Duration of Inpatient Observation After Transition to Oral Diuretics: Effect on 30-Day Readmissions for Heart Failure Patients

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Abstract

Heart failure, the fifth most common cause for hospitalization, is associated with the highest 30-day readmission rate among all diagnoses in the United States (Finger, Barrett, & Jiang, 2017; McDermott, Elixhauser, & Sun, 2017). A strong incentive to reduce 30-day readmissions has come from the association between increased mortality and subsequent heart failure readmissions, as well as reimbursement penalties imposed on hospitals in cases of 30-day all-cause readmissions for heart failure patients (Gupta & Fonarow, 2018, Lin, Chin, Sicignano, & Evans, 2017). Decongestive therapy with intravenous (IV) loop diuretics is part of the standard of care for patients hospitalized with acute-on-chronic decompensated heart failure (Yancy et al., 2013). A large proportion of patients admitted with acute-on-chronic decompensated heart failure are inadequately decongested prior to discharge, putting them at risk for 30-day hospital readmission (Gheorghiade et al., 2006; Lala et al., 2015). Since assessment methods for adequate decongestion have demonstrated limitations, current expert recommendations advocate for at least 24 hours of inpatient observation following the transition from IV to oral loop diuretics (Hollenberg et al., 2019). This quality improvement project designed to elucidate the utility of this recommendation for local implementation did not find evidence to support the use of a 24-hour cutoff point for inpatient observation of patients with chronic stage C heart failure with reduced left ventricular ejection fraction ($\leq$ 40 percent) hospitalized for acute-on-chronic decompensated heart failure. This result should be interpreted with caution given the project's methodological limitations inherent to the observational design and small sample size.

Keywords: heart failure hospitalization, 30-day hospital readmission, loop diuretic therapy, duration of inpatient observation

Introduction

Problem Description

Heart failure is a clinical syndrome caused by the inability of the heart to maintain adequate cardiac output in response to the body's metabolic needs without generating abnormally elevated intracardiac filling pressures (Kemp & Conte, 2012). The primary physiological consequences of this functional impairment are vascular congestion and impaired organ perfusion (Kemp & Conte, 2012). Fluid retention and increased intracardiac pressures leading to pulmonary edema eventually becomes a progressive maladaptive consequence of compensatory neurohormonal and autonomic activation, that often serves as the nidus for patients with heart failure to seek medical attention (Kemp & Conte, 2012). Cardiac remodeling, another important progressive maladaptive consequence of compensatory neurohormonal and autonomic activation, is responsible for the progressive nature of this syndrome which may be partially mediated by chronic treatment with specific sympatholytic and neurohormonal antagonizing medications (Kemp & Conte, 2012).

Heart failure is a complex, heterogeneous condition with variable levels of dysfunction and progression. Heart failure may result primarily from systolic dysfunction characterized by a reduced left ventricular ejection fraction (LVEF) of 40 percent or less, diastolic dysfunction characterized by a preserved LVEF of 50 percent or greater, or mixed systolic and diastolic dysfunction (Inamdar & Inamdar, 2016). Furthermore, heart failure may result from left, right, or biventricular dysfunction (Kirali, Özer, & Özgür 2017). Heart failure can have an acute, chronic, or acute-on-chronic presentation (Sinnenberg & Givertz, 2019). The majority of acute heart failure hospitalizations are related to acute exacerbations of chronic heart failure, termed acute-on-chronic decompensated heart failure (Sinnenberg & Givertz, 2019). Acute-on-chronic

decompensated heart failure may develop in response to a variety of causes, such as myocardial ischemia, arrythmias, medication or dietary non-adherence, uncontrolled hypertension, and acute viral or bacterial infections (Sinnenberg & Givertz, 2019). A progressively increased risk for mortality has been associated with each subsequent heart failure hospitalization that a patient experiences following an initial heart failure hospitalization, which provides an important rationale for avoiding rehospitalizations (Lin, Chin, Sicignano, & Evans, 2017).

Initial treatment with intravenous (IV) loop diuretics is part of the standard of care for patients hospitalized with acute-on-chronic decompensated heart failure, due to their effectiveness for relieving symptoms of intravascular fluid volume overload (Yancy et al., 2013). However, no consensus exists in regard to the appropriate approach for determining stability prior to hospital discharge on maintenance therapy with oral (PO) loop diuretics following the transition from a course of IV loop diuretic therapy (Gheorghiade, Filippatos, De Luca, & Burnett, 2006; Gheorghiade et al., 2010; Ponikowski et al., 2015; Yancy et al., 2013; Yancy et al., 2017). This lack of consensus has placed adult patients hospitalized with acute-on-chronic decompensated heart failure at an increased risk for rehospitalization related in part to the potential for such patients to be discharged prior to achieving optimal decongestion without the establishment of a PO loop diuretic regimen most likely to be effective at maintaining appropriate volume status in the near-term post-discharge setting (Gheorghiade et al., 2006).

