ACUTE KIDNEY INJURY:

CONTINUOUS QUALITY IMPROVEMENT FOR SYSTEMS CHANGE

By

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Abstract

Acute Kidney Injury (AKI) is reduced kidney function over hours to days which can be reversible but can lead to renal failure and death. AKI is diagnosed using serum creatinine and urine output but these factors are not sensitive or specific, and no biomarker has been found for more accurate diagnosis. International guidelines for AKI diagnosis and treatment were released in 2012 by the Kidney Disease: Improving Global Outcomes (KDIGO) group. Many providers are not aware of AKI and guidelines for treatment have not been implemented in practice. The purpose of this continuous quality improvement (CQI) project was to improve healthcare team member knowledge of AKI Guidelines and to develop electronic health records (EHR) tools to improve AKI recognition and diagnosis. EHR tools were developed for implementation during a two-month CQI practice initiative. An Excel spreadsheet for AKI diagnosis and EHR renal protection protocols were created and tested. Updates were made to the tools to allow ease of use based on interprofessional feedback. A trifold AKI educational pamphlet was developed following implementation to fill gaps in knowledge. The interprofessional critical care team survey reported the tools were helpful in facilitating AKI recognition and management according to published guidelines. More work is needed to find sustainable and significant improvements in AKI recognition, diagnosis, and treatment. AKI guidelines should be disseminated to non-nephrology professionals after revision to allow for increased diagnosis and management of this critical and common problem.

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Overview of the Problem of Interest

Acute kidney injury (AKI), formerly known as acute renal failure, is a group of kidney diseases and disorders characterized by changes in kidney function over a short period of time usually evolving within a one week period (Levey, Levin, & Kellum, 2013). If recognized and treated early, it can be a fully reversible condition. AKI results in dysregulation of fluids, electrolytes, acid-base balance and retention of metabolic waste products. If not recognized or treated, kidney failure requiring renal replacement with potential for permanent disability or death can result (Counts, 2015; KDIGO, 2012).

The United States Renal Data System (USRDS) funded by the National Institutes of Health publishes information about kidney disease each year. The USRDS first dedicated a separate chapter to AKI recognizing greater risks for elderly people and the poor health outcomes in 2009 and has been describing AKI annually since then. The USRDS (2015) noted an overall increase in AKI rates at 3.9% when compared with 2003 rate of 1.5%. Case, Khan, Khalid and Khan (2013) reported the incidence of AKI in critically ill patients at 20-50%. Risk factors for AKI include diabetes and chronic kidney disease. The in-hospital mortality rate among Medicare patients with AKI is reported as 14.4% (including those discharged with hospice) and those in the critical care unit who suffer AKI have greater than 50% mortality rates (Case, Khan, Khalid & Khan, 2013).

In 2012 the Kidney Disease Improving Global Outcomes (KDIGO) group published international guidelines to unify clinical diagnosis and staging of AKI. The KDIGO guidelines provide extensively detailed prevention and treatment guidance. Early identification and intervention has been shown to improve long term outcomes for those with AKI (Counts, 2015,

KDIGO, 2012). Despite efforts to disseminate the guidelines at nephrology meetings and across primary care, the guidelines are not well known or utilized within inpatient or outpatient settings (Agege Lobo, & Matheus, 2012; American Hospital Association, 2014; Hassinger, 2015; Joslin, Wilson, Zubli, Gauge, Kinirons, Hooper, Pile, & Ostermann, 2015; Kolhe et al., 2015; Lewington, Cerdá, & Mehta, 2013; Okusa, & Davenport, 2014; Porter et al., 2014; Wilson et al., 2014; Wilson et al., 2015; Xu, Baines, Westacott, Selby, & Carr, 2014). The high risk of AKI and potential for disability and death coupled with the lack of knowledge and implementation of published guidelines demand improvements in AKI recognition and treatment. The purpose of this project was to increase the recognition and diagnosis of AKI among health care providers in the CCU at a northwestern hospital.

Background

AKI is the term that has replaced acute renal failure to provide more accurate description of a sudden reduction in kidney function. Johnson, Feehally and Floege (2015) describe a common definition of AKI as a reduction in kidney function over a period of time (hours to days) using serum creatinine as well as urine output. These authors also note that the most common causes of AKI are tubular or vascular factors. The tubular area of the kidney is the anatomical location of critical absorption and reabsorption of solutes. This area can become damaged from infection, reduced blood flow, nephrotoxic agents, or damaging antibodies as in glomerulonephritis. Gilbert and Weiner (2014) identify that AKI results in retention of waste products such as nitrogen that are normally cleared by the kidneys. Clinical signs and symptoms can range from asymptomatic to life threatening fluid and electrolyte disorders.

AKI Diagnosis Criteria. Recognizing the importance of small changes in creatinine as well as the significant short and long term consequences of kidney injury, the kidney community

began to mobilize to devise criteria to allow for earlier identification of AKI. The term AKI was defined initially by the Acute Dialysis Quality Initiative in 2004 using a set of criteria for diagnosis entitled RIFLE (risk, injury, failure loss, end stage). The RIFLE criteria include five stages and evaluates two major factors: serum creatinine and urine output. The serum creatinine level is evaluated in the context of baseline creatinine; the higher the rise above baseline the greater severity of AKI. Urine output is also taken into account over a period of six to twelve hours and is measured in milliliters of body weight (kg) per hour. Serum creatinine alone has been recognized as having significant limitations for AKI detection (Johnson, Feehally, & Floage, 2015). If there is no urine output for twelve hours, the RIFLE criteria identifies this situation as "F" meaning failure. The RIFLE criteria uses the estimated glomerular filtration rate (eGFR), specifically the modification of diet in renal disease (MDRD) calculation for the diagnosis of AKI. Lopes and Jorge (2013) state the limitations of using this calculation in AKI diagnosis and they further point out that this calculation has not been validated in AKI. The RIFLE criteria were updated and revised by the Acute Kidney Injury Network (AKIN) a few years later to include absolute increases in creatinine and removing the eGFR calculation (Singbari & Kellum, 2012). Both criteria are demonstrated in Figure 1 showing the comparison of the two criteria.

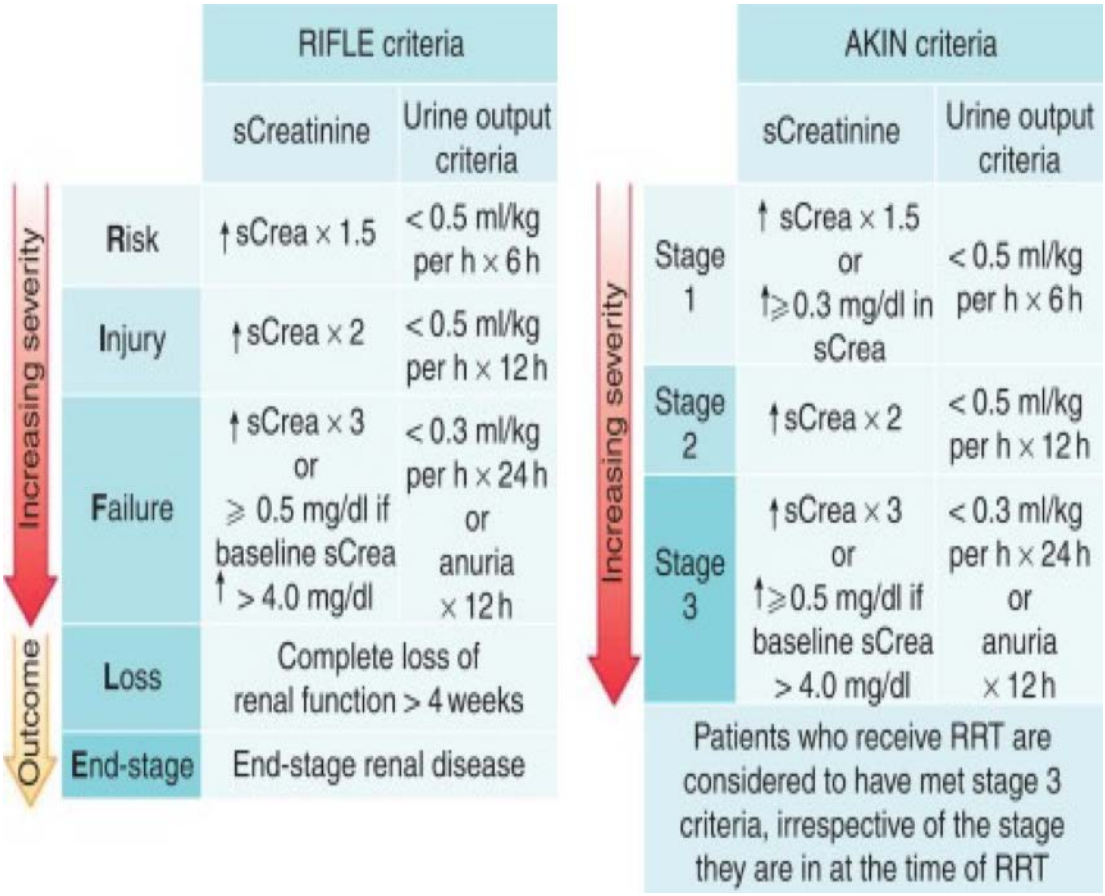

Figure 1. Direct comparison of RIFLE (Risk of renal dysfunction, Injury to the kidney, Failure or Loss of kidney function, and End-stage kidney disease) and Acute Kidney Injury (AKI) Network criteria to classify AKI according to Bellomo et al.7 and Mehta et al.,8 respectively. Reprinted from "AKI in the ICU: definition, epidemiology, risk stratification and outcomes," by K. Singbarti and J.A. Kellum, 2012, Kidney International, 81(9), p.820. Copyright 2012 by Elsevier. Used with permission.

International AKI Guidelines. Many agree that serum creatinine as well as urine output and clinical evaluation for fluid balance and potential kidney insults are important components in diagnosing and staging AKI (Counts, 2015; Johnson et al., 2015). In 2012, the KDIGO group published AKI guidelines that recommended a 48-hour interval for absolute changes in creatinine as well as a seven day interval when relative changes in creatinine could be considered (Gilbert & Weiner, 2014). The KDIGO AKI guidelines used both the RIFLE and AKIN criteria

in an attempt to simplify the definition of AKI. The guidelines defined AKI in three ways: (a) serum creatinine increase by greater than or equal to 0.3mg/dl within 48 hours; (b) an increase in serum creatinine to greater than or equal to 1.5 times baseline occurring within the prior seven days; or (c) Urine volume of less than 0.5ml/kg/h for six hours.

AKI Biomarker. Serum creatinine is an inaccurate and late marker for kidney function (KDIGO, 2012; Lopes & Jorge, 2013; Palewsky et al., 2013). The KDIGO (2012) AKI guidelines state that changes in serum creatinine can take up to 48 hours after kidney injury has occurred. Even with criteria and calculations for determining AKI, the diagnosis is still dependent on clinical assessment (Palewsky et al., 2013) and the criteria can be confusing and difficult to apply in routine practice. A more accurate, timely sensitive and specific biomarker for AKI diagnosis has yet to be discovered and validated (Counts, 2015; KDIGO, 2012).

Conceptual Model for AKI

Murray et al. (2008) suggested a conceptual model to depict AKI. This model was subsequently used in the KDIGO (2012) AKI guidelines. Figure 2 demonstrates that kidney damage is occurring before absolute changes in measured glomerular filtration rate are manifested as increased serum creatinine.

