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Medical Safety in the Care of the Person with End Stage Kidney Disease

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Abstract

Much is written about medical safety as it pertains to patients with chronic kidney disease, yet the transition to end stage kidney disease and processes inherent to the receipt of dialysis present unique safety challenges in this population. Educational efforts in medical safety need to focus on the areas of greatest threat and where intervention can provide the greatest benefit. This paper addresses such safety topics in the dialysis population, and identifies potential strategies that may aid in harm reduction.

Introduction

In response to growing acknowledgment of the frequency of avoidable medical errors, healthcare systems nationwide are promoting a culture of patient safety. The Agency for Healthcare Research and Quality (AHRQ) characterizes a positive safety culture as “communications founded on mutual trust, by shared perceptions of the importance of safety, and by confidence in the efficacy of preventive measures”(1,2). Patients with end stage kidney disease (ESKD) are uniquely vulnerable to medical errors and harm due to a disease process and treatment options that may place them at an increased risk of recurrent infections, adverse cardiovascular events and mortality, and are particularly deserving of a culture of safety (1,3). Frequent health system encounters (hospitals, clinics, nursing homes and dialysis centers) and a high co-morbidity burden synergistically increases the likelihood of adverse patient events in this population. Recognition of this increased susceptibility and identification of targetable aspects of health management and self-care in ESKD are vital to the development of a positive safety culture in this high risk group.

Few studies have evaluated patient safety in the context of ESKD, particularly after the complex transition from chronic kidney disease (CKD) to ESKD. Many safety issues relevant in CKD remain pertinent in the ESKD population, such as hyperkalemia and vascular access preservation, but may necessitate a more focused approach in management. New safety concerns may develop through the life course of the ESKD patient as they traverse the continuum of incident to vintage dialysis patient, to end of life care recipient

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(figure 1). This review will serve to highlight some key areas relevant to promoting a culture of safety through the life course of an ESKD patient on chronic hemodialysis. These areas should be the focus of educational efforts in the area of medical safety in dialysis and include (I) medication safety (analgesics, oral anticoagulants, antimicrobials, and anemia management), (II) intradialytic hypotension, (III) falls, (IV) vascular preservation and finally (V) the overall safety culture of dialysis units themselves.

Medications

Polypharmacy is a prominent issue in ESKD that impacts healthcare related quality of life (4). Despite receiving many therapies intravenously as part of the dialysis treatment, individuals on hemodialysis carry a greater pill burden compared to other chronically ill individuals (4). In addition to taking medical therapies related directly to kidney failure, medical management of other comorbid conditions such as cardiovascular disease, diabetes, hyperlipidemia, mental illness, and chronic pain exacerbate the difficulties of ESKD medication regimens (5). These medication regimens are complicated by the ESKD patient's reduced clearance, uremic milieu, and other medications from comorbid conditions (6). Consequently, the average dialysis patient takes 10 to 12 oral medications a day, with one study showing a quarter of ESKD patients to be taking at least 25 pills per day (4). Further, each additional medication increases the risk of both medication non-adherence and adverse safety events (7), and the balance of derived benefit with potential harm must be considered with each new medication in this high-risk population. Key categories of medications that underscore the relevance of safety with a majority of dialysis patients include (I) analgesics, (II) oral anticoagulants, (III) antimicrobials, and (IV) anemia management medications (erythropoiesis stimulating agents (ESAs) and IV iron).

Analgesics

Pain is the most common symptom reported by ESKD patients, the etiology of which is multifactorial (8). Symptoms may be secondary to underlying conditions that are unrelated to kidney failure such as degenerative joint disease, peripheral vascular disease (PVD), or peripheral neuropathy. Pain symptoms may also be direct sequelae of dialysis treatment such as catheter insertion, repeated needle puncture of access or cramping from hemodynamic shifts. Renal failure can also cause or exacerbate painful conditions such as calciphylaxis, renal osteodystrophy or gout. Consequently, a third of dialysis patients rate their bodily pain significantly higher than the general population (9).