Available Knowledge

Background. A number of potential surrogates for determining congestion status following a course of IV loop diuretic therapy have been identified within the literature. These have included hemoconcentration (based on relative changes in erythrocyte and protein concentration), B-line quantification (via point of care ultrasonography), natriuretic peptide

concentration, and relative weight change; however, each of these potential surrogates has come with limitations including inconsistently defined cutoff points and the requirement for specialized diagnostic equipment (Ambrosy et al., 2017b; Beltrami et al., 2017; Breidthardt et al., 2017; Coiro et al., 2015; Coiro et al., 2016; Darawsha et al., 2016; Fujita et al., 2018; Gargani et al., 2015; Greene et al., 2013; Kiernan et al., 2018; Kociol et al., 2013; Oh et al., 2013; Öhman, Harjola, Karjalainen, & Lassus, 2018; Omar & Guglin, 2017; Pimenta et al., 2010; Stolfo et al., 2017; Ter Maaten et al., 2016; Testani et al., 2010; Testani et al., 2013). In light of such limitations, current expert opinion has suggested that clinicians should assess a combination of clinical signs, symptoms, and laboratory findings to make the determination for patient readiness to transition from IV to PO loop diuretics (Hollenberg et al., 2019). Despite clinicians' best efforts to make an accurate assessment of intravascular volume status at the time of diuretic transition, observational studies have suggested that a large proportion of patients admitted for acute decompensated heart failure are discharged without having achieved adequate decongestion, which has been associated with the need for rehospitalizations in the near-term post-discharge period (Gheorghiade et al., 2006; Lala et al., 2015). The limitations of the clinical/laboratory assessment of intravascular volume have thus raised a question in regard to whether the length of inpatient observation following the transition from IV to PO loop diuretics may have the ability to alter near-term post-discharge readmission risk (Hollenberg et al., 2019).

Literature review. There has been conflicting and limited evidence surrounding the association between length of inpatient observation following the transition from IV to PO loop diuretic therapy and near-term hospital readmission risk. The strongest evidence available has supported the practice of prolonged observation following diuretic transition as a potential way to reduce near-term hospital readmissions. Laliberte et al. (2017) conducted a retrospective

single-center observational study that included 123 adult patients hospitalized with acute decompensated heart failure with reduced LVEF. The sample included 61 patients who were observed for less than 24 hours and 62 patients observed for 24 hours or longer after the ultimate transition to PO loop diuretics following a course of IV loop diuretic therapy. The groups were well matched in terms of age, sex, New York Heart Association functional class, daily loop diuretic dose received, and LVEF (mean LVEF: 25.1 percent vs. 23.4 percent within both exposure groups respectively). The analysis demonstrated a statistically significant higher proportion of 30-day ($p = 0.023$), 60-day ($p = 0.014$), and 90-day ($p = 0.049$) heart failure readmissions among patients observed for less than 24 hours compared to those observed for 24 hours or longer (Laliberte et al., 2017).

Contrasting evidence came from a larger (N = 2179) study of patients admitted with acute decompensated heart failure (43 percent of patients with reduced LVEF) that was reported in abstract form only at the American College of Cardiology 2014 Annual Scientific Session and Expo (Ingrassia, Marino, Shivamurthy, Perucki, & Soucier, 2014). The authors observed no significant difference in 30-day readmission rates between patients treated with IV loop diuretics within fewer than 24 hours before discharge compared to those transitioned to PO loop diuretics at least 24 hours prior to hospital discharge (Ingrassia et al., 2014). Unfortunately, interpretation of these results was extremely limited by the lack of a detailed description of the methodological design employed in this study given the format of its publication (Ingrassia et al., 2014).

Rationale

Thirty-day hospital readmission rates have been established as a quality-of-care marker by the United States Centers for Medicare and Medicaid Services (CMS) for patients who have been hospitalized with a heart failure diagnosis (Gupta et al., 2018). As such, unplanned all-

cause readmissions of Medicare beneficiaries within 30-days of a heart failure hospitalization carries a significant financial penalty levied on the discharging hospital by CMS (Gupta & Fonarow, 2018).

According to the most recent publicly available data, the annual 30-day post-heart failure hospitalization readmission rate for Oregon Health and Science University (OHSU) hospital was 20.1 percent (Centers for Medicare and Medicaid Services, 2018). This was below the national average of 21.6 percent which serves as the standard by which individual hospitals are judged against (Centers for Medicare and Medicaid Services, 2018). Since the national average is a moving target from year to year, hospitals must continue to find ways to reduce 30-day readmission rates in order to avoid financial penalties and to provide this standard of quality care to their heart failure patients (Gupta et al., 2018).

Patients who discharge from the hospital without being adequately decongested appear to be at a higher risk for 30-day hospital readmission (Gheorghiade et al., 2006; Lala et al., 2015). Unfortunately, there are limitations of the clinical/laboratory assessment for guiding the transition from IV to PO loop diuretics and determining whether patients have achieved optimal decongestion prior to hospital discharge (Gheorghiade et al., 2006). Therefore, identifying whether the duration of inpatient observation following the transition to PO loop diuretics has affected 30-day readmission rates in the local context will help to inform providers at OHSU hospital whether implementing a standardized minimum duration observation period following the transition to PO loop diuretics will help to benefit their patients, as well as the hospital.

