Seminars in Dialysis

ASDIN
AMERICAN SOCIETY OF DIAGNOSTIC AND INTERVENTIONAL NEPHROLOGY

Investigations

Evaluation of Potassium Levels Before Hemodialysis Access Procedures

Jamie Ross* and Deborah DeatherageHand†

*Vascular Access Unit, University of California, Davis School of Medicine, Sacramento, California, and †Internal Medicine/Neprology, UC Davis, Sacramento, California

ABSTRACT

Few prospective studies have looked at the incidence of hyperkalemia in outpatient hemodialysis access procedures. Our study prospectively evaluated 167 procedures using a preadmit venous blood gas (VBG) and found that 14.3% had moderate or severe hyperkalemia. When the individual procedures were analyzed it was found that 38% of malfunctioning tunneled dialysis catheter (TDC) patients, 20% of new start TDC patients, 22% of thrombectomy patients, and only 5.8% of the angioplasty patients had moderate or severe hyperkalemia. We have changed our practice and now monitor the preprocedure potassium in all but the routine angioplasty patients and treat with the protocol described in the body of the article.

In the last 5 years there has been an increase in the number of dialysis access procedures done as an outpatient. In the late 1990s the largest of three major vascular access companies had less than a handful of centers and now have expanded to 70 centers listed on their website (1). The United States Renal Data System (USRDS) states the number of angioplasties alone has increased (2). At this time there has been little evaluation of the need for preoperative laboratories in these centers in preparation to do these procedures (3). The empiric consensus has been that it is not necessary.

There are a small number of articles and studies that have been done with regard to the expected laboratory evaluation of hemodialysis patients before any procedure or operation. This literature has a broader focus on multiple comorbidities which relates to much more extensive procedures than the ones which focus on hemodialysis access (4–6). While the under dialyzed patient is vulnerable to all sorts of life threatening problems such as volume overload and acidosis, one of the most immediate concerning abnormalities in these patients is hyperkalemia. While many reasons have been given for not obtaining preoperative laboratory information with regard to these patients, there are two major reasons that have led to the lack of laboratory investigation prior to pursuing outpatient hemodialysis access procedures. The first reason given is these patients are well dialyzed therefore the potassium is expected to be under control. Secondly, this potentially life threatening potassium abnormality is expected to "show up" in a cardiac monitor. If an abnormality is noted, a full 12-lead ECG can be done and would be expected to reveal any evidence of hyperkalemia. In our study over a 6 month period using a venous blood gas for efficiency, a prospective evaluation of every procedure patient who was to have a tunneled dialysis catheter placed or revised, an angiogram, or percutaneous thrombectomy was done. There was a protocol set in place to decide how to handle each level of potassium. The protocol described below defined mild, moderate, and severe hyperkalemia and specified management.

Background Information

Hyperkalemia in Hemodialysis Patients

One of the main reasons for not getting preprocedure labs was the patients were well dialyzed and the likelihood of hyperkalemia was low. The first issue at hand was the frequency of this serious electrolyte abnormality among dialysis patients. While it is commonly acknowledged that dialysis patients have hyperkalemia, the frequency with which this occurs is not well documented. In a large study in Egypt, 400 chronic hemodialysis patients were evaluated for their potassium levels pre- and postdialysis as well as just prior to the next session of treatment. The frequency of hyperkalemia was 41.2% predialysis, 6.5% postdialysis, and 66.9% before the next session of treatment. They found

Address correspondence to: Jamie Ross, Vascular Access Unit, University of California, Davis School of Medicine, Sacramento, CA, e-mail: jamie.ross@ucdmc.ucdavis.edu.

Seminars in Dialysis—Vol 28, No 1 (January–February) 2015 pp. 90–93
DOI: 10.1111/sdi.12243

potassium levels were even higher in patients with little or no residual renal function (7). Another evaluation of predialysis potassium compared diabetic to nondiabetic hemodialysis patients (136 nondiabetics and 16 diabetics). In nondiabetic hemodialysis patients, the values were normal 51.3% of the time, 10% had severe hyperkalemia (>6.0 mEq/l) and low potassium (<3.0 mEq/l) less than 0.3% of the time. In diabetic hemodialysis patients, the frequencies were as follows: normal 57.8%, severe hyperkalemia 8.7%, and hypokalemia in 0.5% (8).