Treatment options for pain in those with ESKD are as heterogeneous as the etiology of the pain itself, and there are limited data on the appropriate management of pain in this group. Non-steroidal anti-inflammatory medications are directly nephrotoxic, and should be avoided in individuals with residual renal function to preserve the beneficial impact of native function as long as possible. Non-opioid pain medications such as Baclofen, often used to treat musculoskeletal pain, have been noted in case reports to cause mild to severe neurological symptoms in ESKD, ranging in severity from myoclonus to flaccid paralysis (10). Slightly more evidence is available on the use of opioid analgesics in the ESKD population. A recent systemic review of analgesic use in ESKD showed an opioid use

prevalence of 5 to 36%, with a direct association with dialysis vintage. There was also evidence of both under- and over-prescribing of opioids to treat pain in ESKD (6), highlighting the challenge providers face in the balance of safety with appropriate pain management and quality of life.

Oral Anticoagulants

Oral anticoagulants, vitamin K antagonist (warfarin) and the non-vitamin K antagonist oral anticoagulants (NOACs) are used in the ESKD population for pro-thrombotic conditions. Chronic use of oral anticoagulants in a population that has a higher propensity of bleeding due to uremic platelet dysfunction or who are frequently exposed to unfractionated heparin (UFH) with dialysis compounds the risk of adverse events (11,12). One study of incident hemodialysis patients revealed a significantly higher mortality following the exposure (prescription) of warfarin and antiplatelet agents (aspirin and clopidogrel) when compared to non-exposure during a 5-yr follow up period (11). The estimated incidence of major bleeding risk with warfarin use was 3.1–10.8 events per 100 person-years (13).

Furthermore, several studies demonstrate an increased risk of harm with no evidence of added benefit with the use of warfarin with non-valvular atrial fibrillation (NVAF) in the ESKD population. NVAF is the most common cardiac arrhythmia in ESKD and a major reason for chronic oral anticoagulation. A retrospective study by Shah et al suggests that warfarin use among dialysis patients with AF does not lower stroke risk, and increases bleeding risk by 44% compared to non-warfarin users (14). Winkelmayr et al looked at incidental AF in hemodialysis patients and found no association between warfarin use and ischemic stroke, but 2.4 fold increased risk of hemorrhagic stroke in the warfarin use group (15). Likewise, a prospective cohort study from Italy showed that warfarin use increased hemorrhagic events in chronic HD patients with AF (16).

The chronic use of warfarin in dialysis patients remains a matter of controversy (17). A recent systemic review and meta-analysis identifying over 2700 references which examined stroke outcome, bleeding outcome and mortality associated with warfarin use in patients with ESKD and AF showed no association with warfarin and all cause stroke (18). Further, warfarin use was associated with significantly increased risk of all cause bleeding though not associated with major bleeding. The study lacked sufficient evidence to demonstrate an association between warfarin use and mortality.

Some have argued that NOACs present a better safety profile in dialysis patients and may become the preferred substitutes to warfarin (19). However, to date there are no randomized trials assessing the risk-benefit profile and safety of NOACs when compared to warfarin in ESKD patients. Therefore, the safety associated with the long term use of classic and novel anticoagulants in the dialysis population requires further investigation.

Antimicrobials

Infections are the second most common cause of death in dialysis patients (3). A major source of infection risk is the use of vascular access devices (20–22). The National Healthcare Safety Network Dialysis Event summary showed of the 2,656 bloodstream infections in outpatient hemodialysis patients between January 2007 through April 2011,

67.3% were in patients with central venous catheters (CVCs) (23). Therefore, antimicrobial stewardship is a safety issue that persists throughout the ESKD life course, and increases the risk of developing infections by multidrug resistant organisms (MDROs) (24).

