

# Guidelines for Diuretic Utilization Reduce High Charge Medications

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## Abstract

**Background:** Decreasing practice variation and following evidence-based clinical guidelines improve patient outcomes and often reduce cost. Essentially all postsurgical cardiac patients require diuretics. The approach to diuresis in the pediatric cardiothoracic intensive care unit (CTICU) is not standardized. Our objective was to develop and implement guidelines for diuretic utilization in the CTICU to reduce high charge medication utilization while maintaining the delivery of high-quality care. **Methods:** Two of the top 10 medications by charge in the CTICU during 2016 were diuretics [fenoldopam and intravenous (IV) chlorothiazide]. Standardized diuretic utilization guidelines were developed to reduce the utilization of fenoldopam and IV chlorothiazide. We implemented guidelines in April 2017. The utilization of fenoldopam and IV chlorothiazide, as well as overall diuretic charges, before and after guideline implementation were compared. **Results:** We normalized all comparisons to 100 CTICU patient-days. Fenoldopam starts were reduced from 1.1 in 2016 to 0.03 in 2019 (through February); days of fenoldopam use were reduced from 4 in 2016 to 0.15 days in 2019 (through February); IV chlorothiazide doses decreased from 20 in 2016 to 8 in 2019 (through February). These changes reduced the mean charges for diuretics from \$25,762 in 2016 to \$8,855 in 2019 (through February). CTICU average daily census did not change significantly during the study period (12.8 in 2016 vs 11.8 in 2018). **Conclusion:** Value-added implementation of standardized diuretic utilization guidelines in the CTICU successfully reduced the use of high-charge diuretics without unfavorably impacting the quality of care delivery. (*Pediatr Qual Saf* 2019;4:e237; doi: 10.1097/pq9.000000000000237; Published online November 25, 2019.)

## INTRODUCTION

There are many reasons for alterations of intravascular and total body fluid in pediatric patients following cardiac surgery, including intrinsic myocardial dysfunction, neuroendocrine response, renal dysfunction, inflammatory cascade induced by cardiopulmonary bypass, increased capillary permeability, decreased plasma oncotic pressure, increased tissue osmotic pressure, and endothelial dysfunction.<sup>1-4</sup> Capillary leak and low cardiac output syndrome were also more

pronounced during the first 6 to 18 hours following cardiac surgery.<sup>5,6</sup> The resulting fluid overload is associated with acute kidney injury, prolonged mechanical ventilation, need for vasoactive support, prolonged intensive care unit and hospital lengths of stay, and mortality.<sup>1,7-9</sup> To combat these adverse effects, reducing extravascular fluid accumulation with diuretics is one of the management mainstays for pediatric patients following cardiac surgery.

Evidence-based clinical practice guidelines have been touted as a modality to reduce practice variation, improve quality of care, and contain cost.<sup>10</sup> Guidelines require a redesign of a work process, effective communication strategies, infrastructure for support, and continuous measurement as well as vigilance for a lag in compliance. According to the Institute of Healthcare Improvement's strategy for designing systems, the first step is to create a simple, standardized approach or guideline that is minimally controversial.<sup>11</sup> The second step is to evaluate adherence to the guideline. The next steps utilize strategies of standard order sets, checklists, education, and training. Finally, once the standardized process is in place, a review of compliance can be used to identify process failures and understand barriers to implementation, which should lead to process revision and guideline improvement.<sup>11</sup> We used this methodology to develop evidence and experience-based diuretic utilization guidelines in our pediatric



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cardiothoracic intensive care unit (CTICU) to reduce the utilization of high charge medications while maintaining quality patient care. We hypothesized that by (1) increasing awareness of the charges for individual diuretic agents and (2) creating logical, simple guidelines for usage we would successfully (a) reduce the number of fenoldopam starts from 1.1 to 0.6 per 100 CTICU days; (b) reduce the number of fenoldopam days from 4 to 2 per 100 CTICU days; (c) reduce the number of intravenous (IV) chlorothiazide doses from 20 to 16 per 100 CTICU days by January 2018. Further, we hypothesized that there would be a reduction of diuretic charges per 100 CTICU days by 25% from \$25,762 (in 2016) to \$19,322 by January 2018.

## METHODS

### Ethical Issues

This quality improvement work involved the development and implementation of guidelines for diuretic utilization in the pediatric CTICU to reduce the utilization of high-charge diuretics while maintaining quality patient care. No interventions involved a comparison of multiple devices or therapies, and patients were not subjected to randomization. Medical records were accessed by health-care staff and quality improvement team members as part of their normal responsibilities. This project does not meet the definition of human subject research. Therefore, institutional review board review was not required.