Several other issues enter into the hemodialysis patient who is sent for evaluation of their access function. In the patient sent for angiogram and possible angioplasty, it is likely there some degree of malfunction present and clearance may be compromised. This alteration in access function is even more of a problem for patients who have a thrombosed access. For the patients who are clotted they are also more likely to have missed a dialysis treatment. These patients may not only have an increased likelihood of hyperkalemia but may have increased intravascular elevation and even metabolic acidosis. This study provides a baseline documentation of the frequency of hyperkalemia which is important to establish preprocedure in the dialysis access patient.

The Accuracy Electrocardiogram (ECG) as a Predictor of the Level of Potassium

While it is still considered a reliable tool to screen for hyperkalemia by many clinicians, the ECG has been shown in many studies to be an unreliable indicator of hyperkalemia (9–11). The largest study by far of nonrenal patients was 220 emergency room patients evaluated with ECGs. Of those patients 87 had hyperkalemia. The sensitivity of physicians for predicting hyperkalemia was at best 0.43 and the specificity was 0.86. The sensitivity improved to 0.62 at best when the potassium was greater than 6.5 mEq/l (12). Another large emergency room study indicated 168 patients were diagnosed by their blood tests as having potassium above or equal to 6.5 mEq/l. A total of 83% of the patients had abnormal ECGs and many did not have classic ECG changes. It was noted, 24% had nonspecific ST-T wave changes, 17% had first degree AV block, and 12% had intraventricular conduction delay. Finally, the traditional peaked T waves occurred in only 34% (13). Thus, the ability of physicians to recognize even classic early ECG changes associated with hyperkalemia is somewhat suspect.

The reliability of this is even less so in patients with Chronic Kidney Disease stage V. For example in a study of 74 stable dialysis patients, who were evaluated to determine the prevalence of ECG changes in hyperkalemia, the mean potassium value was 4.9 mEq/l and the range was 3.3–6.7 mEq/l. There was no significant difference in the T wave amplitude, or T wave to R wave ratio between any of the quartiles of potassium concentration (14). It was proposed by the authors of the study that alterations in the calcium concentration were the reason these changes were not manifested.

Another group looked at only 39 patients with a potassium range from 2.8 to 7.4 mEq/l and 29.4% of these patients had potassium of greater than 5.5 mEq/l. They were able to note peaked T waves in leads V2–V4 only. In two patients, however, with potassium of 5.6 and 6.0 mEq/l there were no ECG changes noted at all (15). In some hemodialysis patients, bradycardia may be the only symptom of hyperkalemia (16). ECG changes seen in renal failure patients may be very different than those seen in patients with normal renal function. These changes may be fairly subtle or even not present in a significant minority despite the presence of what would be considered severe hyperkalemia (12,15). Given the two issues discussed above, we felt it was important to proceed with some objective data to establish the actual risk of hyperkalemia in patients presenting for hemodialysis vascular access procedures.

Methods

The data were collected prospectively over 3 months in 2009 and 3 months in 2011. Patients were sequentially evaluated using a venous blood gas including electrolytes as part of a continuous quality improvement project in the Vascular Access Unit in the University of California, Davis Medical Center (UCDMC). The review of this data was approved by the Investigational Review Board (IRB). The patients who were evaluated were all those sent for tunneled catheter initial placements, malfunctioning tunneled catheter evaluation and treatment, angiograms and angioplasties of arteriovenous fistulas, and grafts and percutaneous thrombectomies of thrombosed fistulas or grafts.

The range of normal potassium at the laboratory at UCDMC is 3.5–5.0 mEq/l. Before the start of the study, a protocol was created to determine the treatment of various levels of abnormal potassium. Any samples that were suspected to have hemolysis were redrawn. The hyperkalemia protocol was as follows: (Low) any potassium below 3.5 mEq/l the patient was to receive 10–40 mEq/l of potassium and the primary Nephrologist was notified, (Normal) from 3.5 mEq/l or a potassium up to 5.7 mEq/l there was no treatment, (Moderate) potassium results from above 5.7–6.3 mEq/l were considered moderate hyperkalemia and medical management was initiated with glucose, insulin, and beta-agonists, (Severe) for a 6.3 mEq/l and above or an elevated potassium associated with any ECG changes suggestive of hyperkalemia. The patients considered to have severe hyperkalemia were treated with intravenous calcium products as well as the treatments used for moderate hyperkalemia. These patients also had a temporary dialysis access placed and were dialyzed prior to any