Only a few studies address the appropriate indications for antimicrobial use in ESKD (25–27). Snyder et al found that among dialysis patients administered antimicrobials approximately 30% were classified as inappropriate (25). The three reasons for inappropriate prescribing included (I) did not meet criteria for infection (53%), (II) failure to use a more narrow-spectrum antimicrobial (26.8%) and (III) patients did not meet criteria for surgical prophylaxis (20.3%) (25). A later analysis of the same cohort characterized patient factors associated with the receipt of antimicrobials and included (I) tunneled catheter access, (II) prior colonization or infection with a MDROs and (III) receipt of hemodialysis during daytime shifts (28). Factors associated with increased risk of receiving inappropriate antimicrobial included patients with tunneled catheters and patients with a greater dialysis vintage at the start of enrollment.

One of the most common antimicrobials used in adults with ESKD receiving dialysis is vancomycin (29), and along with third and fourth generation cephalosporins, is commonly prescribed inappropriately (28). One prospective study showed an 11-fold higher risk of receipt of vancomycin among hospitalized ESKD patients when compared to non-dialysis patients hospitalized during the same time period (30). Due to the heterogeneity of individual dialysis regimens, indications of antimicrobials and variable dosing strategies, it is difficult to establishing clear guidelines for vancomycin administration in the dialysis population. A recent review by Crew et al examining vancomycin dosing and monitoring among dialysis patients showed that there is not a one size fits all approach to vancomycin administration (29). Tailoring vancomycin and hence other antimicrobial administration to (I) patient specific dialysis regimens, (II) infection/microbe specific data and (III) with clear therapeutic targets and monitoring protocols can help reduce adverse events associated with frequent antimicrobial use. Implementing antimicrobial stewardship programs in dialysis centers may help improve outcomes and cost associated with adverse events such as drug toxicity or development of MDROs (31).

Anemia management

The FDA approval of ESAs in 1989 shifted the anemia treatment paradigm in ESKD. The initial appeal of ESAs was rooted in the prospect of fewer blood transfusions and associated complications, improvement in cardiac function, increase in oxygen consumption and overall improvement in quality of life (32–34). ESA dosing soon evolved into a continued topic of medication safety in dialysis. At the onset, the hemoglobin and hematocrit targets attained by ESA dosing went through various iterations based on the initial phase I and II trials of epoetin alfa and later evidence and opinion-based clinical practice guidelines set by the National Kidney Foundation-Dialysis Outcomes Quality Initiative (NKF-DOQI) in 1997(32,33). The Normal Hematocrit Cardiac Trial (NHT) was pivotal by demonstrating increased mortality risk in dialysis patients with ESA dosing targeted to a normal hematocrit (35). Other critical randomized control trials in CKD patients showed ESA dosing targeted towards normal hemoglobin had higher adverse cardiac outcome, stroke and mortality risk

(36,37). The summation of these studies is reflected in the Kidney Disease Improving Global Outcomes (KDIGO) 2012 clinical practice guidelines which recommends ESA dosing with lower hemoglobin targets (38)

In comparison, IV iron use in ESKD anemia management has increased over time (39); however, controversy remains between the association of IV iron and overall mortality in ESKD. Using data from the Dialysis Outcomes Practice Pattern Study (DOPPS), Bailie et al demonstrated an increased risk of mortality and hospitalization among dialysis patients receiving higher IV iron doses (39), which has been corroborated by other retrospective studies within the dialysis population (40,41). In contrast, other studies have shown reduction in all-cause mortality in incidence dialysis patients receiving higher IV iron doses within the first month of dialysis initiation (42). Further, there are conflicting results evaluating the independent association of IV iron administration with infection risk (39, 43, 44). In general, there is limited prospective *in vivo* evaluation of safety protocols with IV iron administration in ESKD.

