Hemodialysis Administration: Strategies to Ensure Safe Patient Care

ABSTRACT

An estimated 367,000 Americans underwent dialysis to treat their renal failure in 2007. The majority of these patients received hemodialysis, typically provided in either freestanding clinics or hospital-based dialysis centers. While the technology for hemodialysis is well established and the treatment is a routine part of healthcare delivery, risks are ever-present, given that hemodialysis patients undergo three treatments each week, take multiple medications, and often have multiple comorbidities. From November 1, 2008, through October 31, 2009, Pennsylvania healthcare facilities submitted 526 event reports involving hemodialysis administration to the Pennsylvania Patient Safety Authority. Medication errors were the most common type event submitted, representing almost 29% (n = 150) of all hemodialysis-related events. Other hemodialysis administration events involved failure to follow policy or protocol such as treatment set-up procedures (12.9%), needle disconnection and needle infiltration (6.1% for each category), and falls (5.9%). Risk mitigation strategies to prevent the likelihood of errors involving hemodialysis administration are provided for medication errors, failure to follow hemodialysis protocol, needle disconnection, needle infiltration, falls, equipment failures, and clotting of the dialysis circuit or blood lines. (Pa Patient Saf Advis 2010 Jun;7[2]:87-96.)

Introduction

An estimated 367,000 Americans underwent dialysis in 2007 to treat renal failure. The most common underlying causes of kidney failure in the United States are diabetes and hypertension.[1] When an individual's kidneys fail, he or she is unable to remove excess fluids, wastes, and minerals from the blood, which causes the buildup of harmful wastes and fluid retention. Dialysis therapy, which is broadly divided into hemodialysis and peritoneal dialysis, removes the harmful wastes and extra fluids and helps to maintain a proper balance of electrolytes like potassium and sodium. During hemodialysis, the patient's blood flows through a tube to a dialyzer, or filter. The dialyzer has two chambers—one for the blood and the other for a cleansing fluid called dialysate—which are separated by a thin, semipermeable membrane. Waste products in the blood (e.g., urea, creatinine, potassium, extra fluid) pass through the membrane and flow into the dialysate and are drained from the patient.

Only about 7.2% of the dialysis population undergoes peritoneal dialysis, a procedure that uses the patient's peritoneum as the semipermeable membrane, allowing the fluid and waste to pass through the lining and flow into the dialysate before it is drained from the patient. Patients can undergo peritoneal dialysis in their homes, whereas patients undergoing hemodialysis, the focus of this article, typically receive the treatment in either freestanding clinics or hospital-based dialysis centers. Hospital-based centers, which treat about 13% of hemodialysis patients, manage both acute and chronic cases, whereas freestanding centers are used almost exclusively for chronic treatment of stable patients with end-stage renal disease (ESRD).[1]

Although the technology for hemodialysis is well established and the treatment is a routine part of healthcare delivery,[2] risks are ever-present, given that chronic hemodialysis patients typically undergo three treatments (each lasting about three to four hours) each week, take multiple medications, and may have multiple comorbidities. During treatment, patients must be monitored for adverse reactions, such as severe hypotension, and other adverse events, such as potentially fatal needle disconnections. Within hospitals, an effective hemodialysis program also requires close coordination with other departments such as the pharmacy, laboratory, and blood bank, which provide services and products necessary during hemodialysis.

Without attention to patient safety and error prevention, even a well-established procedure like hemodialysis can result in an adverse event. To understand the types of errors and patient safety events that can occur during hemodialysis, analysts reviewed event reports submitted to the Pennsylvania Patient Safety Authority involving the administration of hemodialysis and identified important strategies to ensure the safety of patients undergoing hemodialysis.

A Look at the Numbers

In Pennsylvania, there are about 240 chronic dialysis facilities providing 4,275 hemodialysis stations for the state's 14,500 ESRD patients.[3] The 240 facilities include hospital-operated dialysis clinics and units and freestanding dialysis centers. Pennsylvania healthcare facilities submitted 526 event reports involving hemodialysis administration through the Authority's reporting system during a one-year period from November 1, 2008, through October 31, 2009. This analysis excludes reports involving peritoneal dialysis and other similar methods of blood filtration such as plasmapheresis and continuous renal replacement therapy. Additionally, the data is limited to reports from hospital-operated dialysis facilities since freestanding dialysis centers are excluded from the requirements for statewide mandatory event reporting established by Act 13 of the Medical Care Availability and Reduction of Error Act of 2002.[4]

Medication errors top the list of events involving hemodialysis administration, representing 28.5%

(n = 150) of all hemodialysis-related events reported to the Authority. While medication omissions were the most frequently occurring type of medication error, other medication errors during hemodialysis administration involved heparin infusion mistakes, inadequate handoff of information about patients' medications during transitions between the hemodialysis unit and other care areas, and miscommunication of medication orders.

