomycin 2 g combined with gentamicin 0.6 mg/kg or a third-generation cephalosporin added to 1 bag of peritoneal dialysate.

Cardiovascular emergencies in dialysis patients

Cardiovascular diseases (CVD) are the leading causes of death in the general population (WHO 2012 — ca. 31%) among patients undergoing HD (ca. 39%) [9] and PD (ca. 42%). The relative risk of coronary artery disease in these patients is 5–30 times greater than that of the general population. Putative risk factors leading to left ventricular dilation in ESRD include volume overload, anaemia, high-flow *Ateriovenous Fistula* (AVF), as well as poorly controlled uraemia [10]. The best option to facilitate the withdrawal of blood for HD is an AVF. It has already been shown that the cardiac index (CI) can increase 12% and 15% respectively 1 and 3 months after surgery [11]. High vascular access flow can increase CI and can cause high-output cardiac failure [12].

Modern diagnostic tools are needed to assess cardiovascular hemodynamic parameters in order to offer effective identification and treatment in ED. These methods can be divided into the following categories: invasive, the so-called "gold standard" (pulmonary artery catheter [PAC] — thermodilution); minimally invasive (pulse contour analysis); non-invasive, based on finger pressure measurements with an inflatable finger cuff [13]; impedance cardiography (ICG) [14, 15]; and bioreactance technology [16]. Invasive techniques such as PAC are risky and restricted to intensive care and other specialized hospital units [17], while minimally invasive methods are suitable for patients with an arterial line. Doppler echocardiography and thermodilution are not dedicated to serial measurements (beat-to-beat) or trend analyses. Non-invasive methods could be preferable, especially for HD patients. Cardiac output (CO) evaluated by ICG is closely correlated with measurements utilizing thermodilution in patients with or without both benign and severe heart failure [18]. The correlation coefficients of PAC and ICG technology range from $r = 0.63$, reported by Cheung et al. [19], to $r = 0.89$, reported by Cotter et al. [20], and depend mainly on the patient study group. There is an increasing interest in the better hemodynamic management of HD patients, especially in the detection of hemodynamic trends in ED. It is generally considered that a standard electrocardiogram has a limited ability to predict the risk of CVD during dialysis. Haemodialysis-induced hypotension occurs in 15% to 30% of HD patients and depends on the amount of ultrafiltration and the patient's compensatory response to hypovolemia [21].

The advantage of ICG consists of the possibility of continuous measurement of hemodynamic parameters. With this method, we can immediately evaluate (continuous beat-to-beat assessment) the condition of the cardiac muscle and the cardiovas-

cular system, which makes immediate treatment and effective decisions possible. When assessing the hemodynamic parameters, the physician has the ability to immediately apply fluid therapy or medication, thus affecting the cardiovascular system. ICG is a good method to diagnose and monitor cardiac pump function and to explain the mechanisms responsible for the regulation of blood pressure especially during hypotension, which remains one of the most common complications [22, 23].

Karakitsos et al. [24] performed a prospective observational study among 75 HD patients in whom measurements were taken on a midweek morning of a non-dialysis day. The research showed that the CO obtained by ICG (BioZ System) (mean 4.4 ± 1 L) and the CO measured by echocardiography (4.3 ± 0.9 L) were strongly correlated ($r = 0.94$; $p < 0.001$). A regression analysis showed that a CO increase of 1.0 L/min as measured with echocardiography was equivalent to a 0.98 L/min increase as measured with ICG (95% CI, 0.88–1.08). Among various groups of patients, ICG devices were tested in comparison with reference devices (intermittent right heart thermodilution [ITD]). Most studies include patients undergoing cardiac surgery or/and residing in intensive care units (ICU). In a meta-analysis by Peyton et al. [25], including 13 studies where ICG was compared with ITD over 435 measurements, the mean bias was –0.10 L/min (± 0.11) (± 95% CI), the mean precision was 1.14 L/min while the correlation was 0.79. In 24 studies that compared the minimally invasive pulse contour method with ITD over 714 measurements, the mean bias was –0.00 L/min (± 0.09) (± 95% CI), the mean precision was 1.22 L/min while the correlation was 0.79. The worst results of the ICG method were found among ICU patients, a fact which limits the validity and reliability of ICG monitoring. Hirschl et al. [26] tested Cardioscreen among 29 patients; the mean bias was 1.20 while the mean precision was 0.75. Engoren et al. [27] reported using BioZ; the mean bias was 1.00 while the mean precision was 1.30. In postoperative cardiac surgery patients (ICU), Gujjar et al. [28] reported NICOM mean bias of 0.07 and mean precision of 0.68. A study by Wynne [29], using ICG among 35 HD patients, showed that thoracic fluid content (TFC) decreased in all patients during HD sessions (average reduction, 12.7 ± 8 kΩ-1), and the correlation of change in TFC with UFV was moderate ($r = 0.579$; $p = 0.0003$). In the ICG method, TFC represents an estimation of "preload".