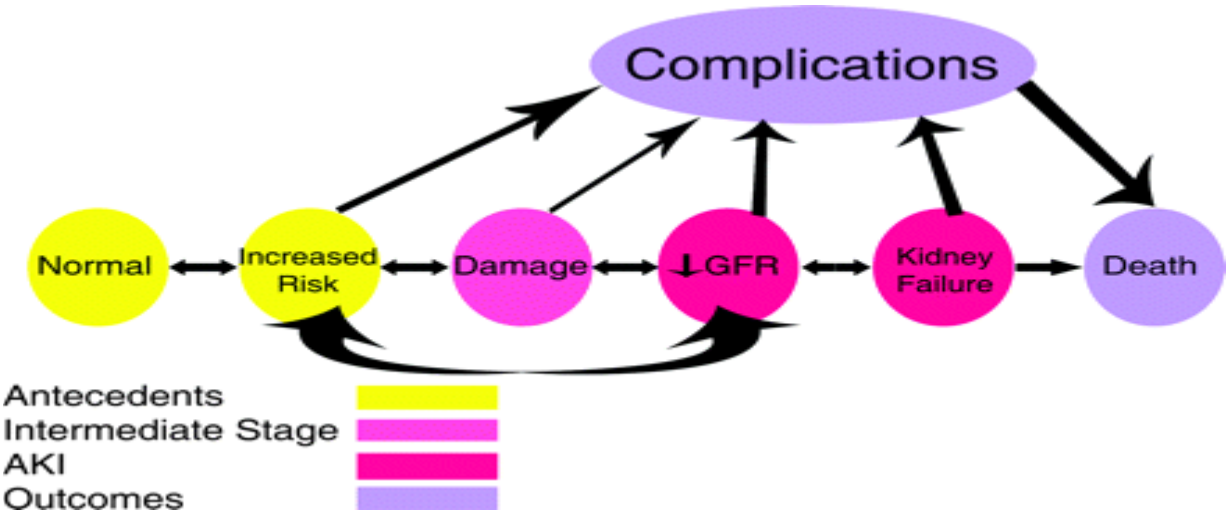

Figure 2. Conceptual model of acute kidney injury. Reprinted from "A framework and key research questions in AKI diagnosis and staging in different environments," by P.T. Murray, et al. 2008, Clinical Journal of the American Society of Nephrology, 3(3), 865. Copyright American Society of Nephrology. Clinical Journal. Online by American Society of Nephrology. Reproduced with permission of American Society of Nephrology in the format Thesis/Dissertation via Copyright Clearance Center.

The left side of the continuum demonstrates the factors that increased risk for AKI influenced by older age and other organ failure. The far right of the graphic shows the outcomes of AKI including death. The arrows depict the potential reversibility period of AKI where intervention can preserve kidney function.

Clinical Significance

AKI is predominantly hospital-acquired and occurs in 22-67% of critically ill patients (American Hospital Association [AHA], 2014). AKI increases the cost of health care and increases morbidity and mortality (AHA, 2014; Counts, 2015). However, AKI occurrence seems to be increasing and is no longer confined to those who are admitted to the critical care unit (CCU) of the hospital. The AHA (2014) reported a 20% increase in non-intensive care unit - acquired AKI while the overall diagnosis of AKI in CCU patients rose to 60% in 2012. Johnson,

Feehally and Floege (2015) note that between 37 and 60% of those with AKI in the CCU die. AKI-related mortality has been found to increase hospital stays as well as health care costs; such risks were found in those with serum creatinine changes as low as 0.3mg/dL. Those who survive an AKI hospitalization have been found to have increased long-term mortality, with an adjusted mortality risk of 1.4 which increases as the stage of AKI increases. Finally, Johnson, et al. reported that those who survive AKI have a higher risk for comorbidities such as cardiovascular and chronic kidney disease.

Two groups of researchers described the problem of AKI and call for action globally. Lewington, Cerda and Mehta (2013) conducted a review of 31 studies about AKI worldwide. This analysis provided global perspective on the problem of AKI and the associated costs. These authors point out that AKI costs exceed 9 million dollars annually. AKI increases inpatient length of stay by three days and 300,000 people die annually of AKI. Similarly, Mehta et al. (2015) published an international statement after analyzing over 1,000 reports in the literature. This statement published through the International Society of Nephrology used the most recent KDIGO definitions for AKI. These authors advocated for establishing the burden of AKI, increasing knowledge and reducing the variation of AKI management, and creating infrastructure that is sustainable. The authors called for zero preventable deaths worldwide from AKI by the year 2025. According to KDIGO (2012):

AKI as defined by the RIFLE criteria (and subsequent AKIN) is now recognized as an important syndrome, alongside other syndromes such as acute coronary syndrome, acute lung injury, and severe sepsis and septic shock (pg 2).

Fewer Nephrologists. The number of nephrology specialists have been steadily

decreasing to the point that some are concerned about the viability of the specialty (Fiore, 2014). The American Society of Nephrology (ASN) (2015) reported that 51% of the nephrology fellowship programs didn't fill open positions recently where previously there were at least 1.5 applicants for every available spot. The lack of nephrology specialists means that many people experiencing AKI will not be evaluated or followed by a nephrology specialist. Fewer nephrologists translate to primary care providers caring for AKI patients, who will need to be knowledgeable about AKI and risks for recurrence, heart, and kidney disease. According to the American Association of Nurse Practitioners (AANP), more than half of the over 222,000 nurse practitioners in the United States provide primary care (AANP, 2016). The Doctorate of Nursing Practice (DNP) prepared nurse is uniquely positioned to help fill the needs of nephrology patients. According to the American Nephrology Nurses Association's Advanced Practice in Nephrology Nursing position statement (2015), advanced practice registered nurses are well prepared to care for the nephrology population and fill the nephrology gap. Advanced practice nurses providing primary care can contribute to improving AKI care regardless of their practice setting.

The problem of hospital-acquired AKI is such that in 2014, the Symposium for Leaders in Healthcare Quality; a forum of the AHA in partnership with Health Research and Educational Trust and the United States Department of Health and Human Services developed a change package on this topic. The package provides evidence-based information about AKI and suggests action plans for hospitals to identify and minimize the impact of AKI. The package contains a checklist and ideas for quality improvement. The aim for this change package was to "decrease mortality from hospital-acquired ARF/AKI by 40% by December 8, 2014" (AHA,

2014, p.1). The first step in reducing AKI in any setting is to recognize it so that appropriate interventions can be employed.

Current Clinical Practice

This project took place at a 150 bed-tertiary level two trauma and referral center for a northwestern state. The hospital holds the coveted nursing excellence Magnet designation from the American Nursing Credentialing Center (ANCC, 2016). The critical care unit (CCU) employs critical care nurses, pharmacists, intensivists, respiratory therapists, and other health care professionals who round daily and work together for optimal clinical outcomes. The CCU employs a registered nurse assigned to quality improvement activities who collects and reports outcomes of care. Diagnoses are easily retrieved using the electronic health record (EHR) for quality reporting purposes. International guidelines advocate for staging AKI; however, ICD-9 and 10 codes do not allow for AKI staging. Thus AKI staging is not utilized in clinical practice despite use in formal research designs. Informal surveys of the interprofessional CCU team revealed little unity in knowledge and application of the available KDIGO (2012) guidelines for identification and treatment of AKI. Each provider had different opinions about when to consult nephrology and which AKI definition was most accurate. It is possible that an electronic health record (EHR) might improve laboratory analysis and recognition of AKI since trends in creatinine and urine output can be easily seen and graphed. Despite many available improvements for AKI care, wide variations of this care were found among providers in the CCU.

Question Guiding Inquiry

The overall focus of inquiry for this project was how to improve care for patients with acute kidney injury. Stillwell, Fineout-Overholt, Melnyk, and Williamson (2010) describe a

systematic way of refining clinical questions using the PICOT format. The acronym PICOT stands for P: patient population, I: intervention or issue of concern, C: description of a comparison, O: the outcome(s) to be discovered and T: the time it will take for the intervention(s) and outcome(s) to be accomplished. This format allows the nurse scholar to efficiently focus so that literature can be searched and projects can be defined for the most effective application of clinical evidence. In contemplating the problem of AKI for the target population, several questions arose such as what evidence-based guidelines are available to guide the diagnosis and staging of AKI? In what ways have others used available guidelines to identify AKI? Are there any tools that would help to guide clinicians in diagnosing and staging AKI? Are there EHR tools that would assist in the diagnosis and staging as well as treatment of AKI? What evidence based interventions have the most impact in treating AKI? Narrowing the broader question of acute kidney injury from the entire population to a smaller and more appropriate scale for an appropriate CQI project, the refined PICOT question emerged.

Clinical Question. Will interprofessional education and development of EHR-based tools improve AKI recognition and diagnosis compared to pre-intervention over a three month timeframe in the CCU at an urban hospital in the northwest?

Population (P). The population included all adults admitted to the CCU.

Intervention (I). The intervention proposed was an EHR-based tool consistent with current guidelines to allow for assistance with proper identification and staging of AKI. Educational training was provided to increase AKI knowledge and introduce the interprofessional team members to the tools.

Comparison (C). AKI diagnosis rates and staff knowledge were compared before and after the intervention. Quantitative comparisons were used to determine differences in AKI

diagnosis rates pre and post development and implementation of EHR tools. Thus comparison was made between the rate of AKI diagnosis before and after project implementation. Additionally, pre and post measures of team member knowledge were compared.

Outcomes (O). The outcome goals were to improve knowledge of AKI identification and increase the percentage of patients diagnosed with AKI.

Time (T). A three month period was chosen from June to August 2016 for implementation and monitoring of interventions.

Conclusion

There is a nationally recognized need for improvement in the identification, staging, and treatment of AKI. The American Hospital Association identified this problem with suggestions for improvements in 2014. While no updates on this change package could be located to date, the published international AKI guidelines (KDIGO, 2012) could be used to realize outcome goals. Such tools could be further implemented outside of the CCU and employed across the hospital campus to benefit all settings in which AKI occurs. Such a set of screening tools using the EHR could improve AKI care.

Review of the Literature

The AKI literature is reviewed in this section. Of particular interest was literature that described how AKI KDIGO (2012) guidelines have been used in practice. This section describes the methods of the search and findings of the literature review, which are summarized in categories for further evaluation and synthesis.

Methodology

The foremost authority on AKI is an international consortium, KDIGO that released AKI guidelines in 2012. The guidelines have been reviewed in conferences and discussed among nephrology professionals worldwide. The United States nephrology experts in conjunction with the National Kidney Foundation published commentary on the KDIGO guidelines in 2013 (Palevsky et al.). After review of the guidelines and associated references, additional information was needed to determine how healthcare providers were implementing these guidelines into daily practice.

Strategies. Search of the University of Alaska Anchorage (UAA) Consortium Library for "acute kidney injury" revealed 165,142 articles. Of those articles, 117,978 were journal articles. Narrowing these findings to include "critical care" yielded much fewer, 30,488 results. Many of the results included pediatric studies. An additional qualifier of "adults" further reduced the total to 16,573 results. Since the project used electronic health records, the acronym "EHR" was added. This search revealed 33 results. The same search in Google Scholar yielded 408 results. A study by Ahmed et al. (2015) utilized an EHR to detect AKI. Review of the references in this study revealed numerous sources to augment the search. In addition, the American Hospital Association change package (AHA, 2014) found using a Google Scholar search for AKI, revealed additional studies in the reference section which were reviewed. Once

the same authors and studies began to appear, saturation of the literature was assumed and other avenues for information were searched.