Intradialytic Hypotension

Proper medication management, both patient-guided and facility-managed, plays an integral role in safety for dialysis patients. So too does the management of intradialytic hypotension (IDH) depend both on modifiable patient and clinic factors. Definition of IDH varies across the literature and may focus on different degrees of systolic blood pressure (SBP) decline during dialysis in addition to distinct symptomatology or clinical response (45,46). The variation in definition may have contributed in part to early controversy regarding the role of pre-, intra- and post-dialysis blood pressure on patient outcomes (45,47–51). The National Kidney Foundation Kidney Disease Outcomes Quality Initiative's (KDOQI) definition of IDH is “a decrease in systolic BP by 20 mmHg or a decrease in mean arterial pressure by 10 mmHg associated with symptoms that include abdominal discomfort; yawning; sighing; nausea; vomiting; muscle cramps; restlessness; dizziness or fainting; and anxiety”(50). By this definition up to 20–30% of all dialysis sessions involve an episode of IDH (52). Some reviews with slightly variant definitions have shown up to 50% of dialysis sessions involving IDH (45).

What is the relevance of IDH and relation to dialysis patient safety? IDH has been shown to be a significant independent risk factor for mortality in dialysis patients (48). For example, a multicenter prospective cohort study involving Japanese dialysis patients demonstrated the lowest intradialytic SBP and fall in SBP upon standing after a dialysis session conferred a significant and independent risk for two year mortality (48).

Using data from the US Renal Data System (USRDS), Stefánsson et al helped establish the link between IDH and adverse cardiovascular (CV) outcomes (46). In a retrospective cohort study analyzed over a two year period, IDH occurred in 31.1% of patients, and was significantly associated with interdialytic weight gain (IDWG). Further, IDH was associated with an increased risk of heart failure, composite heart failure/CV mortality, myocardial infarction and all-cause mortality (46).

Smaller studies have suggested that an increase frequency of IDH may serve as a warning sign for increased risk of death (53, 54). Rocha et al identified frequent IDH in patients with lower dry weights, higher prevalence of diabetes, those who were hypertensive and having higher serum phosphorus levels (51). Although the relationship between these variables and IDH could not be defined as causal, it does present modifiable factors (dry weight, serum phosphorus, and hypertension) that can be addressed to potentially reduce the rate of IDH and improve CV outcomes.

One large study found significant variability in the rate of IDH across several dialysis facilities, and identified the facility itself as an independent risk factor for IDH occurrence, which was thought to reflect differences in practice patterns (55). Additional independent risk factors for IDH included longer ESKD vintage, higher dialysate temperature, female gender, age, Hispanic ethnicity, and greater variability between prescribed and post-HD weights. Therefore, reduction in the frequency of IDH may serve as an appropriate target for quality improvement among dialysis facilities, and strategies such as cooling dialysate (56), reducing the ultrafiltration rate (57) or prolonging or increasing the frequency of having longer more hemodialysis sessions for more effective fluid removal (58) may serve reasonable safety metrics for IDH outcome improvement.

Falls

Recent data from the USRDS Annual Data Report suggest a decline in ESKD incidence among those aged 65 and over, yet the highest prevalence of CKD remains among individuals 60 years old and above (3). Hence, it is prudent for the nephrologist to be knowledgeable of unique issues that may negatively impact the older person with ESKD.

In the general non-dialysis geriatric population, falls are a leading cause of injury-related hospitalizations, disability, and death (59, 60). In addition to age-related risk, dialysis patients have multiple comorbidities, dialysis treatment-related complications, and disease-related conditions that place them at greater risk of fall injuries. Previously mentioned factors such as polypharmacy, IDH, dialysis-related arrhythmias or other factors related to mineral bone disease, anemia, fatigue, frailty or neuropathies can all exacerbate the risk of fall in patients with ESKD (61–63).