Other events involved failure to follow policy or protocol (including treatment set-up procedures), laboratory or blood bank errors, procedure complications, needle disconnection, needle infiltration, falls, equipment or facility failures, clotting of the hemodialysis circuit or blood lines, pressure ulcers, skin tears and abrasions, patients leaving against medical advice, and other miscellaneous reports such as a clipboard falling off a hemodialysis machine and hitting a patient's leg during the hemodialysis session. The analysis of the 526 reports also includes 20 posthemodialysis reports involving events related to the hemodialysis procedure. Examples include four reports of patients found soiled with urine and feces upon being returned to their hospital beds following hemodialysis and one report of a patient whose hemodialysis needles were still in place after he was transferred to an emergency department (ED) after losing consciousness in an outpatient dialysis unit. See Table 1 for a breakdown of all events identified in the 526 reports.

There are a few reports that address infection control issues (e.g., failure to use proper infection control techniques for inserting a hemodialysis catheter, failure to disinfect a hemodialysis unit previously used on a patient whose hepatitis B status was unknown); however, the majority of Pennsylvania facility reports involving infection control are submitted separately to the Centers for Disease Control and Prevention's National Healthcare Safety Network.

While medication errors were the most common type of hemodialysis events submitted to the Authority, one of two Serious Events was related to a needle disconnection before the patient's hemodialysis treatment had ended, as described in the following report (for more information on needle disconnections during hemodialysis and prevention strategies, see "Measures to Prevent Needle Disconnections during Hemodialysis"):

> *The patient presented to the facility and was admitted. The patient underwent an operation for bowel obstruction. The patient had a previous medical history of ESRD requiring dialysis and hypotension. The patient was placed on a dialysis machine alert, oriented, and talking with the nurses. When the machine alarmed, staff presented and changed the dialysate. Approximately three minutes later, a nurse entered the room and found the patient with pale color, agonal respirations, positive pulses, and the dialysis line disconnected. The patient was lying in a pool of blood. The rapid response team was called and responded. A code was called.*

The other Serious Event reported to the Authority did not appear to be related to the hemodialysis procedure but was, instead, related to the patient's condition.

Further analysis of the events by harm score—which addresses the extent to which the event reached the patient and the degree of harm to the patient[5]—shows that 87.6% (n = 461) of the events reached the patient (harm index = C to I), and 5.5% (n = 29) of the events were reported by the facility as resulting in harm to the patient (harm index = E to I).

More than half of the reported events involved male patients (56.5%, n = 297), and the majority of patients were age 65 and older (54.6%, n = 287). The care areas most often cited in these reports include the renal unit (22.2%, n = 117), outpatient dialysis clinic (16.9%, n = 89), and medical/surgical unit (11.4%, n = 60).

This article reviews some of the common events that can occur during hemodialysis administration. Risk mitigation strategies are provided for each of these event types: medication errors, needle disconnections, failure to follow hemodialysis protocols, needle infiltration, falls, equipment/facility failures, and clotting. Prevention protocols for other event types identified in the reports—such as errors involving the laboratory and blood bank and the development of pressure ulcers and skin tears—require patient

Table 1. Events Associated with Hemodialysis Administration (N = 526), November 1, 2008, through October 31, 2009

EVENT TYPE	NUMBER	% OF TOTAL EVENTS (N = 526)*
Medication error	150	28.5%
Failure to follow protocol	68	12.9
Laboratory-/blood bank-related	52	9.9
Procedure complication	45	8.6
Needle disconnection	32	6.1
Needle infiltration	32	6.1
Falls	31	5.9
Equipment/facility failure	25	4.8
Clotting of hemodialysis system or lines	23	4.4
Posthemodialysis event (excludes falls)	20	3.8
Pressure ulcer	20	3.8
Skin tear, abrasion	10	1.9
Patient left against medical advice	9	1.7
Other (e.g., lost patient item, patient dissatisfaction, unable to contact dialysis service)	9	1.7

*Percentages do not add up to 100% due to rounding.

safety interventions that have been reviewed in the general patient safety literature, including past issues of the *Pennsylvania Patient Safety Advisory*. Additional clinical considerations for hemodialysis are outlined in the National Kidney Foundation's guidelines for hemodialysis adequacy and vascular access.[6,7] The guidelines have been developed by the foundation's Kidney Disease Outcomes Quality Initiative.