A search of web sites for more AKI information was undertaken. Web sites reviewed included the American Nephrology Nurses Association, the National Kidney Foundation, and the Society of Critical Care Medicine. The Acute Kidney Injury Network was discovered from the critical care web site and was referenced in much of the literature reviewed.

This project relied on three substantial nephrology texts and review of cited material in these texts (Counts, 2015; Gibson & Weiner, 2014; Johnson et al., 2015). The American Nephrology Nurses Association published updated nephrology nursing practice modules in 2015. These comprehensive modular texts include the latest evidence presented by nephrology nurse experts. Module 4 is dedicated to AKI and covers interventions for treatment (Counts, 2015). A recognized reference text for nephrology practice is the text Comprehensive Clinical Nephrology (Johnson et al., 2015). This text's fifth edition was published in 2015 and was used for its excellent flowcharts and explanations of AKI and other concepts in nephrology practice. The National Kidney Foundation's Primer (Gilbert & Weiner, 2014) is another reference text used in nephrology practice and offers simplified succinct explanations of kidney problems.

Data Evaluation. The KDIGO (2012) authors reviewed and synthesized many studies in developing and publishing the guidelines. Specifically the authors reviewed randomized controlled trials in the area of AKI and provided 87 individual recommendations of which 26 were ungraded and 39 were level 2 recommendations. However, 22 (or approximately 25%) of the recommendations were level 1 which are the highest level of evidence. The KDIGO guidelines are considered the highest level of evidence according to Fineout-Overholt et al. (2010) since the recommendations include extensive analysis of all of the available evidence. As

such, the guidelines were the best resource for guiding this project. The KDIGO guidelines for identifying and staging AKI were published in 2012. To avoid confusion around previously unclear definitions of AKI, the literature for this project was limited to studies and reviews published from 2012 and later.

The focus of this project was predominately limited to adults. However, two pediatric studies were reviewed that focused on medication management in the pediatric population. These studies did involve the use of EHR and AKI and were still applicable to the broader questions of the project and where thus included in the project literature. Several studies were found in hospitalized adults using the EHR for creatinine measurements. The study by Ahmed et al. (2015) met most of the criteria for this critical appraisal as it was conducted in an adult critical care unit, used both serum creatinine and urine output, and used the EHR. This study was designed as a cohort study which is identified as level IV evidence. The algorithm used by Ahmed et.al. provided the best example of using the EHR to identify AKI in the critical care setting. The fact that criteria from the KDIQO (2012) guidelines were applied to the clinical setting as well as an EHR algorithm made this study the most applicable to the project design.

Findings

The KDIGO (2012) guidelines were important in determining the definition of and staging for AKI. This document provided the groundwork for most other implementation studies reviewed. Two other articles were used to apply the KDIGO guidelines to practice. The United States commentary (Palevsky et al., 2013) offers expert guidance for nephrology practice in this country. These authors make the point that diagnosis of AKI requires clinical assessment findings as well as consideration of serum creatinine and urinary output. Additionally, Okusa and Davenport (2014) applied the KDIGO guidelines to various case studies and realistic

situations thereby demonstrating the need to individualize care provided for those with AKI. For comparison, the United Kingdom's National Institute for Health and Care Excellence (NICE) published AKI guidelines in August 2013 which were also reviewed.

Seven studies were found in which the EHR was used to assist the diagnosis and staging of AKI (Almed et al., 2015; Herasevich, Kor, Subramanian, & Pickering, 2013; Kashani & Herasevich, 2015; Kolhe et al., 2015; Porter et al., 2014; Wilson et al., 2014; Wilson et al., 2015). Two studies were EHR-based but were limited to the pediatric population (Kirkendall et al., 2014; Goldstein et al., 2013). Five studies evaluated health care provider knowledge of AKI (Agege & Matheus, 2012; Hassinger, 2015; Joslin et al., 2015; Xu et al., 2014; Yamout Levin, Rosa, Myrie, & Westergaard, 2015). Several themes emerged from the literature including the preventable nature of AKI, automated alerts have met variable success, and lack of provider knowledge is a barrier to early diagnosis and treatment.

AKI is preventable. International KDIGO guidelines (2012) as well as UK guidelines (NICE, 2013), textbooks (Counts, 2015; Gilbert & Weiner, 2014; Johnson et al., 2015) and individual studies (Mehta et al., 2015; Yarmout et al., 2015) have highlighted the commonly occurring and preventable nature of AKI. Yarmout et al. (2015) in a review of 170 inpatient charts found that 30% of AKI cases could have been avoided. Mehta et al. (2015) recommended focusing on risk identification and recognition of AKI as the first two steps in improving care for those with AKI.

Automated Alerts. Several studies have used the EHR to automatically recognize AKI and alert providers (usually attending physicians) with variable success (Almed et al., 2015; Goldstein et al., 2013; Herasevich et al., 2013; Kasha & Herasevich, 2015; Kirkendall et al., 2014; Kolhe et al., 2015; Porter et al., 2014; Wilson et al., 2014; Wilson et al., 2015). Two

pediatric studies focused on automated EHR alerts to reduce nephrotoxic medication prescriptions (Kirkendall et al., 2014; Goldstein et al., 2013). These studies demonstrated successful detection of potentially nephrotoxic medications and actual reduction of AKI episodes. Goldstein et al. (2013) study was a prospective quality improvement project that used the electronic record to screen and make decisions about AKI. The sample size was large with 2,180 hospitalized pediatric patients. The focus of this study was on nephrotoxic medications. The intervention did reduce AKI intensity by 42%. Kirkendall et al. (2014) used a risk stratifying approach for identifying AKI triggers using medication alerts initiated at first by pharmacists and then by the EHR in a 500 bed children's hospital. This quality improvement initiative reduced nephrotoxic medication exposure by close to 100% thereby detecting drug-related AKI before it occurred. These pediatric studies interestingly were the only ones to involve pharmacists in the detection and management of AKI. The pediatric studies focused on medication management so involving the pharmacists was logical. No other studies were found involving a mix of health care professionals other than the pharmacist and the physician.

Other studies have been less successful. Wilson et al. (2014) tested an electronic alert tool for AKI. The following year the same authors designed a rigorous randomized control trial enrolling over 23,000 patients (Wilson et al., 2015). The researchers implemented the previously-tested Wilson et al., (2014) electronically generated alert to inform providers about AKI. The results were disappointing as the outcome measures of dialysis and nephrology referrals showed no difference suggesting that AKI alerts may be overlooked or ignored by providers. Other electronically-generated AKI tools had similar concerns of alarm fatigue and concern for false positive alerts as explanations for lack of realized improvements (Kolhe et al., 2015; Porter et al., 2014;). Kolhe et al. (2015) reported on EHR alerts for AKI that included

care bundles (described as suggested orders for AKI management) to improve the diagnosis and treatment of AKI; only 12.2% of recommended care bundles were implemented within 24 hours. Even so, this smaller number with interventions within the 24-hour timeframe realized improved outcomes including reduced mortality.

Provider knowledge. Several studies have assessed physician and nurse knowledge of AKI. Five of the studies reviewed demonstrated that even with education, physicians and nurses (and in at least one study, including nurse practitioners), there was a lack of improvement in AKI outcomes despite initial improvements in demonstrated provider knowledge (Yamout et al., 2015; Hassinger, 2015; Xu et al., 2014; Agege & Matheus, 2012; Joslin et al., 2015). Joslin et al. (2015) found two years after intensive education of physicians, nurse practitioners, and nurses that while AKI was diagnosed and nephrotoxic medications were reduced, volume status was not addressed nor was intravenous contrast use withheld demonstrating missed opportunities for prevention of renal assault.

Other Studies. In 2010, Go et al. published plans for a long term multi-site prospective study of AKI outcomes. Chronic kidney disease and cardiovascular events including death and other outcomes were and continue to be monitored. Additionally, urine and serum biomarkers which may shed some light on AKI that develops prior to urine or creatinine changes may provide more information and new ways of detecting and preventing AKI. Results have not yet been published. The study entitled ASsessment, Serial Evaluation, and Subsequent Sequelae of Acute Kidney Injury (ASSESS-AKI) may hold some useful answers for clinical practice.

Limitations

Most work in the area of AKI detection and treatment has focused on using the EHR to detect a problem and alert providers. Alert fatigue and inaccurate results have been recognized

as limitations in all studies using the EHR. Some studies have only used serum creatinine changes to identify AKI. Urine output is a vital part of AKI detection per international KDIGO (2012) guidelines, but most studies using automatic detection did not include urine output. It is possible that some AKI could be overlooked until serum creatinine changes thereby affecting the outcomes. The critical care unit is in a position to collect and record urine output hourly thereby making AKI detection more accurate and timely. It may be more difficult to accomplish hourly urine output outside of critical care, but the focus of this project is limited to the critical care unit. The human element of history taking and clinical examination are important parts of effective AKI detection and treatment (Palevsky et al., 2013; Okusa & Davenport, 2014). Other than some studies involving pharmacists, no studies have involved the entire healthcare team in the efforts to recognize and treat AKI. Others have identified the lack of nephrology specialists worldwide and have advocated for each health care professional practicing at the highest level possible in order to have a meaningful impact on AKI recognition and treatment (Lewington, Cerda, & Mehta, 2013).

Conclusion

The nephrology and critical care literature documents the importance of recognizing and treating AKI. Most studies reviewed used an automated system to detect changes in serum creatinine (leaving out important changes in urinary output). Studies also focused on physician notification with variable results. Alert fatigue and knowledge deficits were found to be contributing factors in AKI recognition and treatment.

Based upon the evidence reviewed, renal protection may be improved by a voluntary system that is accessible to all healthcare providers (not just physicians) that would promote casting a wider net of health care providers to identify and stage AKI. Using criteria of both

serum creatinine change and urine output may reduce missed AKI events. In addition, the availability of easy to use care prompts for specific kidney protective recommendations might allow for improved AKI management.

Organizational Framework

The American Association of Colleges of Nursing (AACN) (2006) provides essentials for Doctoral education for advanced practice. This document states "Nursing practice epitomizes the scholarship of application through its position where the sciences, human caring, and human needs meet and new understandings emerge (p.11)". As such, the doctoral-prepared advanced practice nurse applies current evidence from the literature into clinical practice. By applying research to current practice, the AACN document points out that new knowledge is recognized, documented, and disseminated for the advanced practice nurse working with patients in a real-time clinical setting. Anderson, Knestrick and Barroso (2015) identify the essential outcome of evidence-based practice (EBP) projects, which are to demonstrate improved patient outcomes or practice through the application of research. The seven steps of evidenced based practice are described in detail by Anderson, et al. and include cultivating a spirit of inquiry, asking the burning question in PICOT format, searching for and collecting the most relevant best evidence, critically appraising the evidence, integrating the best evidence in combination with experience and values in making a practice decision or change, evaluating the outcomes of those practice decisions or changes and finally disseminating the results of the evidence based decision or change. These steps were applied in the development of the AKI Doctor of Nursing Practice (DNP) project.