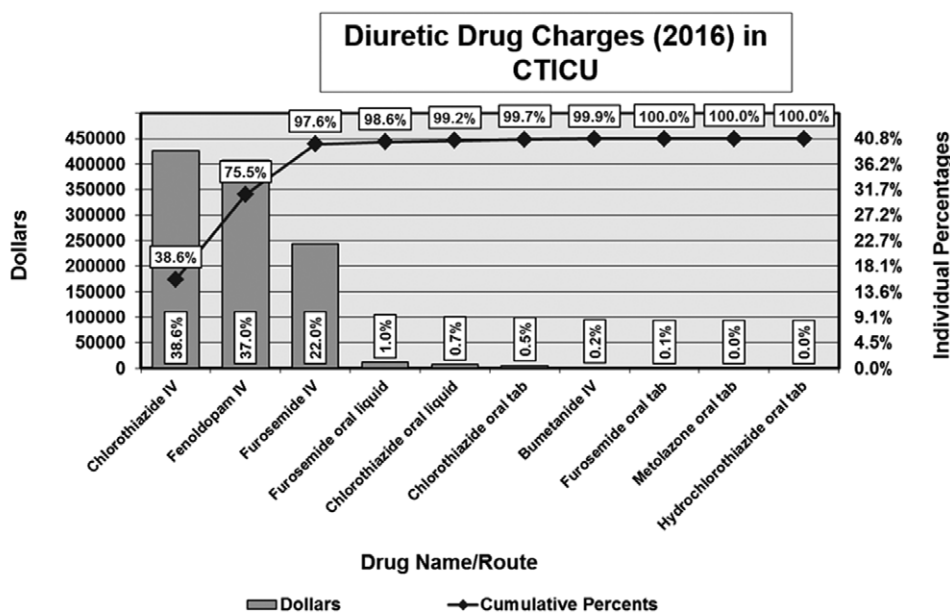
### Setting

Nationwide Children’s Hospital is an academic, nonprofit, freestanding children’s hospital located in Columbus, Ohio. The CTICU is a 20-bed unit with over 600 admissions per

year. All cardiothoracic surgical patients undergoing repair or palliation of congenital heart disease are admitted to the CTICU for postoperative management. The top 5 most common admission diagnoses are postoperative ventricular septal defect repair, hybrid palliation stage I, hybrid palliation comprehensive stage II, pulmonary valve replacement, and Fontan procedure. Approximately 10% of admissions are newborns, defined as <30 days of age. The CTICU staff includes a multidisciplinary team of critical care and cardiology physicians (n = 10), pediatric cardiac surgeons (n = 4), advanced practice nurse practitioners (n = 10), a dedicated clinical pharmacist (n = 1), registered nurses (n = 61), respiratory therapists (n = 14), cardiology and critical care physicians in fellowship training, clinical dietitians, physical and occupational therapists, child life specialist, and social worker. The choice of diuretics utilized for the patients in the CTICU is the responsibility of the critical care and cardiology physicians.

### Planning the Intervention

A multidisciplinary team was recruited to develop and implement standardized guidelines for diuretic utilization in the CTICU. The team included physicians, advanced practice nurse practitioners, a pharmacist, and representatives from the quality improvement team. We began by creating a SMART (specific, measurable, achievable, realistic, timely) aim statement and key driver diagram.<sup>11,12</sup> We identified patient factors, staff education, staff accountability, communication and collaboration among the key stakeholders, standardized guidelines, and measurable outcomes as the relevant key drivers. Our primary (SMART) aims were to (1) reduce the number of fenoldopam starts from 1.1 to 0.6 per 100 CTICU days; (2) reduce the number of fenoldopam days from 4 to 2 per 100



NOTE: Adjacent bars of the same pattern are statistically equal (p > 0.01). Any differences in height should be considered random.

Fig. 1. Top 10 diuretic drug charges in the cardiothoracic intensive care unit in 2016.

CTICU days; and (3) reduce the number of IV chlorothiazide doses from 20 to 16 per 100 CTICU days by January 2018. Our secondary aim was to decrease the charges for diuretics per 100 CTICU days by 25% from \$25,762 (in 2016) to \$19,322 by January 2018.