Medication Errors

Hemodialysis patients typically take between 6 and 10 medications daily.[8] Among the medications routinely administered for hemodialysis patients are intravenous (IV) heparin to prevent blood clotting during treatment, erythropoietic stimulating agents to promote the formation of red blood cells, iron replacement for treatment of anemia, vitamin D preparations, medications to lower parathyroid hormone levels, and phosphate binders. Patients are at risk for medication errors because of the many medications they take, their multiple comorbidities, and the frequent need to change their medications.[9]

Of the 150 hemodialysis events involving medication errors, the greatest percentage involved dose omissions (48%, n = 72). Omissions occurred, for example, when the patient did not receive an intended medication after hemodialysis, did not

Measures to Prevent Needle Disconnections during Hemodialysis

When a hemodialysis blood line disconnects or dislodges from a needle to access the patient's vein or artery, the consequences can range from minimal blood loss to a fatal hemorrhage—particularly with venous needle dislodgements. Unlike an arterial needle dislodgement, which will cause the hemodialysis machine to alarm and shut down, stopping the flow of blood to the dialyzer, venous line dislodgements or disconnections can go undetected because the venous pressure alarm is less reliable in detecting pressure changes in the venous line.[1] During a one-year period, the Pennsylvania Patient Safety Authority received 32 events of line disconnections, representing 6.1% of all the hemodialysis administration events reported during the period (N = 526). In just five to seven minutes, a patient receiving hemodialysis treatment can lose 40% of his or her blood volume from a venous needle dislodgment, resulting in a class IV hemorrhage, the most serious of hemorrhage classifications indicating the need for aggressive treatment to prevent death. In a scientific abstract presented in 2008 at the American Society of Nephrology's annual meeting, a nephrologist and his colleagues at a Pennsylvania hospital estimated there are more than 400 episodes of venous needle dislodgement annually in the U.S. dialysis population and that the mortality rate from these events is 10% to 33%.[1]

In 1998, ECRI Institute reported on two instances of venous line needle dislodgements during hemodialysis that did not trigger a venous pressure alarm.[2] In both cases, the narrow-bore needles used from the treatment created significant flow resistance that produced back pressures that exceeded the patient venous pressure. Even if the needle is fully or partially dislodged, the venous pressure monitor is likely to continue sensing the pressure created by the needle's flow resistance and may miss the smaller drop in pressure associated with the disconnection.

Typically, dialysis staff monitor patients' blood lines to check for problems with the needle connection, but this strategy is an unreliable means to detect needle dislodgements. Other measures to prevent venous line needle dislodgement include the following:[1,3,4]

- Emphasize with dialysis staff that secure needle placement is crucial to preventing dislodgements. Staff must take the time to securely tape the needle to the patient's skin, arm, or access device without taping over the line connector and obscuring potential problems with it.
- Prohibit staff from adjusting alarm limits to minimize nuisance alarms. Typically, the limits are set at ± mm Hg around the existing venous line pressures. Although they may not detect all dislodged needles, continue to use venous pressure monitors because they are useful for detecting obstructions or disconnections that occur elsewhere in the venous line.
- Alert staff to the dangers of solely relying on the venous pressure alarm to detect a venous line needle dislodgement. Require staff to frequently examine the blood lines during patients' hemodialysis treatments if this is not already routine practice.
- Instruct patients to keep all needle and blood line connections from being covered with blankets or other items so that staff can monitor the connections. Educate patients who are capable to watch their blood lines for disconnections and to notify staff immediately—even if the needle is only partially dislodged.

Notes

1. Hurst JA. Venous needle dislodgement (it can happen without warning). Renal Business Today [online] 2009 Sep 9 [cited 2009 Dec 29]. Available from Internet: http://www.renalbusiness.com/articles/venous-needle-dislodgement.html.
2. ECRI Institute. Undetected venous line needle dislodgment during hemodialysis. Medical device safety reports [online]. 1998 Nov [cited 2009 Dec 29]. Available from Internet: http://www.mdsr.ecri.org/summary/detail.aspx?doc_id=8300.
3. ECRI Institute. Hazard report: undetected venous needle dislodgment during hemodialysis can be fatal. *Health Devices* 2003 Aug;32(8):325-6.
4. Zeigler SA. Prevent dangerous hemodialysis catheter disconnections. *Nursing* 2007 Mar;37(3):70.