TABLE 1. Potassium protocol

Normal to mild <5.7 mEq/l	Moderate 5.7–6.3 mEq/l	Severe >6.3 mEq/l
No treatment	Given medical management D50w and insulin 5-10 units IV	Medical management as for moderate IV calcium
Proceed with planned procedure	Albuterol nebulizer	Place temporary dialysis access if needed (temporary catheter if patient could not tolerate the length or stress of original procedure planned)
	IV calcium but would now be considered Severe	Immediate dialysis and consider oral binding agent

TABLE 3. Frequency of hyperkalemia by procedure

Type of procedure & (total number)	Moderate K+ (%) (5.7–6.3 mEq/l)	Severe K+ (%) (>6.3 mEq/l)	Total (%)
New Start TDC[a] 10	1 (10)	1 (10)	2 (20)
Malfunctioning TDC[b] 26	7 (27)	3 (11.5)	10 (38)
Angioplasty 104	4 (3.8)	2 (1.9)	6 (5.8)
Thrombectomy[b] 27	4 (14.8)	2 (7.4)	6 (22)

[a]The patient usually had preop lab values within 48 hours from clinic or hospital—if not checked VBGs.
[b]Determined high risk for hyperkalemia by study.

endovascular intervention. (See Table 1) The data were reviewed with regard to the sex, age, presence of diabetes, type of procedure, and of course level of potassium. The determination was made as to how many times medical management of hyperkalemia was done and how many procedures had to be delayed and/or changed.

Results

The total number of patients tested was 167 patients; of these 85 were diabetic. There were 80 men and 87 women. The age range was 20–98 years and the mean was 59.3 years. Initial tunneled catheter placements were 10, and the tunneled catheter exchange/revisions were 26. The angioplasties numbered 104 and thrombectomy total was 27. (See Table 2) The overall range of potassium was 2.7–7.8 mEq/l. The mean potassium was 4.75 mEq/l. The number in each quartile was: 17 not checked, 8 patients had less or equal to 3.5 mEq/l, 118 between 3.5 and 5.7 mEq/l, 16 patients were between 5.7 and 6.3 mEq/l, and 8 patients had a potassium greater than 6.3 mEq/l.

The total number of patients for which treatment was changed by the admitting physician was 24 equaling 14.3% of all the procedures. There were 9.5% of the patients with a potassium greater than 5.7 up to 6.3 mEq/l and therefore as per our protocol required medical management. There were 4.8% of patients with potassium greater than 6.3 mEq/l or severe hyperkalemia requiring medical treatment and immediate or urgent dialysis.

The patient data were also evaluated by the type of procedure for which they were scheduled. (See Table 2) Of the 27 thrombectomy procedures performed, four patients had moderate hyperkalemia and two patients had severe hyperkalemia. Therefore, 22% of the access thrombosis patients required treatment for hyperkalemia. Of the 10 patients who received tunneled catheters to start hemodialysis, one patient had moderate hyperkalemia and one patient had severe hyperkalemia. This was a total of two patients or 20%. For the exchange or revision of an existing but malfunctioning tunneled dialysis catheter, a total of 10 patients of 26 or 38% had moderate or severe hyperkalemia. Of the 104 angioplasty procedures, a total of 6 patients had moderate or severe hyperkalemia or 5.8%. (See Table 3).

Discussion

The standard of care at this time is to perform endovascular and central line hemodialysis related procedures in an outpatient setting. Currently, there is no consensus on the routine use of preprocedural laboratory evaluation. It was the hypothesis of this study that those patients whose dialysis clearance was the most compromised by their access would be at the greatest risk for hyperkalemia as well as acidosis and volume overload. In this evaluation, we looked at the utility of obtaining a preprocedure potassium level as the most pertinent laboratory

TABLE 2. Treatment protocol and quartile distribution of hyperkalemia in access patients

Potassium	Not checked	<3.5 mEq/l	3.5–5.7 mEq/l	5.7–6.3 mEq/l	>6.3 mEq/l
Category		Low	Normal	Moderate	Severe
Treatment	—	Replace IV KCl 10–40 mEq/l	None	Medical TX[a] +/− IV calcium	[b]Immediate dialysis + Medical TX
Total numbers 167 (%)	17 (10.1)	8 (4.8)	118 (70.6)	16 (9.5)	8 (4.8)

[a]Medical Treatment—see protocol.
[b]Immediate dialysis.
Arranged for dialysis inpatient or outpatient immediately after procedure.
May place temporary dialysis catheter and admit patient if the procedure not appropriate or too long.

guide to determine the correct treatment plan to ensure patient safety.

