NCPD 2.0 ANCC Contact Hours

Acute Kidney Injury: Iterative Development of an Audit Tool for Trauma Patients

Andrew Holt, BSN, RN ■ Jordan Rahm, BA ■ H. Andrew Hopper, MD, FACS ■ Darrell L. Hunt, MD, PhD, FACS

BACKGROUND: Acute kidney injury is a low-volume, high-risk complication in trauma patients and is associated with prolonged hospital length of stay and increased mortality. Yet, no audit tools exist to evaluate acute kidney injury in trauma patients.

OBJECTIVE: This study aimed to describe the iterative development of an audit tool to evaluate acute kidney injury following trauma.

METHODS: Our performance improvement nurses developed an audit tool to evaluate acute kidney injury in trauma patients using an iterative, multiphase process conducted from 2017 to 2021, which included a review of our Trauma Quality Improvement Program data, trauma registry data, literature review, multidisciplinary consensus approach, retrospective and concurrent review, and continuous audit and feedback for piloted and finalized versions of the tool.

RESULTS: The final acute kidney injury audit tool can be completed within 30 min using data obtained from the electronic medical record and consists of six sections, including identification criteria, source potential causes, source treatment, acute kidney injury treatment, dialysis indications, and outcome status.

CONCLUSION: The iterative development and testing of an acute kidney injury audit tool improved the uniform data collection, documentation, audit, and feedback of best practices to positively impact patient outcomes.

KEY WORDS: Acute kidney injury, Audit tool, Performance improvement, Quality improvement, Trauma

Cite as: Holt, A., Rahm, J., Hopper, A., Hunt, D.L., (2023). Acute kidney injury: iterative development of an audit tool for trauma patients. *Journal of Trauma Nursing, 30*(2), 108-114. https://doi.org/10.1097/JTN.0000000000000710

Acute kidney injury is a low-volume, high clinical impact adverse event leading to dramatic increases in trauma patient mortality (Levey & James, 2017; Santos & Monteiro, 2015). For trauma programs, acute kidney injury is defined by the National Trauma Data Standard (NTDS) (Kidney Disease: Improving Global Outcomes Grade 3) using changes in serum creatinine levels, glomerular filtration rate, or the need for renal replacement therapy (NTDS, n.d.). Applying this definition, the incidence of acute kidney injury in trauma patients ranges from 1.5% to 12% (Emigh et al., 2020; Fujinaga et al., 2017; Santos & Monteiro, 2015). Although the annual number of acute kidney injury events in a trauma program may be small, the devastating effect on clinical outcomes makes comprehensive review of each event important for trauma quality and performance improvement programs.

The development and implementation of performance improvement processes pose unique challenges for trauma performance improvement nurses. Little data exist to assist trauma performance improvement nurses with the standardization of reviews of the complex factors contributing to trauma patient morbidity and mortality (Chua et al., 2009; O'Mara et al., 2014; Santana & Stelfox, 2012). There are no standardized guides for performance improvement nurses to review adverse patient events. In addition, there is no standard method for translating patient reviews into changes in clinical care.

To address the need for a standardized process to evaluate adverse patient events, the performance improvement nurses created and worked through a process to comprehensively evaluate acute kidney injury in admitted trauma patients. The authors hypothesized that a performance improvement process of collaborative discussion between clinical providers and performance improvement nurses would standardize a method for identifying common factors that led to acute kidney injury events. Furthermore, we hypothesized that identifying these commonalities would lead to opportunities for changes in patient care.

Dates: Submitted July 8, 2022; Revised November 22, 2022; Accepted November 22, 2022.

Author Affiliations: Department of Trauma, TriStar Summit Medical Center, Mt. Juliet, Tennessee (Mr Holt); Department of Trauma, TriStar Skyline Medical Center, Nashville, Tennessee (Mr Rahm and Dr Hunt); and Department of Trauma & Surgical Critical Care, Vanderbilt Wilson County Hospital, Lebanon, Tennessee (Dr Hopper).

Portions of these findings were presented as a poster at the virtual 2021 TQIP Annual Conference.

The views expressed in this publication represent those of the author(s) and do not necessarily represent the official views of HCA Healthcare or any of its affiliated entities.

The authors have no conflicts of interest to disclose.

Correspondence: Andrew Holt, BSN, RN, Department of Trauma, TriStar Summit Medical Center, 660 S. Mt. Juliet Rd, Mt. Juliet, TN 37122 (Andrew.Holt@hcahealthcare.com).