**Intervention**

The interventions or process changes introduced included: (1) establishment of guidelines for diuretic utilization in the CTICU to reduce variation that were simple and minimally controversial; (2) education and training of the CTICU staff regarding the guidelines and goals; (3) obtaining staff buy-in and accountability; (4) development of measurable outcomes. A Pareto chart of diuretic medication use by charge in the CTICU demonstrated that fenoldopam and IV chlorothiazide accounted for 75% of all diuretic charges

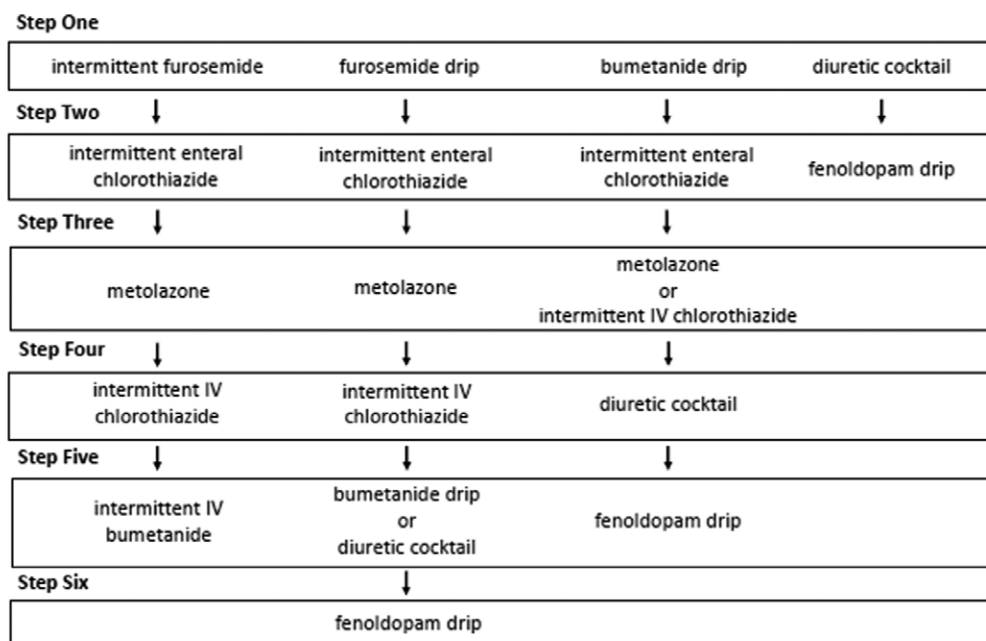
in 2016 (Fig. 1). Standardized diuretic utilization guidelines were developed to reduce the utilization of fenoldopam and IV chlorothiazide, as outlined in Figure 2. After the necessary vetting and education of providers and nursing staff, we implemented these guidelines in April 2017.

We chose patients undergoing procedures in STAT (Society of Thoracic Surgeons-European Association for Cardio-Thoracic Surgery) score categories 1, 2, 3, and 4 as our cohort for counterbalancing measures as they are most likely to suffer from postop fluid overload and edema. The length of CTICU stay would be prolonged if our intervention resulted in ineffective diuresis and post-operative fluid management, and thus was chosen as our balancing measure to verify that these process changes did not impact the overall quality of care provided.

**Guidelines for Diuretic Usage in the CTICU**

**Goal:** Cost effective diuresis. No evidence-based practice or data to support which pathway or algorithm will result in the desired diuresis in a particular patient population. The steps listed below are guidelines only; patient management may be individualized as appropriate per practitioner discretion.

Step one may be intermittent furosemide, furosemide drip, bumetanide drip, or diuretic cocktail (combination of furosemide and chlorothiazide as a 1:5 ratio, dosing based on furosemide content and administered as an infusion).



- Dose and frequency for intermittent drug administration is at practitioner discretion
- At any point in the intermittent furosemide algorithm, one may change to the furosemide drip, bumetanide drip or diuretic cocktail pathway
- At any point in the furosemide drip algorithm, one may change to the bumetanide drip or diuretic cocktail pathway
- If initiation of fenoldopam does not increase urine output by at least 20% after 24 hours of use (once at a max dose of 0.4 mcg/Kg/minute), fenoldopam should be discontinued
- After 3 days of fenoldopam usage, there should be a trial off for 24 hours to assess continued need

Fig. 2. Diuretic utilization guidelines.