One prospective cohort analysis found dialysis patients age 65 were at higher risk of falls (fall-incidence 1.60 falls/person-year) versus published rates for in-community seniors (0.6 to 0.8falls/patient-year) (64). Another study showed that older patients transitioning from CKD to incident dialysis patient had a 1.6-fold higher risk of serious fall injury after dialysis initiation versus pre-dialysis (65). This may suggest that increased in fall risk in dialysis patients may not be all due to progression of renal failure or comorbidities associated with length of time on dialysis, but rather may reflect the degree of deconditioning, reduction in functional status, cognitive decline and weakness that is often associated with dialysis initiation. It has also been found that incident dialysis patients who self-report experiencing frailty have a nearly 2-fold increase risk of medically urgent falls or fractures when compared to their counterparts who did not report frailty (66). This time period becomes a

window of opportunity to screen older incident dialysis patients for fall risk and frailty and implement multifactorial fall risk prevention strategies (65).

Fall risk in ESKD may not be due to age alone. Hemodialysis treatment itself has been shown to cause dysregulation of postural stability that leads to increased fall risk. One study found significantly higher fall index scores in patients post-dialysis versus pre-dialysis suggesting a negative effect of dialysis on postural stability. Interestingly there was no correlation between age and post-dialysis dialysis measurements. This suggests that younger dialysis patients are also prone to increased fall risk following a session of hemodialysis (67). Implementation of effective fall prevention strategies in dialysis units may help reduce the incidence of fall related injuries. These strategies may be multi-pronged including, obtaining detailed fall history, reducing polypharmacy, addressing hypotensive symptoms, educating patients about fall risk immediately following a dialysis session, encouraging exercise programs to improve postural stability or reinforcing better dialysis adequacy as a means of reducing fall risk (67). Moreover, early recognition of dialysis patients who are at increased risk of falls and referral to fall assessment clinics may help to minimize the morbidity and perhaps mortality related to recurrent falls (64).

Vascular Access Preservation

Native vascular access creation can be a physical and psychological barrier for CKD patients approaching the need for dialysis initiation. The presence of an arteriovenous fistula (AVF) is a constant physical reminder of disease state, creates new fears of cannulation/pain, exposes the patient's condition to the outside world and may imbue stigma from disfigurement and the feeling of body mechanization (68). Nevertheless, proper functioning vascular access is the literal and physical life line of an ESKD patient who undergoes chronic dialysis. Preservation of vascular access is as paramount as any other strategy of harm reduction in dialysis patients.

The recommended goal of vascular access type for the dialysis patient is clearly outlined by the KDOQI guidelines and the Fistula First Catheter Last (FFCL) initiative (69, 70). AVFs are the preferred hemodialysis vascular access type followed by arteriovenous grafts (AVG) and lastly CVC. When compared to AVGs and CVCs, AVFs are associated with lower morbidity, mortality and cost. When functioning properly, AVFs have fewer complications than grafts or catheters. (69,70).

Prevalent cases of AVF use have increased significantly among dialysis patients but the use of AVF remains low among incident dialysis patients (71). More than two thirds of patients initiating dialysis use a CVC (71). Lack of access to pre-dialysis care, lack of pre-dialysis education which leads to lack of patient awareness of CKD severity may contribute to the low rates of AVF use at the time of dialysis initiation (70, 72). Furthermore AVFs have a primary failure rate of 30–50% which can delay the use of fistula even if one is placed months in advance of dialysis initiation (73, 74). Studies have also shown that 24%–42% of AVFs will need an intervention prior to maturation with nearly one third never reaching full maturation (75). AVFs are also vulnerable to recurrent stenotic lesions, clotting, ischemia distal to anastomosis leading to steal syndrome, aneurysm formation or decrease patient

acceptance associated with pain or feelings of disfigurement (68, 76). Every effort should be made to preserve a functioning native AVF for as long as possible.