KEY POINTS

- Acute kidney injury dramatically increases trauma patient mortality.
- Collaborative discussion and data review led to the creation of an acute kidney injury audit tool.
- The acute kidney injury audit tool identified opportunities for clinical care interventions.
- Nurse-driven audit tool improved the care of trauma patients with acute kidney injury.

OBJECTIVE

This study aims were to describe the iterative development of an audit tool to evaluate acute kidney injury following trauma.

METHODS

Setting

The performance improvement project was performed at a tertiary referral, American College of Surgeons-verified Level II trauma center that admits nearly 3,000 injured patients annually. The institution is a part of a trauma system consisting of five hospitals serving an area of approximately 28,000 square miles, encompassing an urban city in the American South and the southern portion of a neighboring state. The 298-bed hospital is a part of a national private network of patient care facilities.

Original Audit Tool

During the fourth quarter of 2019, our institution's Trauma Quality Improvement Program (TQIP) 2019 Fall Report revealed an unexpectedly high observed to expected (O:E) ratio of acute kidney injury incidence (O:E ratio >2). This cohort consisted of all patients admitted to the institution from October 2018 until September 2019. The trauma medical director met with the performance improvement nurses to discuss ways to identify commonalities among the patients who developed acute kidney injury. The performance improvement nurses retrospectively reviewed all patients who developed acute kidney injury for a 6-month period, from June 2019 to November 2019. To organize and categorize the data collected from the review, the performance improvement nurses reviewed acute kidney injury and performance improvement literature. The literature search was conducted through PubMed.gov using the key words "acute kidney injury," "kidney injury," "trauma," "traumatic," "process improvement," and "performance improvement" alone and in combination.

Quickly, the performance improvement nurses realized that there were no standardized processes for reviewing or meaningfully organizing collected patient data. To address these gaps, the performance improvement nurses created an audit tool with factors considered important for developing acute kidney injury (Santana & Stelfox, 2012; Tolwani et al., 2008). The trauma medical director was the primary representative of the clinical team. In discussion with him, the performance improvement nurses focused on hypotension as the major clinical sign associated with the development of acute kidney injury. The initial audit tool focused on how hypotension was treated—crystalloid, blood component therapy, vasopressors, or antibiotics—with the understanding that these therapies could be used in combination.

Next, the performance improvement nurses focused on identifying the etiology or combination of etiologies responsible for the development of acute kidney injury: prerenal (related to hypovolemia remote of initial trauma resuscitation), trauma (prerenal related to hypovolemia associated with the traumatic event), nephrotoxic substances, septic shock, and a history of chronic renal disease (acute on chronic renal injury). The performance improvement nurses were also interested in how the acute kidney injury was treated (crystalloid, blood component therapy, vasopressors, minimization of nephrotoxic substances, medical management of hyperkalemia, furosemide, change in antibiotic therapy, or renal replacement therapy).

The audit tool also ascertained whether the treating physician was notified of any preacute kidney injury events—low urine output for 4 hr or more, episode of hypotension lasting longer than 10 min. If the patient required renal replacement therapy, the tool identified the indication. The audit tool also evaluated the outcome and concomitant events associated with the acute kidney injury—cardiopulmonary arrest, nephrology consult, normalization of renal function, continued renal replacement therapy, intubation, or other events. The audit tool was also used as a mechanism for secondary review, where judgments were made on the care provided. Opportunities for improvement were taken through a loop closure process.

Iteration 1

During chart review, the performance improvement nurses found inconsistencies in clinical provider definitions and documentation of acute kidney injury. Clinicians documented acute kidney injury for a variety of reasons: decreased urine output over 24 hr, any serum creatinine above the institutional normal range, doubling of patients' admission creatinine, and estimated glomerular filtration rate (eGFR) less than the institutional normal range. Given the differences in clinical and NTDS nomenclature, the first task in data collection was to ensure that patients truly met the NTDS definition of acute kidney injury. For trauma patients,

acute kidney injury is defined as one of the following (NTDS, n.d.):

1. Serum creatinine 3.0 times the baseline;
2. Increase in serum creatinine to 4.0 mg/dl or more;
3. Initiation of renal replacement therapy; and
4. In patients younger than 18 years, decrease in eGFR to less than 35 ml per/1.73 m^2 or urine output less than 0.3 $ml \cdot kg^{-1} \cdot hr^{-1}$ for 24 hr or anuria for 12 hr or more.