### Method of Evaluation and Analysis

Once implemented, we tracked data on diuretic utilization (including fenoldopam and IV chlorothiazide) and diuretic charges. Charges are defined as what the institution bills the patient for the medication. Compliance with diuretic utilization guidelines was confirmed via the first Plan-Do-Study-Act cycle with monthly reports on prescribing practice, including medication starts and prolonged usage. Data were reviewed at monthly staff meetings as part of a second Plan-Do-Study-Act cycle to maintain compliance with guidelines. Following implementation, we found that fenoldopam and IV chlorothiazide usage had decreased. This success was shared, celebrated, and reinforced with all team members. Results were sustained secondary to (1) continued monthly feedback to practitioners and (2) most importantly, a dedicated pharmacist on daily rounds to reinforce adherence to the guidelines.

### RESULTS

We reduced fenoldopam starts per 100 CTICU patient days from 1.1 in 2016 to 0.03 in 2019 (through February), as shown in the run chart in Figure 3. If fenoldopam was started, its duration of use per 100 CTICU patient days decreased from 4 days in 2016 to 0.15 in 2019 (through February), as shown in Figure 4. IV chlorothiazide doses per 100 CTICU patient-days similarly decreased from 20

doses in 2016 to 8 in 2019 (through February), as shown in Figure 5. The median total monthly diuretic charge was \$100,914 (range \$52,526–\$129,757) pre-guideline implementation versus \$12,998 (range \$6040–\$31,972) post-guideline implementation. Mean per-patient charges for diuretics per 100 CTICU patient-days was reduced from \$25762 ( $\pm$ \$26945) in 2016 to \$8855 ( $\pm$ \$7185) in 2019 (through February), as shown in Figure 6.

There was no significant change in the patient population or the number of patient-days during this timeframe. The CTICU average daily census in 2016 was 12.8; the average daily census in 2018 was 11.8. Our balancing measure of postoperative ICU length of stay for STAT 1–4 patients was not impacted by our change in diuretics utilization; STAT 1–2 ICU length of stay median 4 days (range 1–238) in 2016 (n = 212) versus ICU length of stay median 4 days (range 1–200) in 2018 (n = 177); P = 0.16; STAT 3–4 ICU length of stay median 5 days (range 1–160) in 2016 (n = 99) versus ICU length of stay median 4 days (range 1–142) in 2018 (n = 68); P = 0.56.

### DISCUSSION

High healthcare costs, practice variation, and the impact on the quality of care delivered have spurred the increasing development of value-based care models. Healthcare practitioners have responded to this need, in part, by