Early recognition of AVF complications and barriers can lead to timely interventions that could improve patient outcomes and HR-QOL. One systemic review of qualitative studies identified the importance of incorporating patients in the decision making process regarding management of access (68). Patients should be provided with sufficient and repeated education about access preservation before dialysis initiation and throughout their dialysis life-course. In a prospective cohort study of incident dialysis patients, Cavanaugh et al demonstrated that increased patient knowledge about dialysis had a positive association with AVF use at time of dialysis initiation and 6 months after (77). Increased knowledge may also serve to empower patients to advocate for their own self-care and development of safeguards to protect their vascular access (68).

Educating dialysis staff (nurses, technicians) who are routinely involved in patient's access management may also help to improve the long term use of and AVF. One study exploring the culture of cannulation in at dialysis unit found it challenging for nurses to transition from novice to expert "cannulators" (78). Further, the decreased opportunity to maintain cannulation skills created tension between nurses and their patients. Educational strategies and profession development training were identified as ways of confronting these challenges and improving preservation of mature AVFs (78, 79).

Dialysis units across the United States closely monitor and track types of vascular access used and access related complications as an effort to maintain good vascular care practices. Vascular access monitoring can also serve as focus for quality improvement initiatives. Additionally access care should be a multidisciplinary approach that goes beyond the dialysis nurses, technicians, and nephrologist, and should place the informed patient at the center of treatment decisions.

Culture of safety within dialysis units

Hemodialysis is a complex procedure that requires numerous steps involving constant engagement of persons, technologies, medications, invasive maneuvering and timely response to physiologic and environmental changes. The dialysis center can be a cacophonous arena susceptible to human error, systems breakdown, ineffective communication, high patient and staff turnover that can all crescendo to a point where patient safety is threatened. Addressing medication safety, monitoring for hemodynamic instability, reducing a patient's fall risk or implementing strategies for vascular preservation cannot effectively be executed without first establishing a culture of safety around the dialysis patient.

The use of checklists in the airline industry has long been proven to reduce errors and minimize harm that can occur in settings where numerous complex tasks are required (80, 81). The surgical arena has adopted a "checklist" culture that improves safety and reduces mortality (82). Given the tempestuous proclivities of a dialysis unit, implementation of a checklist culture could potentially provide consistency that engenders an atmosphere for safe

practices. Marcelli et al conducted a feasibility study using a 15 point checklist in a Portuguese dialysis unit. The checklist was divided in sections focused on (I) pre-session safety, (II) session initiation, and (III) post session quality checks. Though the study did not directly assess the effect checklist had on patient outcomes it did demonstrate that a checklist could be used in routine clinical practice. Additionally completion of the checklist was maintained irrespective of staff turnover (83).

The technical aspects of hemodialysis procedure may not always be the source of an error that leads to harm. As the aforementioned topics explored in this paper, much of the propensity for harm to occur involves human and systems error. In a retrospective cohort study reviewing the adverse medical events associated with deaths of patients who underwent renal replacement therapy in a Scottish hospital, Bray et al found that adverse events contributing to death in these patients were associated with everyday management of medical problems and not technical aspects of dialysis (84).

In a more in depth review of dialysis facility safety Garrick and Morey highlight the importance of a non-punitive approach to safety where all stakeholders (patient, nurses, technicians, facility manager, and nephrologist) are engaged as a team to improve safety. The use of specific tools such as root-cause analysis, failure mode and effects analysis can be used to understand the “how” and “why” of errors (85). These tools provide a platform to promote improvement of care.

Conclusion

The medical safety topics presented here are examples of common issues faced throughout the life course of an ESKD patient undergoing hemodialysis and are appropriate topics on which to focus educational efforts.. There are various strategies which warrant further investigation to improve medical safety in each area addressed in this paper (*see table 1*). In no way is this a comprehensive review of all safety issues confronted by dialysis patients. Various topics with equal importance such as management of hyperkalemia, medication reconciliation, AVG management, infection control, volume management, disaster preparedness or end of life care (advance care plans, establishing DNR/DNI, palliative withdrawal from dialysis) and numerous other topics are all relevant to the medical safety of dialysis patients and are beyond the scope of this review. Further, the current review focuses predominately on ESKD patients undergoing in-center hemodialysis, but these topics may confer a nuanced risk profile in peritoneal or home hemodialysis patients. Patients who transition from dialysis to transplant recipient also face unique challenges that threatens their medical safety.