The framework for this continuous quality improvement (CQI) project utilized the Plan, Do, Study, Act (PDSA) rapid cycle improvement process (Moen, 2009). According to the Deming Institute (Moen, 2009), the PDSA model arose out of the work of W. Edwards Deming that started with an improvement wheel in the 1950s for designing products with iterative tests in the market and re-design. Japanese executives transformed the Deming wheel into the Plan, Do,

Check, Act (PDCA) cycle in 1951 (Moen, 2009). This was a simple four step process for developing and improving products. By 1985, Dr Ishikawa (also from Japan) updated the PDCA cycles and added goal setting and targets in the planning stage. The Do step added training and education along with the implementation phase. In 1993, Deming had again revised his model into the well-known PDSA cycle used so widely today. The four steps are 1. Plan: a change or test for improvement; 2. Do: carrying out the change or test; 3. Study: review of the results with focus on what went wrong and what was learned and; 4. Act: adopt changes or abandon the change and run the cycle again. Deming emphasized these cycles were to be on a smaller scale. Interestingly, Moen (2009) documents that Deming intended no relationship between the PDCA and the PDSA cycles and intimated that he had no idea where the PDCA cycle originated. By 1991 Moan, Nolan, and Provost added a predicted theory to the planning stage to allow for comparison to observed results as a way of improving learning from the cycles. These authors believed that the comparisons allowed for the mechanism necessary for the scientific method. Later, additional clarifying questions were added such as

"What are we trying to accomplish?"

"How will we know that a change is an improvement?", and "What change can we make that will result in improvement?" (Moen, 2009, p.8)

The PDSA cycle for quality improvement is well suited to make significant, rapid, and lasting changes in the healthcare setting. Crowl, Sharma, Sorge, and Sorensen (2015) conducted a systematic review of CQI studies using the PDSA cycle. They found that the smaller scale improvements that allowed for changes to the plan resulted in lasting change for organizations. They advocated for PDSA cycling as opposed to larger scale organization-wide implementation

of changes. They pointed out that with the PDSA cycling, real and lasting organizational changes are sustainable.

Conclusion

A continuous quality improvement (CQI) framework was applied in order to adapt the EHR-based diagnosis and treatment tool for AKI by the interprofessional team in the CCU. This framework and the applicable literature describing its use provided the most promise for successfully implementing sustainable evidence-based practice changes within the organization. As such weekly review of the EHR tools were incorporated into CCU rounds to maximize the feedback and staff time and increase participation and buy-in for the project. The feedback was used to make necessary changes to the EHR tool. However, as identified in the PDSA cycling, flexibility was important and changes were made whenever useful feedback was received from end users (Moen, 2009). CQI is a well-known and tested tool for improving outcomes in healthcare. It is used routinely by the hospital quality department; the PDSA cycle is familiar to many of the healthcare team members, making this project more likely to have been accepted by the interprofessional team in the CCU.

Project Design

The purpose of this quality improvement project was to improve identification and diagnosis of AKI by all team members after education and implementation of an interprofessional, EHR-based tools in the CCU. The project goal was to use the electronic health record as a tool to assist in the identification and diagnosis of AKI. It is well documented that early recognition and treatment of AKI results in improved mortality and morbidity outcomes (Counts, 2015). This quality improvement process allowed for changes to the use of the EHR tool and available treatment options using a rapid cycle PDSA improvement approach.

Institutional Review Board

Review of the project by an institutional review board (IRB) is one way that organizations and institutions can ensure the protection of human subjects. Ethical considerations involved in most studies of humans include basic ethical principles (UAA IRB, 2012). The principle of justice is demonstrated in IRB review as respect for people in the form of informed consent, minimizing risks of human subjects and equally selecting human subjects for study. The federal government, through the United States Department of Health and Human Services (DHHS) developed a document entitled the Belmont Report in 1974 to help outline ethical principles for those conducting human research. This report utilized worldwide experiences such as the Nuremberg Military Tribunal and abuses of human subjects in the United States. The Belmont Report was crafted into Health and Human Services regulations coded as 45 CFR part 46, subparts A through D. These regulations define specifics known as “Common Rule” that are followed by federal and nonfederal institutions to ensure the protection of human subjects. These regulations describe in detail what constitutes human subject research. If human subject research is being conducted, these regulations describe the level of protections and

scrutiny required before embarking on such research (United States Department of Health and Human Services [DHHS], 2004).

According to the DHHS charts for human subject research, the first question to be answered is whether or not the activity being planned is designed for "generalizable" knowledge (Chart 1, DHHS, 2004). This evidence based project used CQI principles and was not designed nor intended to be generalizable beyond the experience of the organization. As such, this CQI project was not research. While data such as diagnoses were reported, all information was de-identified and no new data other than what was already collected in the quality measures for the organization was generated or collected. No risks to those admitted to the CCU were discovered on careful review of this CQI project and potential benefits of improved care may be realized based on project status. A Determination of IRB form was completed. The University of Alaska (UAA) compliance officer issued a letter determining this project to be non-human subject. After the approval as a non-human subjects project from UAA, application to the hospital IRB was made. The UAA IRB determination was reviewed and the hospital IRB issued an email determining this project to be quality improvement in nature and not requiring IRB review.

Evidence-Based Practice Change Design

This quality improvement project involved developing and testing an intervention that included staff training and use of an EHR tool. Outcomes measures included AKI diagnosis rates and staff knowledge.

Diagnosis of AKI. Formal and informal weekly meetings were employed to ensure maximum feedback and updates to the EHR tools. The implementation period occurred over a two-month period during which time changes were made to the tools to allow ease of use in practice. The outcomes measured were rates of AKI diagnosis. The sample size for AKI

diagnosis was anticipated to be approximately 160-180 patients based upon monthly volume. The same months from the previous year (2015) were used for the comparison AKI rate and was found to be 16%.

Interprofessional education. The members of the healthcare team assigned to work in the CCU were educated on AKI and the benefits of early identification and treatment using the international guidelines. A pretest and posttest measure of AKI knowledge was used to validate understanding. In addition, the proposed EHR recognition and treatment tool was reviewed as a part of the education sessions. While the focus of the project with on AKI identification and diagnosis, the tools developed did include treatment prompts from the KDIGO (2012) AKI guidelines. The format for educational sessions was informal didactic review and demonstration of ways to use the EHR tools (order set and AKI calculator) based on scope of practice. Interprofessional collaboration was encouraged. The PDSA framework was reviewed to encourage each member of the interprofessional team to provide feedback for improvement of the tools during the implementation timeframe.

EHR staging tools. The KDIGO (2012) AKI guidelines provide specific AKI staging guidance but are difficult to apply in a real-time clinical setting due to alert fatigue and lack of knowledge as described previously. An EHR assisted tool which calculates the presence of AKI along with appropriate stage was necessary if AKI is to be identified, diagnosed, and staged in a consistent manner. The EHR tool was easily accessible to all members of the health care team so that any team member who was concerned about AKI could initiate the tool and receive assistance. When initiated, the EHR tool was used to query the medical record, noting serum creatinine and calculate changes as well as noting urine output based on patient weight over time.

The EHR tool was designed to be easy to use and voluntary thereby avoiding repeated automated reminders or alarms so alert fatigue could be avoided.

EHR treatment tools. The current KDIGO (2012) guidelines for AKI provide multiple suggestions for kidney protection and AKI treatment. Many of the interventions and recommendations are specific to nephrology specialties providing guidance in the use of continuous renal replacement and hemodialysis therapies. Further, these guidelines are lengthy and can be confusing and difficult to implement by front line staff. A treatment tool that combined several possible suggestions from the KDIGO guidelines for AKI management would save time and improve adherence. An interactive list of recommended diagnostic and treatment orders from the evidence-based KDIGO guidelines allowed each member of the interprofessional team to practice at their highest level within their professional scope while encouraging collaboration with others on the team. The more accessible and simple the suggestions, the more likely the guidelines would be utilized.

Resources

The practice change goals for this project included improving the recognition and diagnosis of acute kidney injury. The goal for the interprofessional staff was to become more aware of AKI. The team was educated about the EHR tools available to assist them in early AKI identification. Each team member had responsibility in AKI identification. As stated earlier, AKI is thought to be present in 22-67% of hospitalized patients (AHA, 2014). Even though this is a broad range, without information indicating this population is different, one would expect AKI rates in this setting should fall within this range.

Leadership. It was vital that the critical care leadership were interested and invested in this practice change. Key stakeholders in this project included the medical and nursing leadership

within the critical care unit. The quality RN for the critical care unit was involved in gathering and reporting statistics and kidney care in the unit specifically. Her support for the project was very important as she was a resource for patients receiving dialysis care. The quality indicators for critically ill patients were already reported to the leadership of the organization. Keeping people in leadership and on the team motivated was critical to project success and long- term sustainability. Soliciting feedback for changes during regularly scheduled rounds avoided additional staff time and allowed for interprofessional engagement. In addition, providing team members feedback on interim outcomes was designed to keep staff engaged and motivated throughout the implementation period.

EHR tools. The CCU informatics nurse was an essential team member as the tools where created, tested and improved. The original AKI identification tool designed by Almed et al. (2015) was used as an example for how to automatically diagnose AKI within a patient's chart in the EHR system. This was dubbed an "AKI-sniffer" by Almed and his team and required an electronic data mall to remove and analyze individual patient parameters then return them to the EHR in the patient's chart. The Renal Protection Order Set EHR tool designed for this project was easy to use such that any staff member could initiate some protection orders with the click of one or two buttons within the patient's electronic chart.

Education. Group and individual education was offered to allow for maximum flexibility and low interference with patient care time. Surveys of AKI knowledge were administered before and after the team education sessions. The EHR tools were designed in such a way as to avoid the need for extensive education or training on use. Initial plans called for the development of one button within the chart to reveal if AKI was present (an "AKI-sniffer") and

to show the stage of AKI. In addition, one button in the orders section was planned to reveal treatment options specific to each user's scope of practice.

Challenges of Collaboration

Challenges to interprofessional work did arise**.** Every participant had a different scope of practice. However, there were interventions that could be implemented by staff that did not require provider orders such as closer monitoring of intake and output, review of medications for nephrotoxic agents, as well as careful fluid assessment. The team in the CCU already worked closely together and collaboration was an expectation among team members especially in this Magnet designated organization.

Some foreseeable challenges were anticipated including: 1. Team members who did not have ordering privileges might fail to engage a provider; 2. Team members who did not recognize the value of an EHR tool and could continue to care for patients as usual never even trying to use it and; 3. Team members could decide the tool was too difficult to use thus rendering it obsolete.

Plan for Project Evaluation

In order to mitigate these challenges, the project used daily to weekly PDSA cycles with feedback from team members during regularly scheduled critical care rounds. This allowed for convenient feedback and needed changes to the EHR tools. The informatics staff generated the AKI diagnosis rates in 2015 and for the same timeframe post intervention in 2016.

Data Collection and Analysis

The number of patients in the CCU with the diagnosis AKI was compared to the number without AKI during two months following implementation. This frequency of AKI diagnosis was compared to the same two months in the CCU one year ago (in 2015). It was anticipated that AKI would be identified more often after development and use of the EHR tools. As such,

the number of patients diagnosed with AKI was expected to increase when compared to the same two month timeframe in 2015. Additionally, overall knowledge about AKI should improve with staff education provided.

Two outcome measures, change in level of AKI knowledge after AKI education and diagnosis rate for AKI were analyzed. The pre and post AKI knowledge results were analyzed for significant differences using the chi-squared goodness of fit statistic. This statistic is a nonparametric test to look for differences between the pre and post intervention groups. Since the surveys were not paired, the chi-squared statistic is a good choice. The null hypothesis was that there is no relationship between the pre and post intervention samples. The alternative hypothesis assumes there is a difference (Statistics Solutions, 2016).