Specific Aims

The purpose of this quality improvement (QI) project was to quantify associations between the duration of inpatient observation after the final transition from a course of IV loop

diuretic therapy to PO loop diuretic therapy (either a short (less than 24 hours) or a long (24 hours or longer) duration prior to hospital discharge) and 30-day all-cause readmission rates.

Theoretical Model

This QI project was theoretically grounded by the knowledge-to-action (KTA) framework, which is a constituent part of the knowledge translation theory that has provided a theoretical base for previous healthcare-related QI projects (Graham et al., 2006; Sibley & Salbach, 2015). The KTA framework has provided a stepwise approach for tailoring the generation of knowledge to help identify and intervene on a locally defined problem with the goal of developing a local, contextually meaningful, and sustained intervention (Sibley & Salbach, 2015). This project focused on the initial portion of the KTA action cycle related to knowledge creation and problem identification by: first, by having identified the available knowledge within the published literature related to the effect of inpatient observation duration following diuretic transition on 30-day readmission rates; and second, by conducting a retrospective electronic health record (EHR) review based project in order to identify the effect of inpatient observation duration following diuretic transition on 30-day readmission rates in the local context at OHSU hospital (Sibley & Salbach, 2015).

Methods

Context

This was a single-center investigation that included patients who had been initially admitted to OHSU hospital. Oregon Health and Science University Hospital is a 556-bed tertiary care hospital in Portland, Oregon (American Hospital Directory, 2019). Institutional review board (IRB) approval was granted by OHSU hospital prior to the collection and analysis

of all data. Data was collected and stored in a manner consistent with current ethical standards for EHR review studies and as approved by the OHSU IRB.

Intervention

A retrospective EHR review was conducted to identify patients who were treated with IV loop diuretics for acute-on-chronic decompensated heart failure and subsequently transitioned to treatment with a PO loop diuretic during their hospital stay or at the time of hospital discharge. Descriptive and inferential statistical analysis was then utilized in order to determine whether there was any association between 30-day all-cause readmission occurrence and the duration of inpatient observation during treatment with PO loop diuretic therapy after the completion of a course of IV loop diuretic therapy.

Inclusion and Exclusion Criteria

To be included, patients at the time of the index heart failure hospitalization must have been 18 years or older, with a past medical history of American College of Cardiology/American Heart Association (ACC/AHA) stage C chronic heart failure with reduced ejection fraction (LVEF of 40 percent or less identified at time of admission or on echocardiography at any time prior to admission), had received treatment with an IV loop diuretic during the index hospitalization, and had been discharged with a prescription for a daily PO loop diuretic.

Patients were excluded if they were treated with IV inotrope, IV vasodilator, or IV vasopressor medications during their admission. Additionally, patients were excluded if they received treatment with a temporary ventricular assist device (VAD) during the index hospitalization, were being treated with a durable VAD prior to or during the index hospitalization, had previously received a cardiac transplantation, were concurrently listed for cardiac transplantation at time of the index hospitalization, were currently being treated with

ambulatory IV inotropic medications at the time of the index hospitalization or had been discharged from the index hospitalization on IV inotropic medications, had a plan in place to enroll in hospice at time of discharge, or had end-stage renal disease (ESRD) treated with chronic hemodialysis or peritoneal dialysis prior to or during the index hospitalization. Those who died during or who discharged from the index hospitalization against medical advice were also excluded because these occurrences preclude a hospital encounter being subject to 30-day readmission rules per CMS guidelines (Centers for Medicare and Medicaid Services, 2020). See Appendix for detailed inclusion and exclusion flow diagram.

Cohort Discovery

The sample cohort was identified through the use of the cohort discovery tool administered by Oregon Clinical and Translational Research Institute (OCTRI). The target population was identified via a cohort discovery query of the OHSU EPIC EHR system archive. The query utilized the search terms "Visit Age (Years) >= 18 Years Visit\Age" and "(150.23) Acute on chronic systolic (congestive) heart failure" or "(150.43) Acute on chronic combined systolic (congestive) and diastolic (congestive) heart failure" and "hospital encounter" or "inpatient." The diagnosis codes were linked to the search term "billing" to ensure these diagnosis codes would have been included as discharge diagnoses for each patient record. The dates December 17, 2018 to March 15, 2019 were set as temporal search boundaries. This was done to ensure that all potentially eligible records of patients within the more narrow project period (January 1, 2019 to February 28, 2019) were included, since the cohort discovery tool returns results which may include records from patients admitted for 15 days earlier or later than the temporal boundary endpoints for the purpose of privacy-related records obfuscation. The initial cohort discovery query identified 192 ± 3 deidentified records. Medical record numbers

(MRNs) from 193 records were ultimately identified from the query and provided to the researcher via OCTRI.

Electronic Health Record Review

An EPIC EHR record review was conducted for all MRNs identified by the cohort discovery query in order to identify those patients hospitalized between January 1, 2019 and February 28, 2019. This yielded 101 patient records as eligible for potential inclusion in the project cohort. Each record was manually reviewed for inclusion and exclusion which yielded 19 records for final inclusion in the project cohort.