The first modification of the acute kidney injury audit tool was applying the NTDS definition to patients clinically identified as developing acute kidney injury. Only patients meeting the NTDS definition of acute kidney injury were reviewed. Applying the NTDS definition to data review from trauma patients admitted from June 2019 to November 2019 yielded four patients. The performance improvement nurses did not think this was an adequate sample for data collection to determine salient patient and patient care factors contributing to the development of acute kidney injury. The retrospective review was expanded to include all the trauma patients meeting the NTDS definition of acute kidney injury from January 2017 until April 2020, yielding 28 patients. These patients had an average patient age of 62.5 years, an injury severity score of 18.9, a mortality rate of 42.9%, and an incidence of chronic kidney disease of 32.1%.

Iteration 2

The retrospective review of these 28 patients prompted an ongoing discussion between the clinical team and the performance improvement nurses, leading to a focus on clinical management of admitted trauma patients, including the adequacy of resuscitation using lactate reduction as an endpoint (Aslar et al., 2004; Qi et al., 2021; Sammour et al., 2009). This second iteration also provided volume details for crystalloid and blood component administration as an additional mechanism to evaluate the patient's initial resuscitation.

Iteration 3

The expanded retrospective review showed that 40% of the acute kidney injuries likely had a prerenal etiology associated with the traumatic event. One third of the acute kidney injury cases occurred past the patient's initial resuscitation, more than 96 hr after admission. Half of the patients had pretrauma kidney disease. The product of the collective review led to a focus on two groups of patients: (1) patients with early acute kidney injury, with acute kidney injury developing within the first 4 days of admission; and (2) patients with late acute kidney injury who developed acute kidney injury beyond Hospital Day 4 (Harrois et al., 2018; You et al., 2022). Most patients with early acute kidney injury were patients of all ages who had extended periods of peritrauma hypotension. Most patients with late acute kidney injury were geriatric trauma patients undergoing operative procedures. These findings led to the third iteration of the acute kidney audit tool to include early and late designations for acute kidney injury. Other common factors associated with acute kidney injury, including low fluid intake, timing of antibiotics, fluid administration for septic patients, and timing for treatment of other organ dysfunctions, were also added to the third iteration of the audit tool (Figure 1).

Data reviewed using the third iteration of the audit tool led to the first review-based change in patient care: The standard intravenous (IV) fluid utilized for resuscitation was changed from normal saline to lactated Ringer's except for patients admitted with traumatic brain injuries. At the time, the performance improvement nurses also performed concurrent reviews of all patients with traumatic brain injuries to ensure lactated Ringer's was only administered to the appropriate patient population. Any deviations from appropriate clinical protocol regarding type of crystalloid administration were immediately reported to the clinical team to mitigate any harm to patients. All deviations were elevated to a secondary review process and presented via a clinical dashboard during trauma performance improvement and patient safety meetings.

The institution heavily relied on the TQIP O:E ratio for acute kidney injury to serve as signposts for the overall direction of patient care regarding acute kidney injury. While the performance improvement nurses worked through iterations of the audit tool, the next TQIP report (spring 2020) revealed that the acute kidney injury O:E ratio had worsened to 3.73. The performance improvement nurses realized that there was substantial patient overlap between the two TQIP reports and that the O:E ratio may have increased because of performance improvement process-related focused attention on acute kidney injury influencing data collection. Given that TQIP reports are a retrospective analysis of patients and events, the performance improvement nurses moved to perform concurrent reviews of patients identified as having an acute kidney injury, excluding patients younger than 18 years and patients undergoing renal replacement therapy before traumatic events.

Concurrent evaluation started with screening all admitted trauma patients at morning multidisciplinary rounds, with specific questions about extended periods of hypotension, lactate clearance, low urine output, fluid imbibement, and serum creatinine. Performance improvement nurses discovered significant inconsistencies in the documentation of urine output and fluid imbibement in the patients with late acute kidney injury, mainly geriatric trauma undergoing operative intervention.