Post Intervention Plans

The CCU is the ideal place to start such a project for improved AKI recognition and treatment. Once the tools have been refined using quality improvement techniques, disseminating the AKI monitoring process to floors outside of the critical care unit will be implemented. Ongoing education and monitoring by the nephrology department is required to allow sustained improvements. If the tools were successful in the inpatient setting, then primary care providers could apply them in the outpatient setting as appropriate.

Conclusion

The interprofessional team was educated on the guidelines and assisted with development of the EHR tools. Team engagement was a major factor to improve AKI recognition and thus outcomes. The continuous quality improvement principles along with the PDSA cycles allowed for alterations of the EHR tools in real-time. It was expected that both team member knowledge of AKI and AKI diagnosis rates would increase with successful implementation of this project.

Implementation Process and Procedures

The nurse prepared with a Doctorate of Nursing Practice seeks to translate existing research into practice, also known as evidence based practice. Such efforts require preparation and attention to detail so that meaningful practice changes can improve outcomes. The continuous quality improvement (CQI) model was used to implement international KDIGO (2012) guidelines for acute kidney injury (AKI) into everyday practice in the critical care unit (CCU). The project was a pilot with plans for greater dissemination hospital-wide. This chapter focuses on the implementation phase of the CQI project describing the collaboration, alterations made, and the processes and procedures that resulted. The CQI process utilized rapid cycle methods to involve stakeholders in AKI tool development according to the systems and culture of the environment.

Project Implementation

Implementation was delayed due to IRB approval at the institutional level. The intervention period and follow up had to be shorted to two months instead of three. Implementation began the last week of July, 2016 and continued through the end of September, 2016. The first step of implementation was to devise an evidence-based survey to gather current knowledge of AKI. The survey stakeholders (nurses, physicians, pharmacists, and respiratory therapists in the CCU) conveyed an email survey was preferred. The survey was developed to evaluate AKI knowledge after review of an extensive knowledge survey of pediatricians by Hassinger (2015). KDIGO (2012) AKI guidelines were used to develop an original ten question survey. An online automated program was used to deploy the survey (Appendix A). The survey was emailed to CCU interprofessional staff at the beginning of implementation and again at the end of implementation to allow for comparison of knowledge.

Survey

Approximately 125 members received the survey. Not all email addresses were accurate and some staff had moved to other positions within the hospital reducing the survey number to 112. Staff members were encouraged to complete the anonymous survey using three methods: personal invitation by the project manager, email reminders, and with visual reminders placed in the CCU. The staff were incentivized to complete the survey with candy in the break room on a daily basis over a two-week period. The candy was available for all staff which generated plenty of conversation each morning as new supplies of candy were delivered. Survey reminders asking if they had completed the ten-question survey were also placed in the unit. This process was repeated after implementation with 110 surveys going out to staff members.

Project Training

Once the pre-intervention surveys were received, the staff was invited to AKI training sessions. Project goals were reviewed. The timeframe and CQI process for implementing changes to the AKI tools were developed and shared. One-on-one training was offered to individuals unable to attend the group training. An educational board in the unit was filled with AKI facts and highlighted the project importance. Weekly rounds prompted many informal discussions with various CCU staff members. Topics discussed during these rounds included project process and goals. The AKI tools were developed with stakeholder input. This personal approach created an opportunity for regular feedback promoting stakeholder investment in the project.

AKI Tools

The tools for AKI knowledge were developed for this project in June, 2016. The entire interprofessional team provided input into the modification of the AKI tools as the project

evolved. Effective development of a tool required significant work with the informatics nurse to determine if a manual "AKI sniffer" could be developed for the electronic health record (EHR). The study by Ahmed et al., (2015) utilized an automated system to scan urine output and creatinine and notify providers when results went below a certain threshold. After several hours with the informatics nurse, it was determined that the EHR did not have a data mall (the capacity to remove data from individual charts for analysis). This data mall would be required to allow for automatic analysis of EHR parameters. As such, the process for identifying AKI changed. At one of the regularly scheduled team meetings, a pharmacist in the CCU suggested an Excel spreadsheet might be used to assist staff in identifying AKI as an alternative to the EHR sniffer, or screening tool. After considerable time with an informatics pharmacist, an Excel spreadsheet was developed and tested (Appendix B). The spreadsheet was easy to use when entering creatinine and did provide for AKI stage, however manual entry was required and a baseline creatinine had to be entered. In order to use urine output to diagnose AKI, 48 hours of hourly urine output data was required for the tool to provide an accurate AKI stage. This proved to be too laborious even for the most meticulous staff person. As such, the Excel tool was used primarily for evaluation of creatinine. It was determined that once a data mall has been developed for the EHR, an AKI sniffer could be developed and added to the available tools for individual patients.

The Almed et al. (2015) study also provided impetus for another AKI tool developed during this project. Almed's current study (and others in the literature) contained guidance to providers about AKI treatment and basic kidney protection according to published international guidelines (KDIQO, 2012). Other studies found that resources based on the current guideline had too much information to be clinically useful for providers, linking providers to the entire 38-

page guideline which proved to be less effective in practice. A more practical clinical approach was sought.

Interprofessional stakeholders determined a renal protective order set which provided details about protecting kidneys should be added to the tool set. The initial order set was very detailed. Feedback from the intensivists identified that many of the orders on the renal protective order set (to include vasopressor medications) were already found elsewhere such as the critical care standard order sets. To avoid duplication and cluttering the order protocol, the team determined it was best to include only orders not found elsewhere (Appendix C). In order to expand the watchful eyes of non-provider staff in the efforts to identify and prevent AKI, the team determined it was possible for nursing staff and pharmacists to propose or suggest orders to the provider within the EHR. This function allowed for the recommendation of AKI protective orders be sent to the provider in the EHR which could be accepted or rejected. This step involved more staff in the AKI identification and diagnosis process.

AKI Education

AKI education of staff continued through the two-month implementation period. The post intervention survey was presented via email to the CCU staff. Information about AKI was present both in person during classroom and individual teaching and mentoring sessions. Champions in the process included the quality RN for the unit as well as the pharmacist assigned to the CCU.

Conclusion

The implementation of the AKI CQI project yielded many unanticipated challenges. According to Melnyk and Fineout-Overholt (2015), barriers should be assessed and eliminated after engaging stakeholders at all levels. The timeframe was reduced from three months to two

months after IRB determination delayed implementation. Some of the EHR barriers could not be removed; therefore implementation became flexible and creative. With the help of several champions, tools were developed and refined to allow for improved knowledge of AKI. The renal protection protocol was revised several times and the end product reflected a simple non-redundant approach to applying the international KDIQO (2012) AKI guidelines. The members of the interprofessional team were actively involved to encourage broader use of the tools with more watchful eyes. The nephrology services expanded during this timeframe allowing better access and lower costs of care for patients requiring nephrology services.

Project Outcomes

The collection, tracking, and analysis of data are important parts of quality improvement projects (HRSA, 2011). Collecting data includes determining appropriate numerators and denominators for describing results. Tracking data allows for ongoing evaluation and changes, while analysis allows for acting on the messages the data has revealed. This chapter focuses on data management also known as project outcomes. The outcome measures are described and analyzed. Chapter seven will further explain the meaning of the outcomes and the recommendations for future practice.

Outcome Measures

This quality improvement project measured the rate of acute kidney injury (AKI) diagnosis before and after implementation as well as correct answers on pre and post intervention surveys. The outcomes in this project were collected for a period of two months. There were no significant differences found when comparing the pre-intervention to the post-intervention data for AKI diagnosis rates. The rate of AK diagnosis and seven of the ten pre and post survey answers were compared using the chi-square statistic. The remaining three questions were analyzed qualitatively.

Rate of AKI diagnosis

In order to determine if there was an improvement in the diagnosis of AKI, a simple chi-square comparison calculation was used. For comparison, the same months in 2015 were compared. The total number of CCU admits were evaluated for each period (2015 and 2016). The ICD-9 codes for AKI (584) were used for 2015 and the ICD-10 code for AKI (N17) was used for 2016. The change in diagnosis was six cases (2%) total and is reflected with the p-value in Table 1 below. There were 194 admits to CCU over the two-month period of August and

September, 2015 with 31 or 16% AKI diagnosis rate. The same months in 2016 were collected for comparison. There were 208 CCU admits with 37 or 18% of those carrying the AKI diagnosis.

Table 1

A comparison of AKI diagnosis

	Admits without AKI diagnosis *n* (Percent)	Admits with AKI Diagnosis *n* (Percent)	Total
August and September 2015	163 (84%)	31 (16%)	194
August and September 2016	171 (82%)	37 (18%)	208
Total	334	68	402

The 2% difference was not significant, $\chi 2 = .23$ (2, N = 402), p = .629

Pre and Post AKI knowledge survey

The pre and post intervention ten-question survey was emailed to the entire CCU team. Surveys and responses were anonymous. Individual identifiers were not collected and there was no way to know the professional role, experience or identity of the health care professional completing the survey. The initial pre-intervention survey was emailed to 124 employees with 112 correct emails and 25 responded (22% response rate). The initial pre-intervention survey was emailed to 124 employees with 112 correct emails and 25 responded (22% response rate). After the educational offerings and weekly rapid PDSA cycling was complete, the same survey was again circulated to 120 employees with 110 active emails which yielded 17 respondents (15% response rate). There was no attempt to link individual pretest and posttest survey

responses. The analysis of each question appears below. When appropriate the chi-square statistical test was used to compare pre and post intervention survey answers. Correct answers were compared to incorrect answers. Frequencies and percentages were also used to compare and analyze responses. None of the results were significant at the .05 level. Reasons for this are discussed in the limitations section in chapter seven. When looking at percentages, some questions (question one and question three) demonstrated a 20% or more increase in the number of questions that were answered correctly. However, due to small sample size, results were not statistically significant, but may have some practical significance (discussed in chapter 7). Refer to Table 2 for a summary of the chi-square analysis.

Table 2

Comparison of pre and post intervention survey questions 1, 2, 3, 4, 5 and 7

Question topic	Chi-square	Total	*p**
AKI Diagnosis Criteria	3.21	42	0.07
Comfort Level with AKI diagnosis	1.44	42	0.23
Percent of CCU Patients at Risk for AKI	2.13	42	0.14
Factors Affecting Serum Creatinine	0.01	42	0.94
Clinical Situations Indicating AKI	0.12	42	0.73
Awareness of Guidelines/Criteria	1.44	22	0.23

**Results are not significant at the .05 level*

How is AKI diagnosed. Question one asked how AKI was diagnosed with several choices. The correct answer was both serum creatinine and urine output (KDIGO, 2012). No respondents skipped this question. The pre-survey yielded a majority or 18 of 22 (72%)

choosing the correct answer. Post survey respondents demonstrated an increase in those choosing the correct answer with 16 (94%).

Comfort level with AKI. Question two was a Likert-scale in which the respondents rated their comfort level with diagnosing AKI. Prior to the intervention, 15 (60%) of respondents chose somewhat comfortable or comfortable. While six (24%) chose very comfortable. Zero chose expert, and four (16%) chose uncomfortable. After the intervention, the post survey revealed only one respondent choosing uncomfortable (6%) while 13 (82%) chose somewhat comfortable or comfortable. Again, no one chose expert and only two (12%) chose very comfortable. All respondents answered this question.