receive a medication on the patient care unit before being sent to the dialysis unit for treatment, or missed a scheduled medication on the care unit because the patient was in the dialysis unit. The findings are consistent with a survey of 649 ESRD professionals who reported that the most likely type of medication error in their dialysis centers is omitting one or more medications for a patient.[8]

Although reports of medication omission reported to the Authority do not indicate any harm to the patient, a missed medication can be significant and has the potential to result in harm.[8] Consider the following report submitted to the Authority about a missed dose of an antihypotensive medication:

> *Patient has chronic hypotension. Midodrine ordered 10 mg three times daily on dialysis days and 5 mg three times daily on nondialysis days. Patient had 2 L of fluid removed during dialysis. Dialysis not completed until approximately 6 p.m. Midodrine dose not given at 9 p.m. Patient to be discharged on morning of next day due to late dialysis. On that morning, patient needed a chest x-ray for pain. While the patient was in radiology, the patient became unresponsive, and a code was called. The patient's blood pressure dropped significantly. The patient was given 2 L of IV fluids during the code and transferred to the intensive care unit.*

Heparin was associated with 11.3% (n = 17) of medication events involving hemodialysis. The anticoagulant is listed by the Institute for Safe Medication Practices (ISMP) as a high-alert medication because of its ability to cause significant patient harm when used in error.[10] Examples of heparin errors during hemodialysis administration as reported to the Authority include the following:

> *1,200 units of heparin infused during patient's dialysis treatment. Patient has a documented allergy to heparin.*

> *The patient is to receive 400 units per hour of heparin infusion during dialysis. The patient care technician programs the machine to administer the heparin infusion. The infusion rate is checked by the RN [registered nurse] as she makes rounds in the first hour of a patient's treatment. Upon checking the machine, the RN discovered the infusion rate was set to 5,000 units per hour. The patient was given an extra 4,500 units of heparin in the first hour.*

Other medication events involving hemodialysis administration reported to the Authority suggest ineffective handoff of patient information from one healthcare provider to another when a hospitalized patient is sent from a patient care unit to a renal unit for hemodialysis and miscommunication of drug orders. The following examples from the hemodialysis events reported to the Authority illustrate an ineffective handoff and miscommunication of an order, respectively:

> *The patient receives 20,000 units of Procrit® [a brand name for epoetin alfa] after dialysis. The medication is administered in the dialysis unit. The dialysis RN gave the report to the RN stating that the patient was given Epogen® [another brand name for epoetin alfa]. The RN administered a dose of Procrit at 4:45 p.m., not realizing that Procrit and Epogen were the same medication. The patient received an extra dose.*

> *A vancomycin order for a patient indicated the drug was to be given daily after each dialysis. The order was entered as Q24 hours, give after each dialysis. The nurse read the order as a daily dose with the dose on dialysis days to be given after dialysis.*

Patients with ESRD are also at risk of receiving medications contraindicated for hemodialysis patients—for example, several antithrombotic medications may be contraindicated in hemodialysis patients because of increased bleeding risks[11] and should be used with caution—or of receiving a medication dose that is not recommended for a patient with kidney failure. These types of medication errors are not discussed in this article because it is limited to errors and events occurring during hemodialysis administration.

Failure to Follow Protocol

Sixty-eight events involved failure to follow protocols and procedures during hemodialysis administration. The largest number (n = 14) of these events were related to inadequate communication between healthcare providers about a patient's care or failure to transmit orders about a patient's care to the dialysis setting. (These events exclude inadequate handoff of information about a patient's medications, laboratory tests, or blood needs, which are included in other event categories.) As illustrated in Table 2, the 14 reports represent 20.6% of events involving failure to follow protocol and 2.7% of all 526 events involving hemodialysis administration. Examples reported to the Authority include the following:

> *Physician stated patient was discharged earlier in the day and was not given hemodialysis treatment that the physician wanted the patient to have. No order was written in the patient's chart to have hemodialysis prior to discharge.*

> *The medical service placed a nasogastric tube in a patient while the patient was undergoing dialysis in the dialysis unit. The patient vomited, became unresponsive, and required immediate emergency response. The patient became a full code and was transferred to the critical care unit after receiving advanced cardiac life support. No defibrillation was needed. The purpose of this report is to reiterate that no invasive procedures such as nasogastric tube placement are to be performed on any patients in the dialysis unit unless the procedure is approved by the medical director.*

Table 2 also shows that other events related to failure to follow protocol included incorrect hemodialysis treatment set up, treatment time, or dialyzer; reversed

hemodialysis lines during treatment; and missing catheter caps, which are important in the prevention of catheter-related infections for patients receiving hemodialysis through a hemodialysis catheter. The following events reported to the Authority describe these scenarios:

> *After treatment, the patient complained of feeling unwell and was hypotensive. The patient was sent to the ED for evaluation. The patient's calcium levels were low, and the patient was admitted for therapy. It was noted later that the mixture in the dialysis machine used to treat the patient was not properly mixed with the amount of calcium indicated in the patient's prescription for dialysis. The patient was discharged the next day without problems.*
>
> *The dialysis clinic had two patients with the same name. Both patients had the same treatment ordered but there was a difference in the treatment time length. Patient #1 was to run for three hours and patient #2 was to run for three and a half hours. When treatment started for patient #1, staff questioned if the treatment was for the correct patient. With proper identification, it was noted that patient #1 was set up for patient #2's treatment. The error was noted early in the treatment so that the patients received the correct lengths of treatment.*
>
> *While checking the patient's vital signs, it was found that the patient's dialysis needles were hooked up backwards. The arterial needle was hooked to the venous dialysis line and the venous needle to the arterial line. Treatment was paused, and the lines were correctly connected arterial-to-arterial and venous-to-venous. The treatment was then continued.*
>
> *The patient arrived in the dialysis unit with no caps on both ports of the new dialysis catheter. Both lines were clamped. The dressing in place was changed the same day the catheter was placed. Vigorous cleansing was done before using the catheter. The physician, special procedures unit, IV team, and floor nurse were notified.*

Similar lapses have been reported in published studies and surveys of hemodialysis. For example, a survey of 649 ESRD professionals found that nearly two-thirds reported that at least one incorrect dialyzing solution was set up for a patient over a three-month period.[8]

A separate survey of clinical directors at four Virginia dialysis centers, each providing more than 500 hemodialysis treatments per month, found that an error in hemodialysis treatment—including a wrong dialyzer, incorrect treatment time, incorrect dialysate flow rate, and reversed lines—occurs once per every 733 treatments.[12]

One of the reports to the Authority regarding incorrect treatment set up involved using an incorrect dialysate solution for two hours during a patient's hemodialysis session. The report is as follows:

> *Hemodialysis machine alarmed that the acid concentrate jug was empty. Upon replenishing the acid concentrate, it was found that the incorrect acid concentrate was hooked up. The order was for 2K/2CA acid concentrate; 3K/2.5CA acid concentrate was found on the machine. The incorrect acid concentrate was on machine from the time the treatment was initiated when the machine alarmed for more acid concentrate. The wrong dialysate acid concentrate was used.*

An error such as this can occur because dialysate solution jugs or containers look alike even though solutions may have different electrolyte combinations to meet the specific needs of each patient. Mix-ups can occur in selecting a patient's dialysate when containers of similar size and with look-alike packaging are stored near each other, despite the differences in electrolyte concentrations. Although the report to the Authority indicated that the patient was unharmed by the event, there are published reports of patient deaths from hemodialysis solution mix-ups.[13] Because of the significant patient harm that can occur from such mix-ups, ISMP lists dialysis solutions as high-alert medications.[10]

Needle Infiltration

There are three ways to achieve vascular access during hemodialysis: (1) using an intravascular catheter; (2) placing a synthetic graft, usually in the patient's arm, to connect an artery to a vein; or (3) creating an arteriovenous fistula by connecting an artery and vein, typically in the patient's arm. With either the graft or the fistula, a needle is used to access the patient's blood for the hemodialysis treatment. Sometimes during the insertion or cannulation of the needle, the needle may

Table 2. Predominant Event Types Associated with Failure to Follow Protocol, November 1, 2008, through October 31, 2009

EVENT TYPE	NUMBER	% OF EVENTS ASSOCIATED WITH FAILURE TO FOLLOW PROTOCOL (n = 68)	% OF TOTAL EVENTS (N = 526)
Inadequate handoff, orders not followed (excludes events involving medications, laboratory, blood bank)	14	20.6%	2.7%
Incorrect treatment set up, treatment time, dialyzer	12	17.6	2.3
Lines reversed	9	13.2	1.7
Catheter cap missing, incompatible	6	8.8	1.1
Tourniquets, clamps, needles left in place; items not removed	5	7.4	1.0

unintentionally pierce the back wall of the graft or fistula and cause blood to infiltrate into the surrounding tissue. There were 32 reports of needle infiltration, representing 6.1% of all hemodialysis administration events submitted to the Authority during the one-year period. Most of the reports indicate that needle infiltration occurred during the needle insertion. Infiltrations can occur before hemodialysis starts, during hemodialysis, or after hemodialysis with needle removal. Treatment for an infiltration will vary depending on whether heparin, which can promote bleeding, has been administered. In the reports to the Authority, patients typically had already received heparin when the infiltration occurred. Patients were usually treated by removing the needle, applying pressure and ice to the infiltration site, and cannulating with another needle at a spot away from the infiltration site.