Two changes in clinical care were implemented to address these concerns. Maintenance IV fluids were maintained on geriatric patients with an emphasis on

Acute Kidney Injury (AKI) Audit

Name_____ Trauma Number _____

Date of Admission: _____ Date of AKI identification: _____

AKI Identification:

□ Anuria for 12+ hrs. (< 100ml/day) □ Oliguria (0.3ml/kg/hr. for 24+ hrs.)	Date/Time of decreased urine output _____
□ Creatinine (Cr) 3x baseline □ Creatinine >4	Cr baseline _____ Date/Time_____ Cr peak _____ Date/Time_____
□ Initiated on Dialysis □ Identified in MD notes	Date of Dialysis_____ Date of Nephrology Consult_____

Early AKI (<4 days) □ Appropriate Care □ Care Concerns

□ Advanced Comorbidities: □ Congestive Heart Failure (CHF) □ Chronic Kidney Disease/End Stage Renal Disease (CKD/ESRD) □ Cirrhosis □ Comorbidities inducing hypotension □ Initial Injury/Trauma □ Shock □ Hemorrhagic Shock □ Neurogenic Shock □ Obstructive Shock □ Septic Shock □ Organ dysfunction – respiratory Date: _____ □ Under resuscitation concerns	□ Disease process recognized and care modified to account for concern □ Fluid volume: _____ □ Blood volume: _____ □ Vasopressors (Sepsis and Neurogenic) □ Bleeding control technique performed □ Antibiotics started for known infection □ Appropriate monitoring □ Appropriate hemodynamic monitoring
□ Ongoing hypotension □ 6 – 12 hours post injury □ 12 – 24 hours post injury □ 24 – 48 hours post injury □ Failure to clear lactates	□ Resuscitation concerns:

Late AKI (>5 Days) □ Appropriate Care □ Care Concerns

□ Pneumonia Date: _____ □ Septic Shock Date: _____ □ Dehydration Date: _____	□ Fluids volume: _____ □ Albumin (Sepsis) □ Vasopressors (Sepsis) □ Antibiotics started for known infection

AKI Management: □ Appropriate Care □ Care Concerns

□ Nephrology Consulted □ Fluids Initiated: _____ □ Fluids Stopped: _____ □ Minimized Nephrotoxic agents □ Medical Management of hyperkalemia □ Diuretics □ Bicarb drip: _____ □ Continuous Renal Replacement Therapy/Intermittent Hemodialysis (CRRT/IHD)	Comments: □ Kayexalate: _____ □ D50/ Insulin: _____

Indication for Dialysis: □ Appropriate Care □ Care Concerns

□ Fluid overload □ Hyperkalemia □ Uremia □ Acidosis	Comments:

Outcome/Associated Events

□ Normalized renal function □ Maintained on dialysis □ Cardiac Arrest □ Intubated □ Trauma Death □ Alive at Discharge	Comments:

□ Appropriate care provided □ Event with Opportunity for Improvement

Primary Reviewer/date_____

Figure 1. Acute kidney injury audit: Iteration 3.

documentation of the percentage of meals eaten and the amount of fluid imbibed. Maintenance IV fluids were continued until patients ate at least 50% of their meals and imbibed at least 1 L of fluid. This change did not lead to increased complications, for example, congestive heart failure, atrial fibrillation. The second intervention was to maintain the perioperative Foley catheters until Postoperative Day 1. The institution has a policy of removing all Foley catheters in the postanesthesia recovery unit unless specified by the admitting clinical team. The performance improvement and clinical teams found significant inconsistencies in the documentation of urine output in postoperative patients. Maintaining Foley catheters until Postoperative Day 1 allowed the clinical team to have accurate measurements of urine output to identify patients at risk for acute kidney injury who needed fluid resuscitation or an increase in maintenance IV fluid rates. Perioperatively placed Foley catheters were continued in patients at significant risk for the development of acute kidney injury, defined by a creatinine 2 times baseline and a documented urine output of less than 30 ml/hr. The necessity of a Foley catheter was assessed daily. All Foley catheters were removed when clinically appropriate. This change in clinical care did not lead to increased catheter-associated urinary tract infections.

Use of Audit Tool

It took performance improvement nurses two to four uses to develop alacrity in completing the third iteration of the acute kidney injury audit tool. After these initial uses, performance improvement nurses could accurately produce a comprehensive overview of a patient with or at risk for acute kidney injury in less than 30 min. By intention, the performance improvement nurses choose data fields for which documentation in the electronic medical record was consistently available. This forethought led to 100% completion of all data fields for all iterations. Once the audit tool was completed, it was reviewed by a clinical provider to identify opportunities for changes in patient care.