While the total mean potassium level is at the upper limits of the normal range, it was only by evaluating the number of elevated potassium values as a percent of each type of procedure that the trend became more useful. The results are logically consistent and suggest that patients who have the least clearance preintervention are at the most risk for hyperkalemia. Based on the number of patients with moderate or severe hyperkalemia in each procedural category, it was found to be more significant in some procedures and not as much in others. In descending order of frequency, moderate and severe hyperkalemia were found to be as follows: revision or exchange of a malfunctioning tunneled catheter 38%, percutaneous thrombectomy procedures 22%, new start tunneled catheter placements 20% and angiogram procedures 5.8%. In our practice, we have elected to check a venous blood gas on the revision or exchange patients, new start dialysis patients, and the thrombectomy patients. Further evaluation is needed for the routine use of this tool in the angioplasty patients. In conclusion, this small study is suggestive only and a larger group of patients needs to be evaluated. We as interventional physicians and practitioners need to consider the very real risk of hyperkalemia in these access procedures and be prepared to treat and adjust our care.

References

1. Lifeline vascular access celebrates 10 years as part of the Davita family. Available at http://lifelinevascularaccess.com, accessed July 30, 2013
2. Clinical indicators and preventive measures: vascular access chapter 2, p. 235, USRDS Annual Report 2012. Available at http://www.usrds.org/2012/pdf/v2_ch2_12.pdf, accessed April 6, 2013
3. Petrusky L, Friedman A, Miller G, Falk A, Hoggard J: Suggested guidelines for performing procedures in patients with chronic kidney disease in outpatient centers. *Semin Dial* 24(1):18–21, 2011
4. Pinson CW, Schuman ES, Gross GF, Schuman TA, Hayes JF: Surgery in Long-Term Dialysis Patients. *Am J Surg* 151:567–571, 1986
5. Kellerman PS: Perioperative care of the renal patient. *Arch Intern Med* 154(15):1674–1688, 1994
6. Krishnan M: Preoperative care of patients with kidney disease. *Am Fam Physician* 66(8):1471–1476, 2002
7. Khedr E, Abdelwhab S, El-Sharkawy M, Ali M, El Said K: Prevalence of hyperkalemia among hemodialysis patients in Egypt. *Ren Fail* 31(10):891–898, 2009
8. Tzamaloukas AH, Avasthi PS: Temporal profile of serum potassium concentration in nondiabetic and diabetic outpatients on chronic dialysis. *Am J Nephrol* 7(2):101–109, 1987
9. Martinez-Vea A, Garcia C, Oliver JA: Severe hyperkalemia with minimal electrocardiographic manifestations: a report of seven cases. *J Electorcardiol* 32(1):45–49, 1999
10. Esposito C, Bellotti N, Fasoli G, Foschi A, Plati AR, Dal Canton A: Hyperkalemia-induced ECG abnormalities in patients with reduced renal function. *Clin Nephrol* 62(6):465–468, 2004
11. Nemati E, Taheri S: Electrocardiographic manifestations of hyperkalemia in hemodialysis patients. *Saudi J Kidney Dis Transpl* 21(3):471–477, 2010
12. Wrenn KD, Slovis CM, Slovis BS: The ability of physicians to predict hyperkalemia from the ECG. *Ann Emerg Med* 20(11):1229–1232, 1991
13. Freeman K, Feldman JA, Mitchel P, Donovan J, Dyer KS, Eliseo L, White LF, Temin ES: Effects of presentation and electrocardiogram on time to treatment of hyperkalemia. *Acad Emerg Med* 15(3):239–249, 2008
14. Aslam S, Friedman EA, Ifudu O: Electrocardiography is unreliable in detecting potentially lethal hyperkalemia in hemodialysis patients. *Nephrol Dial Transplant* 17(9):1639–1642, 2002
15. Cobo Sanchez JL, Alconero Comarero AR, Casaus Perez M, Maza Soto MA, Vill Llamazares C, Hiquera Roldan C, Menezo Viadero R, Alonso Nates R: Hyperkalaemia and haemodialysis patients: electrocardiographic changes. *J Ren Care* 33(3):124–129, 2007
16. Mohanlal V, Haririan A, Weinman EJ: Bradycardia without "classical" EKG changes in hyperkalemic hemodialysis patients *Clin Nephrol* 80(6):464–468, 2013