One study of needle infiltration of arteriovenous fistulas calculated an annual rate of 5.2% of major fistula infiltrations resulting in the need for additional diagnostic tests and interventions. In some cases, patients had to resort to continuing with an intravascular catheter for hemodialysis treatments, the least preferred method for achieving access, until the fistula could be used again.[14]

Falls

Falls are common among dialysis patients and can occur at any point before, during, or after a patient's dialysis treatment. Dialysis patients are at increased risk of falling for a variety of reasons: being of advanced age, taking multiple medications, having multiple comorbidities, or experiencing weakness, unsteadiness, and dizziness caused by a change in blood pressure after treatment. In reports of hemodialysis events submitted to the Authority, there were 31 reports of falls, representing 5.9% of all hemodialysis administration events over the one-year period. Patients fell before treatment (e.g., when stepping on a scale to be weighed), during treatment (e.g., when interrupting treatment to use a bathroom), and after treatment (e.g., when transferring from the hemodialysis chair). In one report, a patient bumped into the hemodialysis equipment and fell, and in another report, the patient who fell said she slipped on water that had spilled onto the floor, although the report says that "no water was observed on the floor." There were two reports of serious injuries involving lacerations to the head, as in the following report:

> *Patient on rehab, poststroke with hemiparalysis. While on the progressive care unit for dialysis, the dialysis RN walked the patient to the bathroom and instructed him to call for assistance when done. The patient got up on his own and reports that he "got dizzy" and fell. The patient was seen by a physician. A computed tomography scan of the head was negative for injury. The patient was taken to the ED for assessment and received staples for a small, full-thickness laceration to the left posterior scalp. The patient was returned to the rehab unit.*

A study of falls among patients treated at seven hemodialysis units calculated a falls incidence rate of 12.7%, with 10.7% of the falls meeting the researchers' definition of a serious fall—meaning the fall caused a fracture, required hospitalization, or caused death.[15] The study, which included falls occurring outside the hemodialysis units, calculated an average incidence of 1.18 falls/patient-year. A study of falls among hemodialysis patients 65 years of age and older treated at a hemodialysis unit found that 47% of older hemodialysis patients fell over the one-year period and that 19% of the falls resulted in injuries.[16] The falls incidence rate for this group was 1.60 falls/patient-year. This study and others suggest that falls rates among older hemodialysis patients are higher than that of community-dwelling elderly who do not require dialysis.[16,17] In addition, dialysis patients have a higher incidence of hip fractures than the general population and are at greater risk of dying within one year after the fracture compared with the general population.[17]

Equipment/Facility Failure

Hemodialysis equipment and disposables used for treatment can fail, causing treatment interruptions and delays and possible patient harm. In addition, events within the facility (e.g., loss of power) can interfere with a hemodialysis patient's care. Over the one-year period analyzed, 21 reports to the Authority involved equipment failures during hemodialysis administration, representing 4% of all events. One such report is as follows:

> *After two hours of dialysis, the portable reverse osmosis machine shut off. No lights were lit on the machine. The ground fault circuit interrupter was checked and had not been tripped. The patient was taken off of dialysis due to not having a water supply. The doctor, who was in the room at the time, ordered staff to pull the needles. The treatment was done for the day.*

ECRI Institute maintains a database of hazards and recalls for medical equipment. The Institute has found that dialysis equipment ranks high, along with anesthesia equipment, defibrillators, and ventilators, in the number of hazards and recalls issued for these medical devices. While not all hazards and recalls create life-threatening situations, the technology is not immune from device-related hazards and requires an effective technology management program to ensure its safe operation. Such technology management programs include documentation of the most recent version of software installed on dialysis equipment. An analysis of ECRI Institute's database of dialysis-related alerts found that an increasing percentage of problems reported with dialysis equipment were related to software issues or resolved by software revisions.[18]

In addition to equipment failures, other nonmedical emergencies can occur as a result of events such as fire, power failure, water supply interruption, and natural disaster. Four reports to the Authority, or 0.8% of all hemodialysis administration events over

the one-year period, involved facility failures, including one isolated power failure affecting a hemodialysis patient on a ventilator that required immediate intervention to prevent harm to the patient, as described in the following report:

> *Patient was on dialysis and on a ventilator when the electricity to that unit only went out. The patient was immediately bagged, and the oxygen level was monitored. The patient is now extubated.* [A recommendation accompanying the narrative indicated a faulty electrical outlet for the unit was repaired within 15 minutes.]