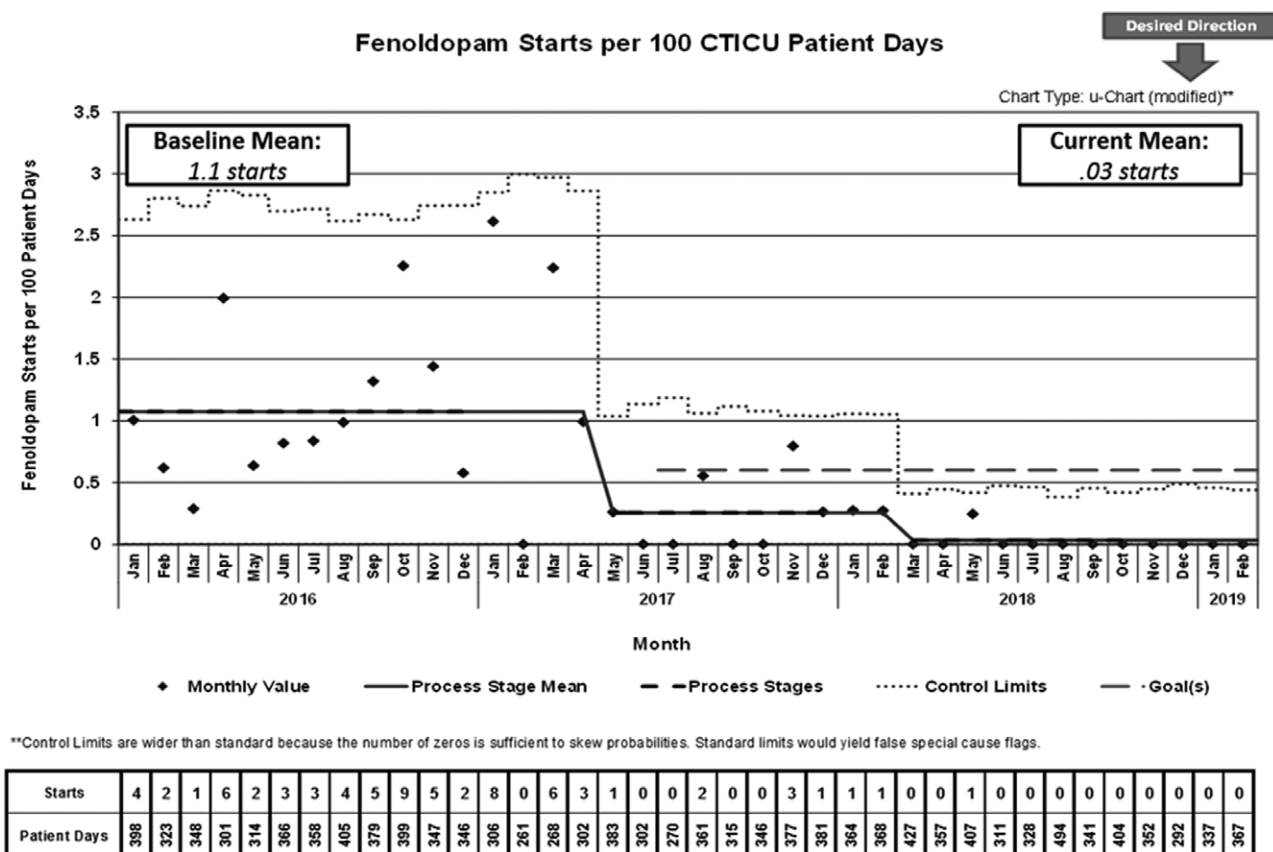


Fig. 3. Fenoldopam starts per 100 cardiothoracic intensive care unit patient days.



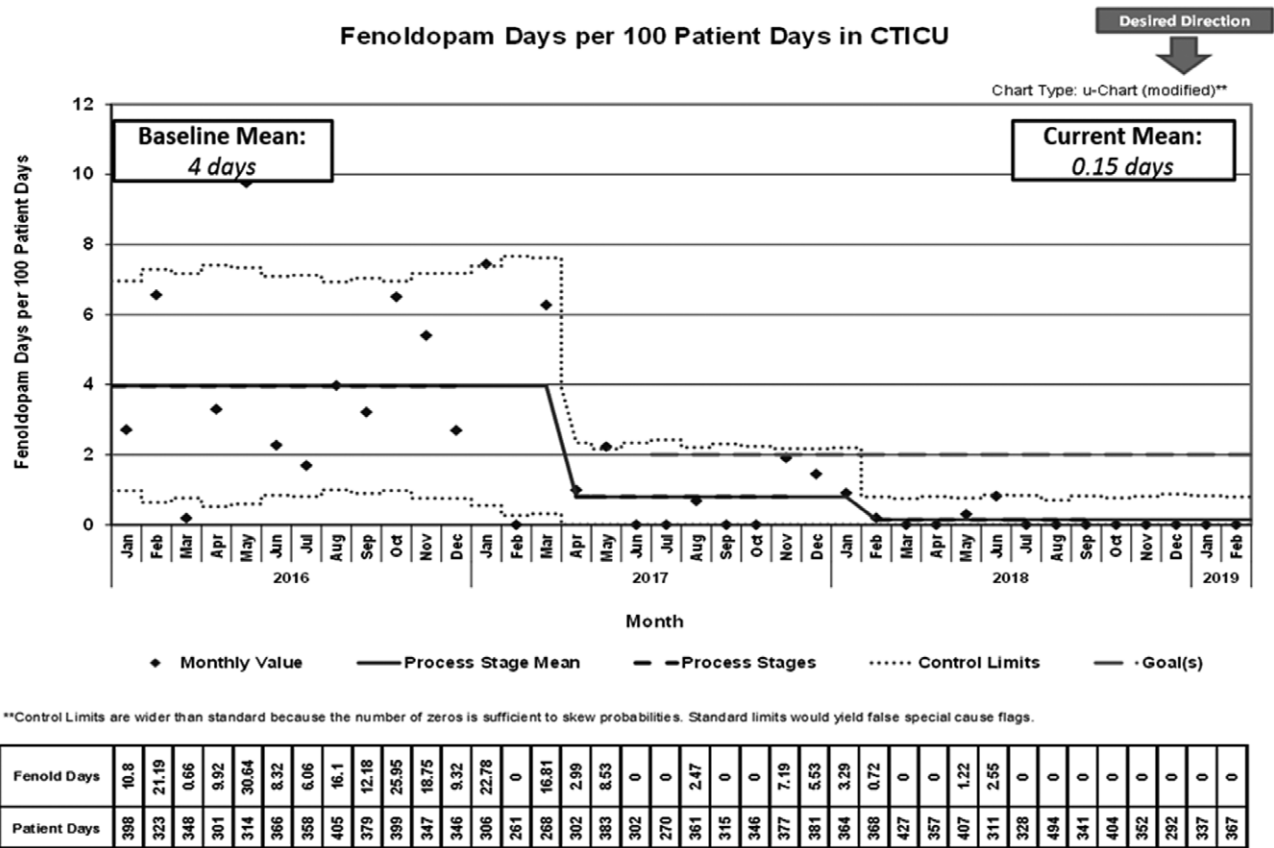


Fig. 4. Fenoldopam days per 100 cardiothoracic intensive care unit patient days.