Dyspnea in dialysis patients

Careful history-taking is the most useful first step in elucidating the aetiology of dyspnea. Fluid overload and pulmonary edema is the most frequent cause of emergency presentation in dialysis patients [30]. The optimal determination of dry weight is a serious challenge for clinicians. Besides traditional methods, such as clinical evaluation and anthropometric measurements, more precise ones, such as bioelectrical impedance, may be applied in evaluating the hydration status of dialysis patients. The dry weight definition as proposed by Charra demonstrates the key role of hypertension in determining the optimal weight, which is determined as a body mass able to maintain normal BP without anti-hypertensive drugs [31]. In PD patients after ca. 2 years, appears hypertonic overhydration due to residual diuresis decreases and peritoneal membrane faliure appears [32–34]. Contributing factors include preexisting left ventricular dysfunction, excessive fluid intake; missed dialysis sessions and failure to achieve dry weight during dialysis. Patients with fluid overload present with the complaints of shortness of breath and dyspnea. Physical examination findings include hypertension and decreased breath sounds while a chest X-ray will show pulmonary vascular congestion and/or pulmonary effusion. In patients with respiratory distress, the most useful first step is non-invasive positive pressure ventilation (NIPPV) using CPAP and then, if needed, intubation and ventilatory support. Longer intervals also make the patient more prone to volume overload. Initial therapy for the fluid-overloaded dialysis patient consists of administration high-dose intravenous furosemide (in patients with residual diuresis) and oxygen supplementation. Usually, emergent HD is the mandatory treatment for volume overload and acute pulmonary edema [30, 35].

Angina/chest pain in dialysis patients

In evaluating coronary ischemia in patients with ESRD, it is important to understand the limitations of the commonly used tests: silent ischemia is more common than in the non-dialysis population and serum troponin levels may be chronically elevated due to reduced eGFR [36]. The dialysis patient with acute coronary syndrome should be treated with traditional therapies including aspirin, clopidogrel, morphine and thrombolytics.

Uremic pericarditis, uremic pleuritis with or without pericardial effusion and deep vein thrombosis

should be considered in the differential of chest pain in the dialysis patient.

Hypertension in dialysis patients

Hypertension (HTN) affects 50–90% of HD patients and 29–80% of PD patients [37, 38]. A significant discrepancy in epidemiological data shows that the HTN pathogenesis in RRT patients is multifactorial and largely depends on the RRT method and the experience of the study center. Noncompliance with antihypertensives in this patient population may precipitate a hypertensive emergency. Key risks in HD patients include hypertonic overhydration [17], decreased vascular compliance [18] and increased renin secretion [35]. The initial goal of therapy for hypertensive emergency is lowering of the mean arterial pressure only by 20–25% using labetalol and nicardipine.

Anemia in dialysis patients

Most patients with ESRD will develop a normocytic and normochromic anemia. Erythropoietin is iron often given to these patients to maintain a hemoglobin level between 10–11 g/dL.

EMERGENCIES RELATED TO ACCESS IN DIALYSIS PATIENTS

Access to circulation is literally the lifeline of HD patients. Blood pressure recording over the AVF and the use of the AVF for drawing blood is contraindicated, except as a last resort in situations such as cardiopulmonary resuscitation. The absence of a palpable thrill or a bruit on auscultation over an AVF requires prompt pharmacologic intervention in order to dissolve the clot or to perform surgical declotting. AVF typically will fail after prolonged use due to an aneurysm or thrombosis.

CONCLUSION

In conclusion, HD and PD patients frequently utilize ED services because of their proneness to a variety of emergency medical problems. Impedance cardiography is a promising noninvasive tool that makes the use of individualized ED care in dialysis patients. Dialysis patients should add emergency phone numbers for ED and dialysis centers, as they will help meet their needs if an emergency happens.

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