Infrastructure failure reports are submitted separately to the Pennsylvania Department of Health;[19] therefore, the limited number of reports of facility failures received by the Authority may not accurately reflect the number of events in this category affecting hemodialysis administration.

Clotting

Reports of hemodialysis administration events submitted to the Authority included 23 instances (4.4% of all events) of clotting in the hemodialysis circuit or lines. Four of the reports indicate that the patient lost blood as a result of clotting, as described in the following:

> *Patient dialysis treatment was initiated. The venous needle had a clot in it. A second venous needle was placed and also resulted in a clot. The third needle was placed by the RN in charge and resulted in a small hematoma. The dialysis line clotted in a very short time, resulting in 200 ml of blood loss. The physician was contacted, and per his request, the patient's fistula is resting today. The patient will have hemodialysis treatment tomorrow with a [red] blood cell count to be drawn to assess the blood loss.*

In addition to blood loss, clotting can lead to a suboptimal treatment from hemodialysis. Unless contraindicated, heparin is used during hemodialysis to prevent clotting of the blood lines and dialysis filter. For patients with allergies to heparin, saline flushes can be used during hemodialysis to reduce clotting.

A study of adverse events and medical errors reported at four Virginia dialysis centers identified clotting of the hemodialysis circuit as the second most commonly reported adverse event behind needle infiltration (medical errors such as medication omissions, reversed lines, and improper treatment set up were analyzed separately). The researchers note that most clotting events occurred when heparin use was contraindicated.[12]

Clotting can also involve the hemodialysis access, although there were no reports of this type among the 526 hemodialysis administration events submitted to the Authority. Fistula First, a federal government initiative that promotes an arteriovenous fistula as the preferred site for removal and return of the blood during hemodialysis, could help to reduce the number of clotted hemodialysis accesses, associated complications, and procedures to remove clots. Unlike the other two alternative access methods—a venous catheter or synthetic graft—fistulas are less prone to clotting.[20] The federal government, which provides coverage for most dialysis treatments through its federal ESRD program, has a goal of 66% of hemodialysis patients using arteriovenous fistulas. As of October 2009, 54.2% of hemodialysis patients were using fistulas, a marked improvement since the Fistula First initiative began in 2003, when only 20% to 30% of patients had fistulas.[21]

Risk Reduction Strategies

Dialysis patients worry that mistakes may occur during their treatment. Of 1,113 dialysis patients surveyed in 2006, almost half indicated that they sometimes, usually, or always worry that a medical mistake will occur during one of their dialysis treatments.[22] Analysis of hemodialysis reports submitted to the Authority confirms patients' fears that mistakes can and do occur. To help prevent future errors involving hemodialysis administration, dialysis facilities can consider the strategies described below.

Medication Errors

- Ensure that pharmacists who participate in rounding on hospital units to review medications prescribed for patients include the medications that patients receive during hemodialysis treatments in their reviews.
- Simplify treatment protocols, including the timing of medication administration during hemodialysis treatment, to reduce the likelihood of medication omissions.[12]
- Perform independent double checks of IV heparin doses and infusions before dispensing.[10]
- Require reconciliation of medications at every transition in the patient's care—including transitions when the patient is sent from a hospital care unit, such as the medical/surgical unit, to the renal unit for hemodialysis and back.
- Ensure clear communication between healthcare providers when a patient is transferred from one level of care to another, specifically emphasizing the use of clear language to provide up-to-date information about the patient's care, treatment and services, medications received, condition, and recent or anticipated changes. The healthcare provider receiving the information should repeat back the information for verification and ask questions to clarify unclear orders or instructions.[23]
- Ask hemodialysis patients to keep a list of all their medications and share it with providers in the dialysis clinic and other care areas where the patient is treated.[24]
- Educate hemodialysis patients about their medications, and ask them to be alert for possible medication errors.[12]