Using daily screening and the third iteration of the audit tool, 45 concurrently reviewed patients developed NTDS defined acute kidney injury of the approximately 3,900 patients admitted from April 2020 to October 2021. These patients had an average age of 61.5 years, an injury severity score of 14.3, a mortality rate of 51.1%, and an incidence of chronic kidney disease of 21.9%. The reviews showed that 28 patients developed acute kidney injury within 4 days of arrival to the hospital. Eight of those patients required the administration of blood products. Ongoing physiological instability, defined as persistent tachycardia (heart rate >100), multiple episodes of systolic blood pressure less than 90 mmHg, need for vasopressors, and failure to clear serum lactate, played the largest role in early acute kidney injury development (Emigh et al., 2020; Harrois et al., 2018; Santos & Monteiro, 2015). The O:E ratios for acute kidney injuries progressively decreased over

the next four TQIP reports but never reached a ratio of 1. The performance improvement nurses and clinical providers continue to discuss and implement modifications in patient care to ameliorate the development of acute kidney injury in admitted trauma patients.

RESULTS

Retrospective and concurrent review of and daily discussions about trauma patients at risk for or who developed acute kidney injury led to the creation of an audit tool capable of identifying institution-specific patient and patient care factors related to this adverse event. A total of 73 acute kidney injury events were reviewed from January 2017 to October 2021.

Since the development and implementation of the acute kidney injury audit tool, two important findings have been observed. First, a standardized acute kidney injury audit with defined data fields created consistency in the data collected and presented for review, which was important for a high-volume center with a high acuity patient population. Second, the acute kidney injury audit tool was a common point of reference for the performance improvement nurses and clinical providers to review data. Joint data review revealed two populations of trauma patients who developed acute kidney injury: (1) late—mostly geriatric patients undergoing operative intervention; and (2) early—patients of all ages with traumatic event-related physiological instability.

Through the joint review of the data, the following changes were made in patient care: (1) Except for patients with traumatic brain injury, resuscitation crystalloid was changed to lactated Ringer's; (2) geriatric trauma patients were kept on maintenance IV fluids until they could demonstrate intake of at least 1.0 L of fluid; (3) perioperatively placed Foley catheters were continued in patients at risk for development of acute kidney injury as defined by a creatinine 2 times baseline and a documented urine output of less than 30 ml/hr until Postoperative Day 2 to ensure accurate urine output in geriatric trauma patients and removed when medically appropriate. Complications related to these changes were closely monitored with no identified complications, including catheter-associated urinary tract infections. These clinical care interventions contributed to a decrease in the O:E acute kidney injury ratio in admitted trauma patients over the next 18 months, from a peak of 3.73 to a low of 1.51 (Figure 2).

DISCUSSION

There is a significant dearth of information on the performance improvement processes in the care of trauma patients. Several trauma programs have applied the Lean Six Sigma methodology, originally designed to detect and prevent error while reducing waste and process variation (Kaswan & Rathi, 2019; Rathi et al., 2022; Yeh et al., 2011). The Lean Six Sigma's *Define, Measure,*