All aspects of the EHR review were conducted by a single reviewer. Patient age at the time of index hospitalization was determined through EPIC demographic banner data. Eligibility based on heart failure ACC/AHA stage, chronicity, and LVEF was determined by review of the discharge summary note written by the primary medical team, the admitting history and physical (H&P) documentation, and any available cardiology consult documentation. Review of primary echocardiographic reports was additionally completed in order to confirm agreement between the designation of heart failure with reduced ejection fraction within provider documentation and the primary echocardiographic report data. No disagreements related to chronicity of heart failure were identified via this process. A single disagreement regarding ACC/AHA stage was identified (stage C versus stage D designation). In this instance, the staging opinion of the heart failure cardiology provider who saw the patient for heart failure specific follow-up was utilized for the decision to ultimately include this patient (with stage C heart failure) in the final sample cohort. This decision was bolstered by review of the patient's described symptomatology and response to heart failure medical therapy noted in the hospital and post-hospital heart failure

clinic documentation and was consistent with current heart failure clinical practice guideline staging recommendations (Yancy et al., 2013).

The medication administration record (MAR) of each potentially eligible record was reviewed to confirm administration of IV loop diuretic medication during the index hospitalization and to identify whether any IV inotrope, IV vasodilator, or IV vasopressor medications had been administered during the index hospitalization. The discharge medication list present within the discharge summary was reviewed to identify whether potentially eligible patients had been prescribed a daily PO loop diuretic upon discharge. The admitting H&P and discharge summary were reviewed for documentation of VAD therapy, listing for or prior receipt of cardiac transplantation, discharge disposition to hospice, comorbid ESRD treated with dialysis, or the use of ambulatory inotropic medications at the time of admission or upon discharge.

Measures

Duration of inpatient observation on any PO loop diuretic dose

The MAR was reviewed to determine the date and time of the first PO loop diuretic administration after which no additional IV loop diuretic doses were administered. The discharge date and time were then identified by the timestamp associated with placement of the hospital discharge order, and the duration of inpatient observation was calculated as the timespan between these two time points; recorded as the absolute duration and categorized as either less than 24 hours or 24 hours or greater duration.

Duration of inpatient observation on discharge PO loop diuretic dose

The discharge medication list within the discharge summary documentation was reviewed in order to determine the discharge dose of PO loop diuretic for each patient included

in the sample cohort. The MAR was then reviewed to determine the date and time of the first occurrence that the discharge dose was administered after which no further dose adjustments were made. The duration of inpatient observation was then calculated and categorized as described above. If a patient had been discharged with twice-per-day dosing, the duration of inpatient observation time was calculated starting from the time that the second dose (comprising receipt the total daily dose) was administered. If a patient had been discharged with twice-per-day dosing and had been administered only one half of the total daily discharge dose prior to being discharged, this was categorized as less than 24 hours of inpatient observation while being treated with the discharge dose.

Unplanned all-cause 30-day readmissions

Two methods were used to determine whether any unplanned all-cause 30-day hospital readmissions occurred. The hospital encounters tab within the EPIC EHR was reviewed in order to identify any hospital readmissions to OHSU hospital or OHSU affiliated hospitals. Additionally, heart failure clinic follow-up visit documentation written most recently after the 30-day post-discharge period was reviewed for any notation suggesting a hospital readmission had occurred. Heart failure follow-up clinic documentation was present for all patients included in the final sample. Documentation from any 30-day readmission that did occur was reviewed in order to determine that the hospitalization was unplanned, since only unplanned readmissions are subject to 30-day readmission rules per CMS guidelines (Centers for Medicare and Medicaid Services 2020; Centers for Medicare and Medicaid Services, 2017a). All 30-day post discharge hospital encounters were further reviewed to ensure that they encompassed at least two midnights duration in order to be counted as an applicable readmission per CMS guidelines (Centers for Medicare and Medicaid Services, 2017b). All identified readmissions except for

one were coded as inpatient stays. A single readmission was coded as an observation stay but was counted as an applicable readmission for the purposes of the current investigation because there was clear documentation within the emergency department and internal medicine service notes that the hospitalization encompassed two midnights duration.

Statistical Analysis

Standard descriptive statistics were used to describe the sample, including proportions and measures of central tendency and dispersion. A chi-square test was used to compare duration of observation (< 24 hours and ≥ 24 hours) and 30-day all-cause readmission occurrence. The alpha was set at 0.05. The two-tailed Fisher's exact test of independence was utilized because the two-variables being analyzed were categorical and the expected cell count was five or greater in less than 80 percent of the cells for each of the tests that were run. Logistic regression was also used to quantify the effect of duration on 30-day all-cause readmission occurrence. Multiple tests were run using this model. Length of observation time was treated as a categorical variable (< 24 hours versus ≥24 hours) in one model and as a continuous variable in another model. Since the duration of observation among the sample cohort did not appear to be normally distributed when plotted as a continuous variable, a log10 transformation with further logistic regression analysis was also performed. SPSS statistical software Version 26.0.1 was utilized for all statistical analysis (IBM Corp., Armonk, N.Y., USA).