Those at risk for AKI. Question three asked about risks for AKI in terms of how many (percentage) patients admitted to the CCU were thought to be at risk. According to the current literature (KDIGO, 2012) all CCU admissions should be considered at risk. This is an important concept in the understanding of AKI. If all team members are recognizing the potential for risk of AKI, then perhaps this knowledge will lead to actions that protect the kidneys of all patients. All respondents answered this question. More than half or nine (58%) of the post intervention respondents were able to recognize that all CCU admissions are at risk for AKI.

Factors affecting the accuracy of serum creatinine. Serum creatinine is the only marker (aside from urine output) that is currently used in the diagnosis of AKI (KDIGO, 2012). It is well known that the accuracy of serum creatinine is highly variable (KDIGO, 2012) and is affected by many variables to include age, gender, muscle mass, illness, fluid and nutritional status. If serum creatinine is being used to identify AKI, it is important for those caring for patients to recognize the limitations of serum creatinine by understanding the factors that

influence this marker. As such, all of the choices on the survey were correct and should have been chosen. All those responding to the survey answered this question. While most respondents chose more than one variable 15 (97%), a similar number picked all six variables in pre and post intervention surveying (15/60% and 9/56% respectively).

Clinical situations indicating AKI. Recognition of the situations in which AKI is most likely to develop is another important factor that was stressed during interventional education and interactions. All respondents answered this question. Fluid overload, hypotension, intravenous, contrast and nephrotoxic medications are recognized as the most commonly encountered reasons for AKI in the acute care setting (KDIGO, 2012). The correct answers on the pre and post surveys were similar (16/64% and 9/56% respectively).

Timing of creatinine rise. Question six was specific to the length of time after an AKI event that the serum creatinine rises. This question was cause for some confusion among those who had previously been surveyed with pediatric health care providers recognizing delay only 20% of the time in one study (Hassinger, 2015). The KDIGO (2012) AKI guidelines state that 48 hours is the maximum time for rise in creatinine, however the very definition of AKI includes the wording hours to days. This question was designed with the correct answer being two days after AKI based on the guidelines. However, 12% of the respondents correctly answered this question prior to the intervention and none of the respondents answering the post survey answered this question correctly. The KDIGO AKI guidelines state that clinical judgment and assessment as important factors in diagnosing AKI. The CCU staff are in the habit of reviewing labs daily. The critical illness of those in the CCU coupled with the confusing wording on the definition of AKI may have contributed to this question being misunderstood. It was therefore eliminated from further analysis.

Guideline and criteria knowledge. Question seven asked participants to list any known guidelines or criteria about AKI. It allowed for free text and eleven respondents skipped this question pre-survey and nine skipped this question on the post-survey. According to KDIGO (2012) guidelines, serum creatinine and urine output should be used since the estimated glomerular filtration rate calculations are unreliable when kidney function is not at a steady state. The KDIGO guidelines cite the AKIN and RIFLE criteria and so any of these responses were counted as correct. Eleven (44%) of those completing the pre-intervention survey did not answer this question. The 11 (56%) who did answer this question did so by stating one or more of the following: KDIGO, KDOQI, AKIN, RIFLE, serum creatinine, eGFR, and I don't know. Ten (58%) of those completing the post-intervention survey skipped this question. Of the seven who did answer, none stated that they did not know and two (28%) indicated serum creatinine and urine output as criteria. The rest indicated either one or both of the known tools AKIN and RIFLE (eight or 57%) from the guidelines. Overall, in both the pre and post intervention surveys, 10 of the respondents answered correctly, but since there were more respondents in the pre- survey the percentage of correct answers increased from 40% to 58%.

Nephrotoxic medications. Question eight asked which medications should be stopped or reduced when AKI is recognized. This allowed for free text input. Seven participants skipped this question in the pre-intervention survey while seven skipped on the post survey. Those who answered the pre-survey answered with a variety of medications to include ACE inibitors (ACEi), angiotension receptor blockers (ARB), , non-steroidal anti-inflammatory drugs (NSAID), , intravenous (IV) contrast, metformin, pyridium, thiazides, enoxaparin, glucophage, and statins should be discontinued while noting that gentamicin, vancomycin, and others listed the term antibiotics should be watched. Three pre-intervention respondents correctly noted

aminoglycosides as a group and one also noted many cephalosporins. Unusual or incorrect answers included, penicillins, paracetamol (acetaminophen) and vasopressors in the discontinue list. Two respondents listed electrolytes to be reduced or discontinued but it was unclear if these participants were listing things that should be replaced or stopped based on the wording.

The post-intervention survey question about medication was answered by nine with a 52% response rate and seven (44%) skipped the question. Of those who answered, all (100%) identified some sort of antibiotic naming specifically most often aminoglycosides such as gentamycin were to be discontinued or reduced with AKI. Most or seven (77%) were able to name vancomycin as well. Over half or six (66%) noted NSAIDs or named one such as ibuprofen while almost half or four (44%) noted ACEi/ARBs. IV contrast was also listed by most or five (55%). One respondent incorrectly identified acetaminophen as needing to be discontinued or reduced in AKI. Two named vasopressors and three listed diuretics as needing to be discontinued or reduced in AKI. The survey did not ask respondents to elaborate on their answers and so it is difficult to know if these respondents were aware that diuretics and vasopressors may be used in the treatment of patients but that volume status and hypotension prevention are more concerning when using vasopressors and diuretics as opposed to their effects on the kidney function directly (KDIGO, 2012).

Nephrology consultation and follow up. Questions nine and ten asked if nephrology is routinely consulted for AKI and if follow up nephrology is expected, ordered or arranged after discharge. Two people skipped question 9 and 10 in the pre-survey and one in the post- intervention survey.

Responses on these questions were somewhat confounding as those completing the surveys provided feedback that most were not needing nephrology specialty help (12/52% and

10/67% pre and post). Question ten asked about follow up care after AKI and a majority of both pre and post intervention surveys had incorrect answers (14/65% and 10/67%). It was discussed that those caring for critically ill patients rarely discharge patients to the community and so the wording of the question in which they were asked if they expect/order/arrange for nephrology follow up for AKI after discharge could have been misunderstood.

Discussion of Results

The outcomes of the two-month intervention period yielded modest increases in AKI knowledge among staff members surveyed. Those participating in the post survey did indicate improvement in the understanding of how AKI is diagnosed but there was little appreciable change in self-rated comfort levels. Knowledge of available criteria and guidelines for AKI was increased from 40% to 58% correct. However, only a small increase in AKI diagnosis was realized during implementation (2%). The less than dramatic outcomes for this project mirror other studies on AKI understanding in the literature (Wilson et al., 2014; Wilson et al., 2015). Even when successful education of AKI is realized, these improvements have not been sustained (Xu, Baines, Westacott, Selby, & Carr, S., 2014). After the results were evaluated, a trifold AKI informational brochure was created addressing specific knowledge gaps and several copies were distributed to staff members on the unit with plans for this education to remain long term.

Conclusion

The project goal was to improve the identification and diagnosis of AKI using electronic tools and education. AKI diagnosis rates and pre and post intervention survey results showed modest improvements or no statistical difference. Application of international guidelines in the knowledge of AKI proved to be as difficult as reflected in previously published interventions. The limitations of this project are described in detail in chapter seven.

Implications for Nursing Practice

This chapter reviews the implications for nursing practice as well as conclusions, limitations, and interpretations regarding the results. The American Association of Colleges of Nursing (AACN) (2006) has developed eight *Essentials for Doctorate of Nursing* (DNP) education. These *Essentials* are described as necessary for all DNP programs and allow for individualization and creativity in fulfilling each essential. This project addressed or described all eight *Essentials*. The discussion of limitations and implications is framed within the context of each of the *Essentials*.

Essential I: Scientific Underpinnings for Practice

Essential I addressed the complexities of AKI regarding hospitalized patients having contact with their environment (AACN, 2006). Specifically, kidney injury is often the result of treatments performed for other medical problems and carries risks for immediate and future kidney function (Johnson et al., 2015).

The project endeavored to improve identification and diagnosis of AKI using international guidelines for practice from KDIQO (2012). The ANNA (2015) core curriculum for nephrology nursing also provided guidance in the area of the nursing role in particular. The pre and post survey on AKI revealed deficits in AKI understanding, and it was clear that comfort levels with recognizing AKI was low. An AKI trifold education pamphlet and electronic health record order set were creative ways to overcome these concerns and provide evidence-based details about various signs and symptoms for AKI.

Essential II: Organizational and Systems Leadership for Quality Improvement and Systems Thinking

Essential II addressed the procedures and policies of organizations to allow for positive changes for specific populations (AACN, 2006). The DNP-prepared nurse is in a unique position to identify ways to improve policies and procedures so quality of care can be improved. The nurse practitioner is well versed in both nursing and medical protocols and terminology, which enables the DNP-prepared nurse to translate complex concepts to the interprofessional team. In this way, the clinical nurse practitioner is uniquely able to improve system thinking to improve care for all patients served.

This *Essential* is the most applicable to the AKI project in that it required changes to the health care system to improve AKI recognition. The project revealed no systematic or consistent way of determining AKI was present and while many staff members were aware of guidelines, most did not feel comfortable recognizing this condition. As such, the order set protocol and AKI education trifold were systematic ways to attempt ongoing improvements in AKI. The translation of these nephrology specialty specific guidelines (KDIGO, 2012) was the basis for two clinically relevant and usable tools developed which became a strength of this project.

Essential III: Clinical Scholarship and Analytical Methods for Evidence-Based Practice

Essential III describes using scholarly study as a hallmark of doctoral level education. This essential, however, reviews more than just research activities recognizing that indeed the DNP-prepared nurse must synthesize research and apply it to daily practice (AACN, 2006). Knowledge of current research and best practices as well as guidelines to resolve various health care problems is required. Innovative and efficient ways to apply it to the practice setting is part of the analysis and synthesis of this information. The nurse practitioner must take into account the population being served and analyze the evidence for the best ways to apply such scholarly

work in practice. This project required applying research to practice with creation of an evidence-based intervention and development of outcome measures consistent with the literature.

Essential IV: Information Systems/Technology for the Improvement and Transformation of Health Care

Essential IV describes the use of technology to assist with improving health care (AACN, 2006). The power of electronic health record (EHR) technology should be harnessed to simplify complicated concepts for busy health care providers. The literature highlighted EHR alarm fatigue as a major limitation in improving care (Goldstein, et al., 2013; Kolhe, et al., 2015; Porter, et al., 2014; Wilson, et al., 2014; Wilson, et al., 2015). Yet, EHR systems must be easy to use and integrative of current evidence for the best care and patient outcomes.

A limitation of this project proved to be the EHR itself in that a one button analysis was not possible. The Almed et al. (2015) study used an EHR with the capability of an "AKI sniffer" that automatically analyzed the creatinine and urine output in fifteen-minute intervals for every patient. This information had the capacity to be automatically relayed to providers to alert them to the possibility of AKI. This project relied heavily on informatics specialists who attempted to develop an automated tool. It was discovered that the EHR system in use did not allow for separate analysis of individual parameters, and offered no capacity for an automatic or on- demand analysis of an individual patient in real time. The lack of technology for one button calculation of AKI staging was overcome with an Excel spreadsheet. However, this tool required the user to input creatinine at baseline and then current creatinine levels. If urine output was used, the spreadsheet required 48 individual hourly urine output measurements to be entered. This effort proved to be too time-consuming, and staff members were not motivated to enter the required data. The evaluation of urine output was therefore not applied as consistently

in the tools developed. As such, AKI identification and recognition could have been missed. The spreadsheet was easier to complete with creatinine levels but having this tool separate from the patient's individual chart was somewhat problematic. The hope for future capabilities within the EHR may allow for a one button tool to identify AKI may yet be a possibility.