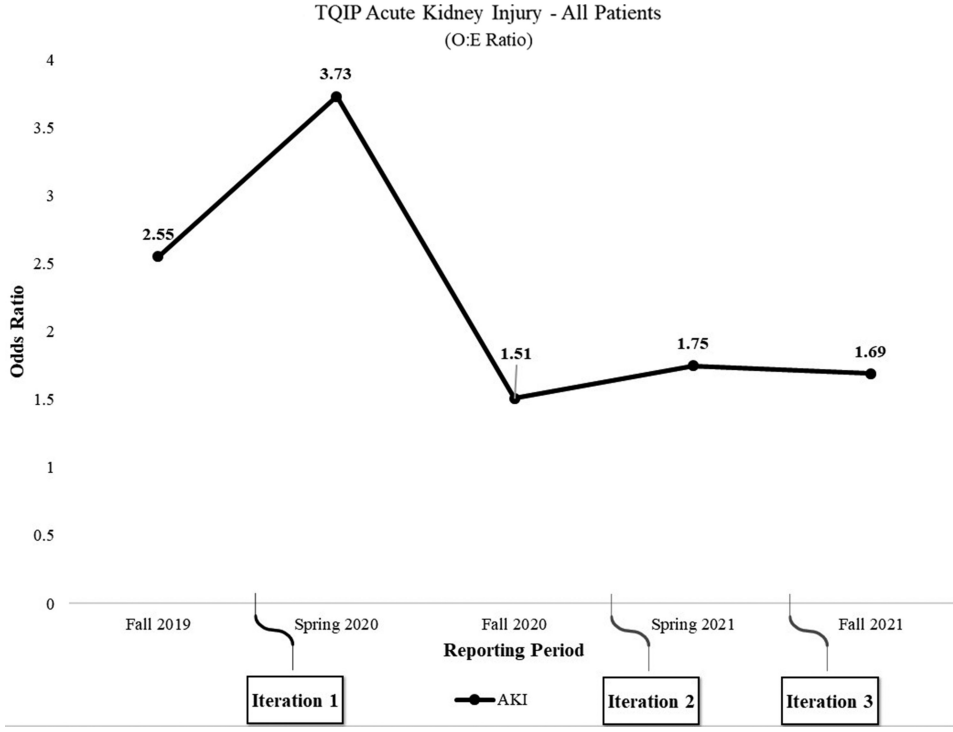

Figure 2. TQIP acute kidney injury by O:E ratio—All patients. AKI = acute kidney injury; O:E ratio = observed to expected ratio; TQIP = Trauma Quality Improvement Program.

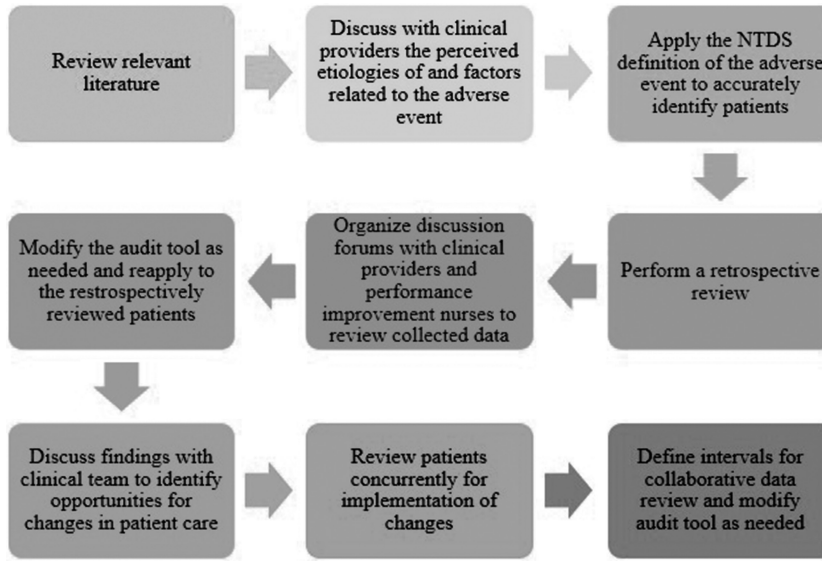

Figure 3. Key steps of the iterative quality improvement process. NTDS = National Trauma Data Standard.

Analyze, Design, and Verify methodology was used for diverse trauma performance improvement projects, from increasing the use of depression screening protocols to increasing the screening of head computed tomography in patients with intracranial hemorrhage (Moran et al., 2020; Niemeijer et al., 2010; Parks et al., 2008). Other projects focused on process efficiency in the care of trauma patients when resuscitative endovascular balloon occlusion of the aorta was deployed but did not use the Lean Six Sigma methodology (Burkard et al., 2020). Although these projects successfully improved process efficiency, there is scant guidance on identifying and categorizing institution-specific patient and patient care factors contributing to adverse patient events.

Audit tools have also been developed to review pediatric trauma cases flagged for adverse events and to measure best practice compliance for geriatric patients with fragility hip fractures (Curtis et al., 2017; MacDonald et al., 2018). Like our adverse event audit tool, the first iterations of these audit tools were created using a literature review, but the iterative maturation of each tool was different. The pediatric audit tool was refined using the consensus opinion of a multidisciplinary team of trauma professionals with the intent of widespread dissemination, whereas the hip fracture audit tool utilized an international cohort of orthopedic nurses to revise and establish a global standard of care and clinical practice evaluation (Curtis et al., 2017; MacDonald et al., 2018). We remained focused on institution-specific patient factors and medical decision-making to highlight the process by which other institutions may develop a mature audit tool.