Results

Between January 1, 2019 and February 28, 2019, 19 patients were identified who met the inclusion and exclusion criteria. Following completion of IV loop diuretic course, 8 patients were observed for less than 24 hours and 11 patients were observed for 24 hours or longer on any dose of PO loop diuretic prior to hospital discharge. The mean duration of observation on any

dose of PO loop diuretics was 38.00 hours (*SD* = 44.96). Among those observed for less than 24 hours, there was one (12.5%) all-cause 30-day readmission compared with five (45.5%) all-cause 30-day readmissions among those observed for 24 hours or longer. No statistically significant association was seen between the length of inpatient observation on any dose and 30-day all cause readmissions (two-tailed Fisher's exact test $p = 0.177$).

Following completion of IV loop diuretic course, 14 patients were observed for less than 24 hours and 5 patients were observed for 24 hours or longer on their discharge dose of PO loop diuretic prior to hospital discharge. The mean duration of observation on the discharge dose of PO loop diuretic was 18.47 hours (*SD* = 16.59). Among those observed for less than 24 hours, there were four (28.6%) all-cause 30-day readmissions compared to two (40%) all-cause 30-day readmissions among those observed for 24 hours or longer. No statistically significant association was seen between the length of inpatient observation on the discharge dose of PO loop diuretic and 30-day all cause readmissions (two-tailed Fisher's exact test $p = 1.00$).

In the logistic regression model, there was no statistically significant association between the duration of inpatient observation time during treatment with any dose of PO loop diuretic (< 24 hours vs. ≥ 24 hours) and the likelihood of 30-day hospital readmission (OR 5.833, 95% CI 0.525-64.823, $p = 0.151$). Likewise, there was no statistically significant association between the duration of inpatient observation during treatment with the discharge dose of PO loop diuretic (< 24 hours vs. ≥ 24 hours) and the likelihood of 30-day hospital readmission (OR 1.667, 95% CI 0.198-14.054, $p = 0.639$).

When the length of observation time was treated as a continuous variable in the logistic regression model, there was no statistically significant association between the duration of inpatient observation during treatment with any dose of PO loop diuretic and the likelihood of

30-day hospital readmission (OR 1.015, 95% CI 0.989-1.042, $p = 0.249$). Likewise, there was no statistically significant association between the duration of inpatient observation during treatment with the discharge dose of PO loop diuretic and the likelihood of 30-day hospital readmission (OR 0.991, 95% CI 0.925-1.061, $p = 0.799$). Similar results were found when log transforming time to approximate normality (any dose of PO diuretic: OR 3.315, 95% CI 0.495-22.213, $p = 0.217$; discharge dose of PO diuretic: OR 1.168, 95% CI 0.132-10.371, $p = 0.889$).

Discussion

Summary

In this sample of acute-on-chronic decompensated heart failure patients with reduced LVEF, no statistically significant association was found between the length of inpatient observation during treatment with PO loop diuretics after the completion of an IV loop diuretic course and 30-day all-cause readmission occurrence. Despite a lack of statistically significant results, given the QI project limitations (detailed below), it would not be reasonable to form any conclusion about whether a longer duration of observation is or is not an effective strategy for reducing the occurrence of 30-day all-cause readmissions following hospitalization for acute-on-chronic decompensated heart failure with reduced LVEF. This result was surprising in light of the best available evidence from previous observational data which showed a statistically significant association between higher risk for 30-day hospital readmissions and less than 24 hours duration of inpatient observation during PO diuretic treatment after a course of IV diuretic therapy among patients hospitalized for acute heart failure with reduced LVEF (Laliberte et al., 2017). This could be explained by unappreciated differences between the demographic characteristics present within the current sample and the sample included in aforementioned prior study.

The lack of statistically significant findings was most likely due to the small sample size included in the QI project. This notion was supported by the wide confidence intervals yielded from the logistic regression analysis in which the length of observation was dichotomized into binary categories. However, the narrower confidence intervals resulting from the logistic regression model when length of observation on PO loop diuretics was treated as a continuous variable (non-log10 adjusted data) did suggest that there might truly have been no relationship between the duration of observation and 30-day readmission occurrence. These results might also have indicated that a larger sample size and an observation duration cut-point other than 24 hours would have revealed the true nature of this relationship. Given these possibilities, this QI project has provided valuable data that can be used to estimate the needed sample size for future investigations which can help to further elucidate whether an association exists between 30-day readmission risk and duration of inpatient observation during treatment with PO loop diuretics following a course of IV loop diuretic therapy.

Limitations

There are limitations to this QI project. Since the project was observational and retrospective, any conclusions drawn from the results must not be considered causative given the inherent risk for bias that comes with this methodological approach. Additionally, the lack of demographic data collection during the project limited the ability to analyze for confounding variables which may have accounted for any association or lack of association between the primary variables under investigation. Further, since this sample was drawn from a single academic medical center in the Pacific Northwest and limited to those hospitalized with acute-on-chronic decompensated heart failure with an LVEF of 40 percent or lower, the sample is not generalizable to all acute-on-chronic decompensated heart failure patients.

Care was taken to conduct a methodical and thorough search for the occurrence of readmissions within the confines of the OHSU EHR system. However, there was the chance that 30-day all-cause readmissions not noted within hospital follow-up visit documentation or having occurred at a non-OHSU affiliated hospital may not have been visible to the investigator at the time of data abstraction. Additionally, while a thorough search using the Cohort Discovery Tool was performed, it is possible that eligible patients who could have been included in the sample cohort were inadvertently missed.