The Renal Protection order set was able to be accessed through the EHR. The informatics nurse was heavily involved in developing and editing this tool. The tool not only provided details about guidelines specific to AKI management but also provided "notes" that gave the user information about AKI, again from the guidelines. This order set was a strength of the project and has been deployed to the entire hospital so that all providers can access it in any individual chart. Additionally, it was discovered that non-prescribing members of the interprofessional team were able to access these orders and "propose" them to prescribers. This means that when a nurse or pharmacist had a reason to suspect AKI for an individual patient, the renal protective orders could be "suggested" electronically to an attending practitioner to allow for signing and implementation. In this way, the EHR tool can help to improve outcomes for all patients within the system. Nurses and pharmacists will need ongoing education on ways to propose orders since it is not common practice within the facility.

Essential V. Health Care Policy for Advocacy in Health Care

Essential V describes the DNP-prepared nurse influencing health care policy. This project was specific only to the organization's CCU experience with AKI. AKI can lead to end stage renal disease in some cases if kidney function does not recover, requiring renal replacement of some type (KDIGO, 2012). One of the unanticipated influences on this project was the development of a flex, or step down unit outside the CCU. This unit opening pulled nurses for staffing. During this same time, the flex-unit underwent further construction to allow

for hemodialysis outside the CCU. The expanded nephrology services within the organization prevented costly transfers to other hospitals. This change and increased capacity might have prevented some nurses from attending educational offerings or participating in the PDSA cycling that was happening on a regular basis. Providing hemodialysis for patients (some of whom suffered AKI) during project implementation meant that the requirements and policies surrounding dialysis must also be met. Beyond the project, weekly meetings were also occurring to ensure the dialysis rooms met the requirements as outlined by the federal government. Required education was provided to the entire nursing staff on hemodialysis safety (in May) just before implementation of the AKI project (in June and July). These back to back educational offerings might have reduced, overwhelmed, distracted, or confused the CCU nursing staff who were involved in both training sessions. This limitation was addressed with the AKI education trifold and informational notes in the renal protection order set. This project did not make any changes to the policies regarding AKI or dialysis, but health care policies in the form of federal regulations about dialysis were reviewed and monitored carefully as new services were brought on line.

Essential VI: Interprofessional Collaboration for Improving Patient and Population Health Outcomes

Essential VI highlights the value of professionals from multiple disciplines working together to improve health care. This project relied heavily on the CCU team to create valuable and valuable evidence-based tools for AKI knowledge. Regular formal and informal meetings involved staff members at all levels. Staff suggested many of the changes made to the Renal Protective order set during these PDSA cycles. An intensivist, for example, identified some duplicate orders available elsewhere for all admissions. Removing this duplication simplified

the elements to only those that were not available elsewhere. The Renal Protection order set included a link to the CCU order set for blood glucose management instead of separate details and orders about blood sugar. A pharmacist made another great suggestion. On initially learning that the EHR was not able to be used for one button AKI identification and staging, a pharmacist suggested an excel spreadsheet. His idea came from other Excel spreadsheet documents used by pharmacists in evaluating drug dosages. Interprofessional work was a highlight of this project and demonstrated the power this *Essential* to improve systems of care.

Essential VII: Clinical Prevention and Population Health for Improving the Nation's Health

Essential VII describes population health and defines population as a variety of groups (AACN, 2006). AKI was the population focus for this project within the CCU at a northwestern hospital. Dissemination of the developed tools to the rest of the organization hospitalized population was planned. Since this facility is a tertiary referral center for the state, this project has the capacity to impact those who are eligible for care within the hospital health system which includes the entire state for those eligible for care. A limitation of this project was the incorrect answers about AKI follow up in the pre and post intervention surveys. Since CCU rarely discharges patients to the community, it was thought that follow up after AKI was not a focus for this staff. The expectation was that the other inpatient floors would be more inclined to arrange for follow up services after AKI.

Essential VIII: Advanced Nursing Practice

Essential VIII describes the role of the DNP-prepared nurse in improving health care (AACN, 2006). The American Nephrology Nursing Association (ANNA) (2011) defines advanced practice nursing in various roles. The consultant role is one in which the advanced

practice nurse provides expert advice in the nephrology field to various groups such as healthcare consumers, other members of the health care team and colleagues. The organization also recognizes that the APRN provides leadership and expert competency in providing care to those with potential or actual kidney disease. The nurse practitioner has the training from the understandings of science, anatomy, genetics, and pharmacology. As health care providers, nurse practitioners have learned to communicate to physicians using complicated language while at the same time translating such concepts to other staff, patients, and families. While physicians are trained in the business of curing diseases, advanced practice nurses are trained in how to help people live with diseases and preventive services. In this way, nurse practitioners are uniquely qualified to use creative and innovative ways to solve problems.

One of the limitations of this project was the lack of significant changes in pre and post intervention survey answers. None of the CCU staff surveyed rated themselves as “experts” in AKI diagnosis. In addition, none of the CCU staff correctly chose the timeframe of 48 hours for changes in serum creatinine after AKI. The lack of improved scores in the post intervention surveys could have been related to the summer months of the intervention when staff members were more inclined to be on vacation and absent from work and complications brought about by the initiation of hemodialysis within the project timeframe. Other possibilities include perhaps not enough educational offerings were provided or perhaps the education was not effective in presenting the material in a way that enhanced retention. Additionally, the pre and post intervention surveys were not paired and so it is not possible to know if the survey population was the same. Several individual conversations happened during the rapid cycle PDSA, but these were focused on the EHR tools instead of the details about AKI diagnosis. Some of the

survey questions could have been misunderstood thereby preventing the measurement of knowledge about AKI. Another possibility for the lack of demonstrated understanding could be the guidelines themselves are too complicated and are in need of revising.

The current KDIGO (2012) AKI guideline is very nephrology specialty focused. Much of the information is of interest only to nephrology professionals who are debating about when to initiate dialysis and what modality to use. There is a possibility that such detail is not useful to non-nephrology providers and as such, the guidelines are less helpful to this important group. There is a need for the nephrology community to make an effort to define and communicate clinically useful information about AKI to non-nephrology professionals. For example, the written definition for AKI states that kidney function is reduced over hours to days but the guideline later makes note that serum creatinine is slow to change taking up to 48 hours to increase after an AKI event (KDIGO, 2012). This small wording difference in the definition of AKI means that a non-nephrology professional might assume that serum creatinine changes happen within hours after an AKI event. This confusion might have been the case for the incorrect answers received in this project. Additionally, the staging of AKI seems practical for research studies as opposed to daily practice. There is no ICD-10 modifier for the stage of AKI as is the case for chronic kidney disease (CKD). This is an indication that staging of AKI may only be useful for research and may not be applicable to routine clinical practice. The current diagnostic criteria (RIFLE and AKIN) are difficult to use. If guidelines were revised to simplify these criteria, then implementation would be accelerated. Efforts have been extensively made to educate and disseminate details about how to diagnose and manage CKD for primary care providers (NKF, 2016). The nephrology community could launch a similar initiative for AKI diagnosis and management which may improve overall rates of CKD. Efficient diagnosis and

treatment might be realized if the definition of AKI was simplified and clarified and if the issue of eGFR (which is known to be inaccurate in changing kidney function) was eliminated from the definition.

The use of serum creatinine and urine output for AKI diagnosis are known to be surrogate markers for kidney injury and are not sensitive or specific enough for timely and accurate AKI diagnosis (KDIGO, 2012). If a reliable marker for AKI could be found, then AKI could be more easily diagnosed. Those looking to diagnosis heart damage are able to measure the troponin level. If a "troponin for the kidney" was available, confusion about AKI could be reduced and time saved allowing immediate treatment and protection of kidney function.

The nurse practitioner is in the best position to improve kidney care. Fewer physicians are choosing nephrology specialty (David & Zuber, 2014, Fiore, 2014). The advanced nurse practitioner is able to fill the gap in nephrology care. Davis and Zuber (2014) note that it takes six months for a nurse practitioner to work independently in nephrology. Further, the skills required for nephrology nurse practitioner practice includes nephrology, endocrinology, internal medicine, psychology, nutrition, and pharmacology. These are the scientific foundations which are the underpinning of the DNP *Essentials*.

Conclusion

This project demonstrated integration of the eight *DNP Essentials* for advanced nursing practice. There were identified limitations including a short two-month implementation period during summer months, as well as the small sample of health professionals and the confusing criteria for diagnosing AKI. However, the AKI education brochure, AKI Excel spreadsheet, and renal protective order set are tools that remain for ongoing improvements in AKI knowledge and management. The nurse practitioner is uniquely qualified to support ongoing improvements in

understanding and translation of AKI evidence into daily practice. Refinement and dissemination of AKI definition and management tools to non-nephrology professionals may improve identification and diagnosis of AKI in the future.

Summary and Conclusions

Continuous quality improvement projects use rapid cycle reviews to make real-time changes while applying the scientific model of hypothesis testing to predict results (Moen, 2009). This project is likely underpowered for demonstration of significant differences. The improvements developed are thought to have clinical importance with potential for significant improvements in the future. Significance and importance can be realized with ongoing application of research into practice.

Ernest Boyer's (1990) landmark work on scholarship remains relevant for today's ever changing health care world and in the world of nursing education. Boyer argued for the scholarship of application in which discovering and integrating new knowledge is surpassed. This type of learning requires the scholar to responsibly apply such new information to current problems (Boyer, 1990). This focus on application is precisely what the doctorate of nursing practice (DNP) seeks to accomplish and is as scholarly an endeavor as traditional research in which new knowledge is discovered. Boyer further describes this academic work as dynamic and necessary to produce meaningful service for the world in which we all live.

Boyer's (1990) scholarship of application, when applied to this project, provides redeeming hope for the future of AKI knowledge. Certainly, the lack of nephrology specialists will continue in the future, and while nurse practitioners can fill the gap, it is likely that most episodes of AKI will continue to be managed by non-nephrology professionals. This reality means that efforts should be made to translate complex AKI definitions and calculations to everyday practice to allow non-nephrology professionals confidence in the management of this dangerous problem. Efforts to simplify and disseminate AKI definitions and management techniques have the potential for improving AKI globally. Boyer eloquently states that some of

the most complicated questions in this world require skills from the ivory tower to solve. But he recognizes that resolving these problems requires the application of human knowledge to serve our fellow man. The action of applying this knowledge (evidence) provides invaluable new information that acts as a PDSA cycle of its own in supplying and providing new insights to a problem. This “relating learning to real life” (p.76) is a noble and worthy endeavor that the nephrology community should embrace and apply to the diagnosis and management of AKI. The DNP-prepared nurse practitioner is trained to use academic knowledge in leading the interprofessional team to translate the complexities of AKI into daily practice to improve outcomes. Johann Wolfgang von Goethe was a 19th -century German writer, statesman, and scientist. His understanding of the application of science to practice is useful to the DNP: “Knowing is not enough, we must apply. Willing is not enough, we must do” (Goethe, 1906, p. 130).

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Appendix A

ANMC CCU AKI Awareness Survey

You are invited to participate in a survey intended to measure awareness of acute kidney injury (AKI) in the critical care unit. This survey is part of a continuous quality improvement (CQI) project about AKI.