Figure 3 displays the key steps of the iterative quality improvement process. Using this process, the acute kidney injury audit tool proved invaluable to the trauma program. Presentation and review of audit tool data become a routine part of trauma care, including daily multidisciplinary rounds and monthly performance improvement meetings. Furthermore, the audit tool helped bridge the gap between the performance improvement nurses and clinical providers, creating a collaborative environment in which new ideas were encouraged and prior solutions reimagined. Given the significant success of the acute kidney injury audit tool, the performance improvement team has created similar audit tools to review other medical issues (i.e., severe traumatic brain injury, shock, etc.). The audit tool had an unintended benefit that the authors had not anticipated—a change in culture. As the quality of acute kidney injury reviews increased and more members of the trauma program became involved, the team's expectations changed. The clinical providers demanded longitudinal data collection and review to assist with their clinical decisions. Moreover, longitudinal data review became a focus for all trauma leadership meetings. This surprise benefit strengthened the entire program and improved the teams' collaboration and communication.

The authors acknowledge that the O:E ratio of acute kidney injury incidence is not the most robust measure of improvement in patient care and outcomes. This article is focused on the description of a performance improvement process. The biannual TQIP O:E ratios served as signposts of the overall direction of patient care and were not meant to substitute for a powered quantitative analysis.

CONCLUSION

Standardized performance improvement processes are necessary for consistently evaluating adverse

events in trauma patients. An iterative process of collaborative discussion and data review led to the implementation of an audit tool that impacted clinical care. This process can be adopted by trauma performance improvement programs seeking to positively impact patient outcomes.

Acknowledgment

Data collection and preliminary analyses were sponsored by TriStar Skyline Medical Center. This research was supported (in whole or in part) by HCA Healthcare and/or an HCA Healthcare-affiliated entity.

Orcid iDs

Jordan Rahm https//orcid.org/0000-0001-9067-8365

REFERENCES

Aslar, A. K., Kuzu, M. A., Elhan, A. H., Tanik, A., & Hengirmen, S. (2004). Admission lactate level and the APACHE II score are the most useful predictors of prognosis following torso trauma. *Injury*, *35*(8), 746–752. https://doi.org/10.1016/j.injury.2003.09.030

Burkard, D. J., Thompson, J., Dull, M., Haverkamp, J., Koestner, A., Davis, A., Chadwick, C., Gibson, C. J., Iskander, G., & Chapman, A. J. (2020). Resuscitative endovascular balloon occlusion of the aorta process improvement: Examining a novel case evaluation tool and standardized simulations. *Journal of Trauma Nursing*, *27*(2), 82–87. https://doi.org/10.1097/JTN.0000000000000491

Chua, W. C., D'Amours, S. K., Sugrue, M., Caldwell, E., & Brown, K. (2009). Performance and consistency of care in admitted trauma patients: Our next great opportunity in trauma care? *ANZ Journal of Surgery*, *79*(6), 443–448. https://doi.org/10.1111/j.1445-2197.2009.04946.x

Curtis, K., Mitchell, R., McCarthy, A., Wilson, K., Van, C., Kennedy, B., Tall, G., Holland, A., Foster, K., Dickinson, S., & Stelfox, H. T. (2017). Development of the major trauma case review tool. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*, *25*(1), 20. https://doi.org/10.1186/s13049-017-0353-5

Emigh, B. J., Sahi, S. L., Teal, L. N., Blake, J. C., Heron, C. H., Teixeira, P. G., Coopwood, B., Cardenas, T. C., Trust, M. D., & Brown, C. V. (2020). Incidence and risk factors for acute kidney injury in severely injured patients using current kidney disease: Improving global outcomes definitions. *Journal of the American College of Surgeons*, *231*(3), 326–332. https://doi.org/10.1016/j.jamcollsurg.2020.05.027

Fujinaga, J., Kuriyama, A., & Shimada, N. (2017). Incidence and risk factors of acute kidney injury in the Japanese trauma population: A prospective cohort study. *Injury*, *48*(10), 2145–2149. https://doi.org/10.1016/j.injury.2017.08.022

Harrois, A., Soyer, B., Gauss, T., Hamada, S., Raux, M., & Duranteau, J., & Traumabase® Group. (2018). Prevalence and risk factors for acute kidney injury among trauma patients: A multicenter cohort study. *Critical Care (London, England)*, *22*(1), 344. https://doi.org/10.1186/s13054-018-2265-9

Kaswan, M. S., & Rathi, R. (2019). Analysis and modeling the enablers of Green Lean Six Sigma implementation using interpretive structural modeling. *Journal of Cleaner Production*, *231*, 1182–1191. https://doi.org/10.1016/j.jclepro.2019.05.253

Levey, A. S., & James, M. T. (2017). Acute kidney injury. *Annals of Internal Medicine*, *167*(9), ITC66–ITC80. https://doi.org/10.7326/AITC201711070