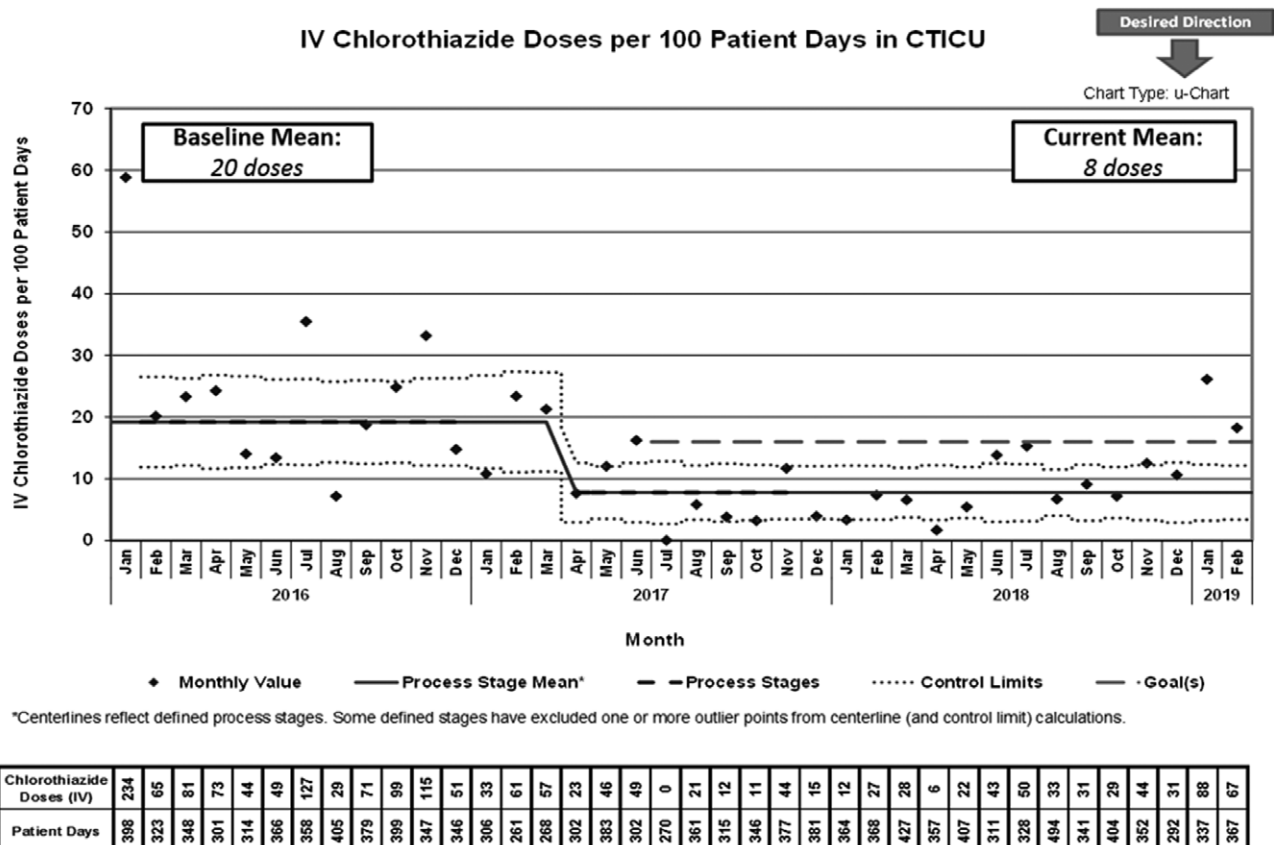


Fig. 5. Intravenous chlorothiazide doses per 100 cardiothoracic intensive care unit patient days.