Finally, the project was limited by the use of a single investigator for completion of the chart review, data abstraction, and statistical analysis. This increased the chance of error in the applying the inclusion/exclusion criteria to potentially eligible patients as well as the chance of data abstraction and data entry errors. An attempt to partially mitigate this limitation was made through consultation by the student investigator with the clinical faculty advisor regarding inclusion/exclusion of select patients prior to completion of data analysis.

Conclusion

This QI project has provided a basis for future projects to address the question surrounding whether an increased length of inpatient observation during treatment with PO loop diuretics after completion of an IV loop diuretic course for the treatment of acute-on-chronic decompensated heart failure with reduced LVEF can alter the risk for 30-day all-cause hospital readmission. By sharing the methodology and results of this inquiry with OHSU affiliated heart failure providers and researchers specializing in heart failure, further investigations can be conducted with the power to shape future practice caring for patients hospitalized with acute-on-chronic decompensated heart failure at OHSU hospital. Future investigations should specifically consider the incidence of each duration of observation category and 30-day all-cause

readmissions that was observed within this investigation to determine an appropriate sample size. Such investigations should also be designed to identify covariates that might affect the relationship between duration of inpatient observation on PO loop diuretics and readmission risk. Future investigations would also benefit from the inclusion of cost-effectiveness analysis in light of findings from prior investigations showing an association between prolonged inpatient observation on PO loop diuretics and an increased overall length of hospital stay (Ingrassia et al., 2014; Laliberte et al., 2017).

References

Ambrosy, A., Cerbin, L., Armstrong, P., Butler, J., Coles, A., Devore, A., . . . Mentz, R. (2017b). Body weight change during and after hospitalization for acute heart failure: Patient characteristics, markers of congestion, and outcomes: Findings from the ASCEND-HF trial. JACC: Heart Failure, 5(1), 1-13. doi: 10.1016/j.jchf.2016.09.012

American Hospital Directory. (2019). Free profile: Oregon Health and Science University Hospital. Retrieved from https://www.ahd.com/free_profile .php?hcfa_id=6d51152aa74 45670b7c 77037d9723a76&ek=75c6d546a4b6b8eed6307595c57fb7d8

Beltrami, M., Ruocco, G., Ibrahim, A., Lucani, B., Franci, B., Nuti, R., & Palazzuoli, A. (2017). Different trajectories and significance of B-type natriuretic peptide, congestion and acute kidney injury in patients with heart failure. Internal and Emergency Medicine, 12(5), 593-603. doi: 10.1007/s11739-017-1620-1

Breault, J. (2013). Bioethics in practice: A quarterly column about medical ethics: Ethics of chart review research. The Ochsner Journal, 13(4), 481-482. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3865822/

Breidthardt, T., Weidmann, Z., Twerenbold, R., Gantenbein, C., Stallone, F., Rentsch, K., . . . Mueller, C. (2017). Impact of haemoconcentration during acute heart failure therapy on mortality and its relationship with worsening renal function. European Journal of Heart Failure, 19(2), 226-236. doi: 10.1002/ejhf.667

Centers for Medicare and Medicaid Services. (2020). CMS measure inventory tool: Heart failure (HF) 30-day readmission rate. Retrieved from https://cmit.cms.gov/ CMIT_public/ ReportMeasure?measureRevisionId=26

Centers for Medicare and Medicaid Services. (2018). Hospital profile: OHSU Hospital and Clinics. Retrieved from https://www.medicare.gov/ hospitalcompare/ profile.html#vwgrph=1&profTab=4&ID=380009&loc=PORTLAND%2C%20OR&lat=45.5234515&lng=-122.6762071&name=OHSU%20HOSPITAL %20AND %20CLINICS &Distn=2.2

Centers for Medicare and Medicaid Services. (2017a). 2015 Measure information about the 30-day all-cause hospital readmission measure, calculated for the value based payment modifier program. Retrieved from https://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/PhysicianFeedbackProgram/Downloads/2015-ACR-MIF.pdf

Centers for Medicare and Medicaid Services. (2017b). Clarifying medical review of hospital claims for part A payment. Retrieved from https://www.cms.gov/Outreach-and-Education/ Medicare-Learning-Network-MLN /MLN Matters Articles/ downloads/ MM10080.pdf

Coiro, S., Rossignol, P., Ambrosio, G., Carluccio, E., Alunni, G., Murrone, A., . . . Girerd, N. (2015). Prognostic value of residual pulmonary congestion at discharge assessed by lung ultrasound imaging in heart failure. European Journal of Heart Failure, 17(11), 1172-1181. doi: 10.1002/ejhf.344

Coiro, S., Porot, G., Rossignol, P., Ambrosio, G., Carluccio, E., Tritto, I., . . . Girerd, N. (2016). Prognostic value of pulmonary congestion assessed by lung ultrasound imaging during heart failure hospitalisation: A two-centre cohort study. Scientific Reports, 6(1), 39426. doi: 10.1038/srep39426