MacDonald, V., Maher, A. B., Mainz, H., Meehan, A. J., Brent, L., Hommel, A., Hertz, K., Taylor, A., & Sheehan, K. J. (2018). Developing and testing an international audit of nursing quality indicators for older adults with fragility hip fracture. *Orthopaedic Nursing*, *37*(2), 115–121. https://doi.org/10.1097/NOR.0000000000000431

Moran, M. E., Sedorovich, A., Kish, J., Gothard, A., & George, R. L. (2020). Addressing behavioral health concerns in trauma: Using Lean Six Sigma to implement a depression screening protocol in a Level I trauma center. *Quality Management in Health Care*, *29*(4), 218–225. https://doi.org/10.1097/QMH.0000000000000266

National Trauma Data Standard (NTDS). (n.d.). *ACS*. Retrieved May 4, 2022, from https://www.facs.org/quality-programs/trauma/quality/national-trauma-data-bank/national-trauma-data-standard/

Niemeijer, G. C., Trip, A., Ahaus, K. T. B., Does, R. J. M. M., & Wendt, K. W. (2010). Quality in trauma care: Improving the discharge procedure of patients by means of Lean Six Sigma. *The Journal of Trauma*, *69*(3), 614–618; discussion 618–619. https://doi.org/10.1097/TA.0b013e3181e70f90

O'Mara, M. S., Ramaniuk, A., Graymire, V., Rozzell, M., & Martin, S. (2014). Lean methodology for performance improvement in the trauma discharge process. *The Journal of Trauma and Acute Care Surgery*, *77*(1), 137–142; discussion 142. https://doi.org/10.1097/TA.0000000000000261

Parks, J. K., Klein, J., Frankel, H. L., Friese, R. S., & Shafi, S. (2008). Dissecting delays in trauma care using corporate Lean Six Sigma methodology. *The Journal of Trauma*, *65*(5), 1098–1104; discussion 1104–1105. https://doi.org/10.1097/TA.0b013e318188e8ad

Qi, J., Bao, L., Yang, P., & Chen, D. (2021). Comparison of base excess, lactate and pH predicting 72-h mortality of multiple trauma. *BMC Emergency Medicine*, *21*(1), 80. https://doi.org/10.1186/s12873-021-00465-9

Rathi, R., Vakharia, A., & Shadab, M. (2022). Lean Six Sigma in the healthcare sector: A systematic literature review. *Materials Today: Proceedings*, *50*, 773–781. https://doi.org/10.1016/j.matpr.2021.05.534

Sammour, T., Kahokehr, A., Caldwell, S., & Hill, A. G. (2009). Venous glucose and arterial lactate as biochemical predictors of mortality in clinically severely injured trauma patients—A comparison with ISS and TRISS. *Injury*, *40*(1), 104–108. https://doi.org/10.1016/j.injury.2008.07.032

Santana, M. J., & Stelfox, H. T. (2012). Quality indicators used by trauma centers for performance measurement. *The Journal of Trauma and Acute Care Surgery*, *72*(5), 1298–1302; discussion 1303. https://doi.org/10.1097/TA.0b013e318246584c

Santos, P. R., & Monteiro, D. L. S. (2015). Acute kidney injury in an intensive care unit of a general hospital with emergency room specializing in trauma: An observational prospective study. *BMC Nephrology*, *16*, 30. https://doi.org/10.1186/s12882-015-0026-4

Tolwani, A. J., Campbell, R. C., Stofan, B. S., Lai, K. R., Oster, R. A., & Wille, K. M. (2008). Standard versus high-dose CVVHDF for ICU-related acute renal failure. *Journal of the American Society of Nephrology*, *19*(6), 1233–1238. https://doi.org/10.1681/ASN.2007111173

Yeh, H.-L., Lin, C.-S., Su, C.-T., & Wang, P.-C. (2011). Applying Lean Six Sigma to improve healthcare: An empirical study. *African Journal of Business Management*, *5*(31), 12356–12370. https://doi.org/10.5897/AJBM11.1654

You, B., Yang, Z., Zhang, Y., Chen, Y., Gong, Y., Chen, Y., Chen, J., Yuan, L., Luo, G., Peng, Y., & Yuan, Z. (2022). Late-onset acute kidney injury is a poor prognostic sign for severe burn patients. *Frontiers in Surgery*, *9*, 842999. https://doi.org/10.3389/fsurg.2022.842999

The test for this nursing continuing professional development activity can be taken online at www.NursingCenter.com/CE/JTN.