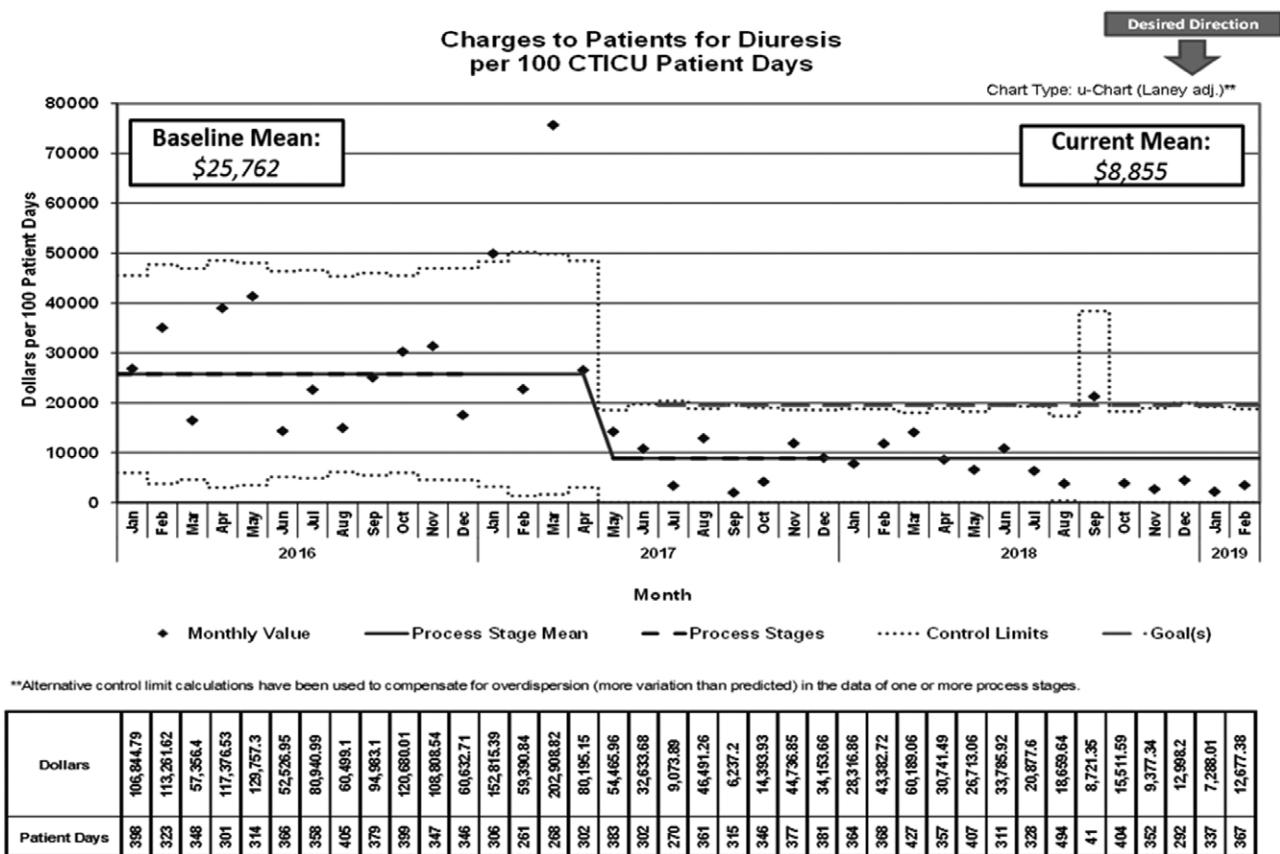


Fig. 6. Charges to patient for diuresis per 100 cardiothoracic intensive care unit patient days.

generating evidence-based clinical guidelines.<sup>10</sup> Practice guidelines are systematically developed management protocols intended to assist with decisions regarding appropriate care for certain medical situations.<sup>11</sup> These guidelines are intended to improve decision-making and optimize patient outcomes. They may reduce patient charges and institutional costs if appropriate.<sup>10,11</sup> With the development and implementation of guidelines for diuretic utilization in the CTICU, we successfully reduced the utilization of fenoldopam and IV chlorothiazide, which resulted in decreased diuretic charges to the patient without impacting the length of CTICU stay.

Our first step towards obtaining staff buy-in for the guidelines was the review of the diuretic utilization and charges from the previous year. We highlighted the variability of diuretic selection by practitioners and associated charges for certain drugs (specifically fenoldopam and IV chlorothiazide). The awareness of practitioner variation in diuretic utilization coupled with a hospital-wide initiative to reduce cost in all units spearheaded the initiative. Practitioners ultimately realized that their choice in diuretic was based on individual preference and experience due to a lack of published evidence supporting superiority or inferiority. The guidelines still allowed for individual preference with 2 caveats: (1) assuring trial of cheaper diuretics before initiation of fenoldopam and IV chlorothiazide and (2) limiting the duration of fenoldopam

if there was a lack of response. Individual practitioner buy-in and accountability were reinforced by periodic review of usage, patient outcomes, and charges throughout the year at staff meetings and via email communications. A key to success was unit-based pharmacist participation during rounds to guide the diuretic choice according to the guidelines.