Cummings, P. (2009). The relative merits of risk ratios and odds ratios. Archives of Pediatrics & Adolescent Medicine, 163(5), 438-445. doi: 10.1001/archpediatrics.2009.31

Darawsha, W., Chirmicci, S., Solomonica, A., Wattad, M., Kaplan, M., Makhoul, B., . . . Aronson, D. (2016). Discordance between hemoconcentration and clinical assessment of decongestion in acute heart failure. Journal of Cardiac Failure, 22(9), 680-688. doi: 10.1016/j.cardfail.2016.04.005

Fingar, K., Barrett, M., & Jiang, H. (2017). A comparison of all-cause 7-day and 30-day readmissions, 2014. Retrieved from https://www.hcup-us.ahrq.gov/ reports/statbriefs /sb230-7-Day-Versus-30-Day-Readmissions.jsp

Fujita, T., Inomata, T., Yazaki, M., Iida, Y., Kaida, T., Ikeda, Y., . . . Ako, J. (2018). Hemodilution after initial treatment in patients with acute decompensated heart failure. International Heart Journal, 59(3), 573-579. doi: 10.1536/ihj.17-307

Gargani, L., Pang, P., Frassi, F., Miglioranza, M., Dini, F., Landi, P., & Picano, E. (2015). Persistent pulmonary congestion before discharge predicts rehospitalization in heart failure: A lung ultrasound study. Cardiovascular Ultrasound, 13(1), 40. doi: 10.1186/s12947-015-0033-4

Gheorghiade, M., Filippatos, G., De Luca, L., & Burnett, J. (2006). Congestion in acute heart failure syndromes: An essential target of evaluation and treatment. The American Journal of Medicine, 119(12), S3-S10. doi: 10.1016/j.amjmed.2006.09.011

Gheorghiade, M., Follath, F., Ponikowski, P., Barsuk, J., Blair, J., Cleland, J., . . . Filippatos, G. (2010). Assessing and grading congestion in acute heart failure: A scientific statement from the Acute Heart Failure Committee of the Heart Failure Association of the European Society of Cardiology and endorsed by the European Society of Intensive Care Medicine. European Journal of Heart Failure, 12(5), 423-433. doi: 10.1093/eurjhf/hfq045

Graham, I., Logan, J., Harrison, M., Straus, S., Tetroe, J., Caswell, W., & Robinson, N. (2006). Lost in knowledge translation: Time for a map? Journal of Continuing Education in the Health Professions, 26(1), 13-24. doi: 10.1002/chp.47

Greene, S., Gheorghiade, M., Vaduganathan, M., Ambrosy, A., Mentz, R., Subacius, H., . . . Filippatos, G. (2013). Haemoconcentration, renal function, and post-discharge outcomes among patients hospitalized for heart failure with reduced ejection fraction: Insights from the EVEREST trial. European Journal of Heart Failure, 15(12), 1401-1411. doi: 10.1093/eurjhf/hft110

Gupta, A., Allen, L., Bhatt, D., Cox, M., Devore, A., Heidenreich, P., . . . Fonarow, G. (2018). Association of the hospital readmissions reduction program implementation with readmission and mortality outcomes in heart failure. JAMA Cardiology, 3(1), 44-53. doi: 10.1001/jamacardio.2017.4265

Gupta, A. & Fonarow, G. (2018). The hospital readmissions reduction program—learning from failure of a healthcare policy. European Journal of Heart Failure, 20(8), 1169-1174. doi: 10.1002/ejhf.1212

Hollenberg, S., Warner Stevenson, L., Ahmad, T., Amin, V., Bozkurt, B., Butler, J., . . . Storrow, A. (2019). 2019 ACC expert consensus decision pathway on risk assessment, management, and clinical trajectory of patients hospitalized with heart failure: A report of the American College of Cardiology Solution Set Oversight Committee. Journal of the American College of Cardiology, 74(15), 1966-2011. doi: 10.1016/j.jacc.2019.08.001

Inamdar, A. & Inamdar, A. (2016). Heart failure: Diagnosis, management and utilization. Journal of Clinical Medicine, 5(62). doi: 10.3390/jcm5070062

Ingrassia, J., Marino, E., Shivamurthy, P., Perucki, W., & Soucier, R. (2014). Diuretics within 24 hours of discharge. Journal of the American College of Cardiology, 63(12), A532. doi: 10.1016/S0735-1097(14)60532-5

Kemp, C. & Conte, J. (2012). The pathophysiology of heart failure. Cardiovascular Pathology, 21(5), 365-371. doi: 10.1016/j.carpath.2011.11.007

Kiernan, M., Stevens, S., Tang, W., Butler, J., Anstrom, K., Birati, E., . . . De Las Fuentes, L. (2018). Determinants of diuretic responsiveness and associated outcomes during acute heart failure hospitalization: An analysis from the NHLBI heart failure network clinical trials. Journal of Cardiac Failure, 24(7), 428-438. doi: 10.1016/j.cardfail.2018.02.002

Kim, H. (2017). Statistical notes for clinical researchers: Chi-squared test and Fisher's exact test. Restorative Dentistry & Endodontics, 42(2), 152-155. doi: 10.5395/rde.2017.42.2.152