Ultimately the medical community (nephrologist, surgeons, pharmacists, nurses, technicians and most importantly patients) should actively engage in creating/promoting a safe health delivery and health consumption culture. Early identification of safety pitfalls and focused team lead approaches to improve dialysis patient outcomes should be the “value” and “perception” of all individuals committed to the culture of safety (80). Efforts to improve education in these area and effectively deliver it to those providing patient care are clearly warranted.

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Figure 1.
Medical safety concerns as patients transition from CKD to ESKD and dialysis

Table 1

Suggested strategies to improve medical safety in dialysis patients.

Safety Topic	Preventative strategies to reduce patient harm.
Medications in general	<ul style="list-style-type: none"> i. Include pharmacist as part of medical treatment team (86) ii. Having up to date medication list through frequent medication reconciliation (7) iii. Reduce pill burden (4, 5) iv. Address patient concerns related to medication indication, side effects; assessment of medication adherence (5) v. Improve provider-patient communication by using tools such as “teach-back” method (86) vi. Assessment of health literacy (possible instruments for assessment include Drug Regimen Unassisted Scale (DRUGS)(87) or Beliefs About Medication Scale (88)
Analgesics	<ul style="list-style-type: none"> i. Differentiate between somatic and non-somatic pain (89) ii. Use of pain assessment tools such as McGill Pain Questionnaire (MPQ)(90) or the Brief Pain Inventory (BPI) (9, 91) iii. Use of pain ladder scale to titrate treatment such as the World Health Organization analgesic ladder (90) iv. Use of non-pharmacological therapies to treat pain (92) v. Use of Opioids such as fentanyl and methadone that have a safer risk profile in ESKD patients (93, 94)
Oral Anticoagulants	<ul style="list-style-type: none"> i. Routine checks of INR to ensure therapeutic level with warfarin use (17) ii. Stopping oral anticoagulation when no longer indicated or following major bleeding episode
Antimicrobials	<ul style="list-style-type: none"> i. Ensure patient meets criteria for infection prior to antimicrobial use(25) ii. Use narrow-spectrum antimicrobial based on culture sensitivity data (25) iii. Ensure patient meets surgical prophylactic criteria for antimicrobial use (25) iv. Reduce use of CVCs (23) v. Tailor antimicrobial administration to patient specific dialysis schedules (29) vi. Have clear therapeutic targets and drug monitoring (i.e. Vancomycin level) protocols (29) vii. Early identification of patients with MDROs (31)
Intradialytic hypotension	<ul style="list-style-type: none"> i. Cooling dialysate (56) ii. Reduction in ultrafiltration rate (57) iii. Increasing dialysis frequency or duration (58) iv. Ensure accurate dry weight is set (95) v. Avoid low dialysate calcium and magnesium (96, 97)
Falls	<ul style="list-style-type: none"> i. Screen patients for fall risk, obtain fall history(65) ii. Reduce polypharmacy (67) iii. Early referral to fall assessment clinics (64) iv. Encourage exercise and gait stability programs (67) v. Minimize IDH (62)
Vascular Preservation	<ul style="list-style-type: none"> i. Timely placement of AVF (69, 70) ii. Include patient in process of access management (68) iii. Increase training and educational sessions for nurses and technicians regarding access care (78, 79)

Safety Topic	Preventative strategies to reduce patient harm.
	iv. Establish standard protocols for identifying access complications (i.e. stenosis, aneurysms) and stepwise interventions
Dialysis unit safety	i. Incorporating checklist for dialysis procedure (83) ii. Have standardized protocols to reduce system errors (84) iii. Use specific tools such as root cause analysis to evaluate and improve on errors/near misses (85)