Fenoldopam is a selective D1 dopamine receptor agonist that promotes renal vasodilation. There are mixed data in adults regarding its utility to promote urine output and preserve renal function.<sup>15-18</sup> In the pediatric population, the outcome data are also limited and inconsistent.<sup>19-22</sup> Ricci et al,<sup>21</sup> in a prospective trial of empiric use, was not able to demonstrate increased urine output or improved renal function. In a second prospective, randomized, double-blind, placebo-controlled study of empiric high dose fenoldopam use following cardiac surgery in infants, Ricci et al<sup>22</sup> demonstrated a decreased need for vasodilators and diuretics. Based on these inconsistent results, and its high charge, we chose fenoldopam as a targeted drug in our diuretic utilization guidelines. Despite the limited evidence regarding fenoldopam use in postoperative pediatric cardiac surgery patients, we felt fenoldopam could be indicated in certain cases. Therefore our guidelines were written to allow the use of fenoldopam in the case of insufficient urine output once all other diuretics had been trialed. However, if the

initiation of fenoldopam did not increase urine output by 20% after 24 hours of use at a max dose of 0.4 µg/kg/min, the guidelines advised the discontinuation of fenoldopam. Additionally, after 3 days of fenoldopam use, the guidelines recommended a trial off fenoldopam for 24 hours to assess continued need.

IV chlorothiazide was targeted as the second agent to reduce usage. While there are limited studies regarding the efficacy of thiazide diuretics in the pediatric cardiac population, there is ample anecdotal experience.<sup>1</sup> Chlorothiazide is commonly used in the pediatric cardiac population in conjunction with loop diuretics to increase urine output in the setting of loop diuretic resistance.<sup>1,13,14</sup> IV chlorothiazide is much more costly compared with the enteral form with similar bioavailability and efficacy. Therefore, we chose the enteral route as the preferred route for initial chlorothiazide diuretic utilization before utilizing the IV route if appropriate for the individual patient in our guidelines.

Fenoldopam and IV chlorothiazide utilization decreased with guideline initiation. Most practitioners agreed that the lack of evidence for fenoldopam usage in this patient population and its cost warranted the limitation of its use in the guidelines. We reduced the IV chlorothiazide usage, and the enteral route increased for chlorothiazide administration after the implementation of guidelines. Practitioners were comfortable utilizing the enteral route of administration as most of the patients were receiving some enteral nutrition by 24–48 hours postoperatively. The option to utilize the IV route of chlorothiazide was included in the guidelines if inadequate diuresis was not achieved with the enteral formulation, but we found that the enteral route resulted in effective diuresis in most cases.

To confirm that we did not adversely affect the quality of patient care from the implementation of diuretic utilization guidelines, we reviewed the CTICU average daily census and length of stay for STAT category 1–4 patients during the study timeframe. The average daily census was similar before and after the institution of the guidelines. Importantly, there was no increase in the length of stay for STAT category 1–4 patients following guideline initiation, suggesting that guideline use did not impair our ability to achieve adequate fluid removal within this cohort or adversely prolong CTICU stays.

Compliance with the guidelines was reinforced daily during rounds by the unit-specific pharmacist. This intervention was key in reminding the practitioner of the presence of the guidelines and the next steps in diuretic utilization. There was a dramatic decrease in fenoldopam and IV chlorothiazide usage in the months following guideline implementation, and we have sustained the decrease for almost a year. We believe that the reduction in the use of fenoldopam and IV chlorothiazide was related to the introduction and actual use of the guidelines, as opposed merely to a general change in the use of fenoldopam and IV chlorothiazide.

## Lessons Learned

Key components that contributed to our successful process include involving a multi-disciplinary team to question and explore our current practice variability; developing and implementing simple guidelines to reduce variation and change the practice pattern; holding staff accountable for implementation and outcomes; monitoring to ensure the intervention was successful; and sharing the results with the staff of the CTICU.

## CONCLUSIONS

Implementation of standardized diuretic utilization guidelines in the CTICU was successful in decreasing fenoldopam and IV chlorothiazide usage, thus reducing patient diuretic charges. Quality of care was maintained, as evidenced by no change in CTICU length of stay for all STAT categories.

## DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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