The survey consists of 10 questions about AKI and should take no more than 10 minutes for you to complete.

Participants are invited to participate in an AKI awareness education to include use of electronic health record (EHR) tools to diagnose, stage and manage AKI. You will be asked to re-take the survey after education is completed.

This CQI project is supported by the CCU and quality team at ANMC and is being conducted by Robin Bassett ANP, Internal Medicine, Nephrology as part of the requirements for a Doctorate of Nursing Practice degree with the University of Alaska Anchorage. UAA IRB has reviewed and approved this project. There are no risks associated with participation as the survey collects no identifying information of any respondent and all responses to the survey will be recorded anonymously. While you will not experience any direct benefits from participation, you will receive AKI education and your involvement could help improve AKI awareness and management in the future.

If you have any questions regarding your participation in this survey or the AKI CQI project please contact Robin Bassett, ANP at rabassett@anthc.org.

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By completing and submitting this survey, you are indicating your consent to participate in this CQI project. Your participation is not required but is greatly appreciated

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1. How is AKI diagnosed?

(Answer is: By changes in serum creatinine and urine output) ___ By changes in serum creatinine

___ By changes in serum creatinine and urine output

___ By changes in creatinine clearance

___ Other: Please describe

2. Are you comfortable with recognizing, staging and managing AKI? ___ Uncomfortable ____ Somewhat comfortable ____ Comfortable ___ Very comfortable ____ Expert

3. What percentage of CCU admissions do you consider as AT RISK for AKI? (Answer is: all admissions to CCU)

____ Few <10% ____ Some, <25% ____ Several, 26-50% ____ A majority, >50% ____ All admissions to CCU

4. Do any of the following affect the accuracy or value of serum creatinine as a surrogate measure of renal function (check all that apply)?

(Answer is: All of the following)

___Critical Illness ___Muscle Mass ___Age ___Gender

___ Nutritional Status ___ Fluid Overload

5. Which of the following clinical situations would indicate to you that AKI might be present (check all that apply)?

(Answer is: All of the following)

___ Fluid Overload___ Hypotension ___ IV imaging contrast ___ Nephrotoxic medications

6. How long after AKI occurs do you expect serum creatinine to indicate that AKI has occurred? (Answer is: 2 days after AKI)

____ Within 12 hours ____ Within 24 hours ____ 1 day after AKI

____ 2 days after AKI____ More than 2 days after AKI

7. List the names of any guidelines or criteria for diagnosing and staging AKI: (Answer is: KDIGO, RIFLE, AKIN, could state criteria of serum creatinine and urine output)

ACUTE KIDNEY INJURY 73

8. Please list the medications that you believe to be nephrotoxic or that should be reduced/stopped when AKI is suspected or diagnosed:

(Answer is: Should Stop NSAIDs, Monitor levels of high risk drugs such as: Vanco, Gentamycin, Amphotericin B liposomal, If hypotensive stop ACEi/ARB and other BP medications, Use Diuretics only in the case of fluid overload)

9. Do you routinely request a nephrology consultation for those you believe have suffered AKI? (Answer is: Yes) ___ YES ___ NO

10. If someone suffers AKI, do you routine expect follow up as an outpatient? (Answer is Yes) ___ YES ___ NO

Modified from: Hassinger, A. B. (2015). Knowledge and practice patterns of pediatric critical care attending physicians in the diagnosis and management of acute kidney injury (Order No. 1594720). Available from ProQuest Dissertations & Theses Global. (1705562244). Retrieved from http://search.proquest.com.proxy.consortiumlibrary.org/docview/1705562244?accountid=14473

Appendix B

AKI Staging - Creatinine and Urine Calculator

				DATE	Time	UO (ml/Hr)		DATE	Time	UO (ml/Hr)
Baseline SCr (mg/dL)		<-- ENTER BASELINE SCr								
Current SCr (mg/dL)		<-- ENTER CURRENT SCr								
Pt on RRT (Y or N)?		<-- ENTER Y or N								
Pt weight (kg)		<-- ENTER WEIGHT								
Date of last UO (mm/dd/yy)		<-- ENTER DATE								
Time of last UO (24H - h:mm)		<-- ENTER TIME								
ENTER UO History in Grid										
AKIN Stage Onset From SCr										
AKIN Stage Onset from UO										

Appendix C

Protocol for Renal Protection

Communication

Communication Order - Keep MAP 65 or greater

If underlying CKD or Creatinine baseline 1.5 or greater, AVOID PICC's and midline catheters

Vital Signs

Weight - Daily Weight - AM

Nutrition

Therapeutic Diet - Renal Diet Standard, 20-30 Kcal/kg/day. Noncatabolic not on renal replacement 0.8-1.0 g/kg/d protein Therapeutic Diet - Renal Diet Standard, 20-30 Kcal/kg/day. AKI on renal replacement 1.0-1.5 g/kg/day protein

Therapeutic Diet - Renal Diet Standard, 20-30 Kcal/kg/d protein diet. Hypercatabolic on renal replacement maximum of 1.7 g/kg/d protein diet Low Potassium Diet Low Phosphorus Diet I&O - STRICT

IV Solutions

Consider if metabolic acidosis is present (NOTE)* sodium bicarbonate 100mEq (2 amps) in D5W 1000mL (IVS)* Dextrose 5% In Water sodium bicarbonate IV additive

sodium bicarbonate 150mEq (3 amps) in D5W 1000mL (IVS)* Dextrose 5% In Water sodium bicarbonate IV additive Sodium Chloride 0.9% Lactated Ringers

Medications

Stop NSAIDs (NOTE)*

Monitor levels of high risk drugs such as: Vanco, Gentamycin, Amphotericin B liposomal (NOTE)*

If hypotensive and/or AKI stop ACEi/ARB and other BP medications (NOTE)* Use Diuretics only in the case of fluid overload (NOTE)*

Ensure phosphorus binders are given WITH MEALS (calcium acetate, sevelamer, calcium carbonate) In case of hyperphosphatemia (NOTE)* Consider if phosphorus is greater than 4.5 (NOTE)*

calcium acetate - 667 mg, Oral, TIDWM calcium carbonate - 500 mg, Oral, TIDWM sevelamer - 800 mg, Oral, TIDWM

Patient Care

ACUTE KIDNEY INJURY 77

Consider if metabolic acidosis - CO goal =22 (NOTE)*

sodium bicarbonate - 650 mg, Oral, BID

Albumin 25% (25gm) 100mL - 25 gm, IV Piggyback, Daily, Start date:

Special Instruction: For volume expansion in certain cases (liver failure).

CONTRAINDICATED in head injury.

Procrit 10,000 units/mL injectable solution - 10,000 unit(s), SQ, qWeek, Special Instruction: Target Hgb is 8 or above

Procrit 20,000 units/mL injectable solution - 20,000 unit(s), SQ, qWeek, Special Instruction: Target Hgb is 8 or above

Do not give IV iron if patient has an active infection (NOTE)*

Venofer 20 mg/mL intravenous solution - 200 mg, IV Piggyback, Daily, Duration: 5 time(s),

Special Instruction: Infuse over 30 minutes.**DO NOT give if active infection

Avoid hyperglycemia - goal blood sugar 110-149mg/dL (NOTE)* Protocol for Corrective Insulin (SUB)*

Laboratory

CBC w/ Auto Diff - Blood, Routine collect, Target Hgb is 8 or above (NOTE)*

BLOOD Protocol for Transfusion Inpatient (SUB)* Ferritin - Blood, Routine collect,

Iron Profile - Blood, Routine collect,

Protein/Creatinine Ratio - Urine, Routine collect,

Renal Function Panel - Blood, Routine collect,

Magnesium Level - Blood, Routine collect,

Urinalysis Microscopic - Routine collect,

Urine Sodium Level - Urine, Routine collect,

Urine Urea Nitrogen - Urine, Routine collect,

Consider Fractional Excretion of urea if Diuretics have been given.

FENA= 100 X (Sodium Urinary X Creatinine Plasma / Sodium Plasma X creatinine Urinary); Results less than 1% points to pre-renal; Results greater than 2% points to ATN or post renal (NOTE)*

Diagnostic Tests

NO IV contrast studies (NOTE)*

If obstruction is suspected order Renal Ultrasound (NOTE)*

US Renal

Consults/Referrals

Consult to Nephrology Inpatient - Please call Dr. Manpreet Bhandal (832) 213-6502, Dr. Sohaib Karim (520) 878-8733 or Robin Bassett ANP (907) 223-8949

Consult to Pharmacy - Review all medications for nephrotoxicity

*Report Legend:

DEF - This order sentence is the default for the selected order GOAL - This component is a goal

ACUTE KIDNEY INJURY 78

IND - This component is an indicator INT - This component is an intervention IVS - This component is an IV Set NOTE - This component is a note

Rx - This component is a prescription SUB - This component is a sub phase

Appendix D

AKI Trifold Handout

AKI Awareness

The AKI excel calculator can help identify and stage AKI.

Enter the baseline creatinine.
Enter current creatinine level.

If available, consider entering 48 hourly urine output measurements.

AKIN and RIFLE criteria are used to determine and stage AKI.

Serum creatinine rise > 50% or >.0.3mg/dl over baseline.

Remember, serum creatinine is affected by many factors, including:

- Critical illness
- Muscle mass
- Age
- Gender
- Nutritional status
- Fluid overload

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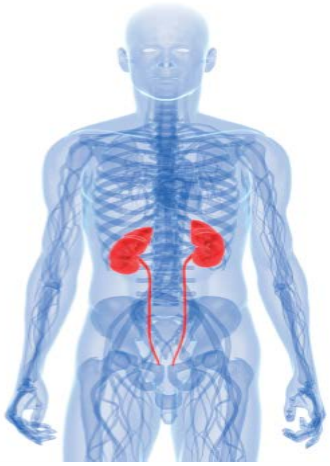
Acute Kidney Injury



What is acute kidney injury?

Acute kidney injury (AKI) is a potentially reversible condition in which kidney function is reduced.

- Serum creatinine and urine output are used to diagnose AKI. Do not use glomerular filtration rate (eGFR) as this is inaccurate.
- AKI occurs hours to days after insult or injury but serum creatinine can take up to 2 days to change.
- AKI is preventable, costly and increases the risk of chronic kidney disease, cardiovascular disease, hospital length of stay and morbidity and mortality.

What causes acute kidney injury?

The cause of AKI should be determined and treated whenever possible. AKI is usually the result of acute tubular injury commonly due to:

- Medications
  - NSAIDs
  - Aminoglycosides
  - Vancomycin
  - Amphotericin B
  - IV Contrast
- Decreased blood flow (low BP)
- Sepsis
- Combination of factors (stacking)

Acute kidney injury is preventable

The top 4 things to know about acute kidney injury:

1. AKI increases length of stay by three days and 300,000 people die annually.
2. AKI is not well recognized by health care providers.
3. Those who survive AKI have a higher risk of cardiovascular and kidney disease.
4. AKI costs in excess of nine million dollars annually.

What can you do to increase AKI awareness?

- Use excel spreadsheet to help identify and stage AKI
- Assess fluid status frequently
  - Weight changes
  - Intake and output
- Review medications
- Review BP and avoid hypotension when possible (MAP at least 65)
- Use the Protocol for Renal Protection Orders in Cerner to help initiate and guide care for AKI
- Consult Nephrology **early**

Appendix E

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