Failure to Follow Protocol

- Provide dialysis technicians with checklists for appropriate hemodialysis set up. Require double checks of the set up.[8]
- Establish red rules (specific requirements that must be exactly followed) for certain set-up procedures.[8]
- Involve patients in their hemodialysis care so that they speak up if something seems amiss, such as if the label on the dialyzing solution does not match the patient's prescription or the dialyzer is not labeled with the patient's name.[25]
- Enforce measures to prevent hemodialysis treatment mix-ups of patients with similar names. Alert staff to the potential for mix-ups, and use two patient identifiers—for example the patient's name and the patient' date of birth—to verify a patient's identification.
- Trace all lines to their point of origin to verify that correct connections are made.[26] While some arterial and venous lines are colored red and blue, respectively, to help healthcare providers identify the lines, use of the colored lines will not necessarily prevent misconnections. (For more strategies to prevent misconnections, refer to the article "Tubing Misconnections: Making the Connection to Patient Safety" in the June 2010 issue of the *Advisory*.)
- Require aseptic technique for the placement of intravascular and central venous catheters used for hemodialysis.[27]
- Consider the use of bar-coded labels to confirm correct dialyzers, solutions, and other aspects of the patient's hemodialysis treatment.[24]
- When storing or using solutions, separate look-alike dialysis solutions with different electrolyte combinations. When possible, standardize solution purchases to a limited number of vendors to limit product variation.[28]
- Provide regular education for dialysis healthcare providers of the risk of hemodialysis treatment errors and strategies to prevent such errors.

Needle Infiltration

- Ensure that dialysis staff understand the basics of vascular access and are competent in needle cannulation of a fistula and graft.[29]
- Provide training that follows the National Kidney Foundation's clinical practice guidelines for vascular access.[7]
- Evaluate infiltration problems that occur within the dialysis setting to determine whether adjustments to cannulation techniques are necessary to decrease the number of infiltrations.[29]
- Educate staff to respond quickly to needle infiltration events to minimize damage to the access.[7]

Falls

- Provide staff education on fall assessment and prevention, and establish a policy to assess all hemodialysis patients for their risk of falling.
- Instruct staff to ask patients about any falls they may have experienced since the last treatment and to determine whether any adjustments to the hemodialysis treatment or physician notification are necessary.[30]
- Consider adding a physical therapist or exercise physiologist to the hemodialysis unit's multidisciplinary team to work with patients on strength training and balance.[17]
- Evaluate the environment of the dialysis center or unit for hazards that cause falls. Remove any tripping hazards that may obstruct a patient's path.[31]
- Ensure that equipment is readily available to mop up spills.[31]
- Require staff to assess patients' assistive devices such as canes and walkers for stability.[32]
- Weigh patients before and after treatment with shoes to prevent slips and falls.[33]
- Provide a bathroom call bell within easy reach of the patient, and require assistance and attendance in the bathroom for patients who are hemodynamically or physically unstable.[33]
- Instruct staff to assess patients' posthemodialysis blood pressure level, ask whether patients feel steady, and assist patients as they stand up or transfer to a bed or wheelchair after treatment. If patients feel dizzy after treatment, they should be instructed to remain sitting until they meet specific discharge criteria.[8,34]
- Educate patients about their risk of falling and provide falls prevention instruction.
- Evaluate falls that do occur to identify risk factors that may have contributed to the falls and interventions to prevent such falls from happening again.[33]

Equipment/Facility Failure[35]

- Establish a technology management program for regular inspection and preventive maintenance of equipment used in the dialysis unit.
- Maintain an effective recall program to identify and address hazards and alerts involving the dialysis unit's equipment inventory.
- Require staff to remove malfunctioning equipment from service without changing any control settings and to notify appropriate personnel to examine and repair the equipment.
- Develop processes and procedures for managing nonmedical emergencies that threaten the health or safety of patients, staff, and others in the facility.

Clotting

- Ensure that protocols are in place for heparin use during hemodialysis to prevent clotting of the dialysis lines and circuit. Facilities should also ensure

that hemodialysis staff are provided guidance on implementing the protocols, including identification of patients for whom heparin is contraindicated.

- Provide training that follows the National Kidney Foundation's clinical practice guidelines for vascular access.[7]
- Ensure that hemodialysis staff routinely assess vascular accesses for flow problems that may suggest clot formation, as recommended by the National Kidney Foundation's clinical practice guidelines for vascular access.[7]
- Instruct patients about the importance of fluid and weight management between hemodialysis treatments to help prevent clotting as a result of postdialysis hypotension, which can result in decreased blood flow through the fistula or graft.[36]
- Instruct patients to assess their hemodialysis access for adequate flow between hemodialysis treatments to help identify problems and to immediately notify their doctor or hemodialysis care team of any indications of flow impairment (e.g., absence of or changes to vibrations and sounds in the access).[20] Provide patients with additional tips for maintaining their hemodialysis access (e.g., avoiding tight clothing or jewelry on the access limb to prevent clotting).
- Promote the use of a fistula as the best choice for patients for hemodialysis access.[20]

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