Kirali, K., Özer, T., & Özgür, M. (2017). Pathophysiology in Heart Failure. In K. Kirali, Cardiomyopathies: Types and treatments (pp. 17-38). doi: 10.5772/66887

Kociol, R., McNulty, S., Hernandez, A., Lee, K., Redfield, M., Tracy, R., . . . Felker, G. (2013). Markers of decongestion, dyspnea relief, and clinical outcomes among patients hospitalized with acute heart failure. Circulation: Heart Failure, 6(2), 240-245. doi 10.1161/CIRCHEARTFAILURE.112.969246

Lala, A., McNulty, S., Mentz, R., Dunlay, S., Vader, J., Abouezzeddine, O., . . . Stevenson, L. (2015). Relief and recurrence of congestion during and after hospitalization for acute heart failure: insights from Diuretic Optimization Strategy Evaluation in Acute Decompensated Heart Failure (DOSE-AHF) and Cardiorenal Rescue Study in Acute Decompensated Heart Failure (CARESS-HF). Circulation: Heart Failure, 8(4), 741-748. doi: 10.1161/CIRCHEARTFAILURE.114.001957

Laliberte, B., Reed, B., Devabhakthuni, S., Watson, K., Ivaturi, V., Liu, T., & Gottlieb, S. (2017). Observation of patients transitioned to an oral loop diuretic before discharge and risk of readmission for acute decompensated heart failure. Journal of Cardiac Failure, 23(10), 746-752. doi: 10.1016/j.cardfail.2017.06.008

Lin, A., Chin, J., Sicignano, N., & Evans, A. (2017). Repeat hospitalizations predict mortality in patients with heart failure. Military Medicine, 182(9), E1932-E1937. doi: 10.7205/MILMED-D-17-00017

McDermott, K., Elixhauser, A., & Sun, R. (2017). Trends in hospital inpatient stays in the United States, 2005-2014. Retrieved from https://www.hcup-us.ahrq.gov/reports/statbriefs/sb225-Inpatient-US-Stays-Trends.jsp

Oh, J., Kang, S., Hong, N., Youn, J., Han, S., Jeon, E., . . . Ryu, K. (2013). Hemoconcentration is a good prognostic predictor for clinical outcomes in acute heart failure: Data from the Korean Heart Failure (KorHF) Registry. International Journal of Cardiology, 168(5), 4739-4743. doi: 10.1016/j.ijcard.2013.07.241

Öhman, J., Harjola, V., Karjalainen, P., & Lassus, J. (2018). Focused echocardiography and lung ultrasound protocol for guiding treatment in acute heart failure. ESC Heart Failure, 5(1), 120-128. doi: 10.1002/ehf2.12208

Omar, H., & Guglin, M. (2017). Rise in BNP despite appropriate acute decompensated heart failure treatment: Patient characteristics and outcomes. Herz, 42(4), 411-417. doi: 10.1007/s00059-016-4478-5

Pimenta, J., Paulo, C., Mascarenhas, J., Gomes, A., Azevedo, A., Rocha-Gonçalves, F., & Bettencourt, P. (2010). BNP at discharge in acute heart failure patients: Is it all about

volemia? A study using impedance cardiography to assess fluid and hemodynamic status. International Journal of Cardiology, 145(2), 209-214. doi: 10.1016/j.ijcard.2009.08.001

Ponikowski, P., Voors, A., Anker, S., Bueno, H., Cleland, J., Coats, A.,… Davies, C. (2016). 2016 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure. European Heart Journal, 37(27), 2129-2200. doi: 10.1093/eurheartj/ehw128

Sabbatini, A., & Wright, B. (2018). Excluding observation stays from readmission rates - What quality measures are missing. The New England Journal of Medicine, 378(22), 2062-2065. doi: 10.1056/NEJMp1800732

Sarkar, S. & Seshadri, D. (2014). Conducting record review studies in clinical practice. Journal of Clinical and Diagnostic Research, 8(9), JG01-JG04. doi: 10.7860/ JCDR/2014 /8301 .4806

Sibley, K. & Salbach, N. (2015). Applying knowledge translation theory to physical therapy research and practice in balance and gait assessment: Case report. Physical Therapy, 95(4), 579-587. doi: 10.2522/ptj.20130486

Sinnenberg, L. & Givertz, M. (2019). Acute heart failure. Trends in Cardiovascular Medicine, Advance online publication. doi: 10.1016/j.tcm.2019.03.007

Stolfo, D., Stenner, E., Merlo, M., Porto, A., Moras, C., Barbati, G., . . . Sinagra, G. (2017). Prognostic impact of BNP variations in patients admitted for acute decompensated heart failure with in-hospital worsening renal function. Heart, Lung and Circulation, 26(3), 226-234. doi: 10.1016/j.hlc.2016.06.1205

Ter Maaten, J., Valente, M., Damman, K., Cleland, J., Givertz, M., Metra, M., . . . Voors, A. (2016). Combining diuretic response and hemoconcentration to predict rehospitalization

after admission for acute heart failure. Circulation: Heart Failure, 9(6), e002845-e002845. doi: 10.1161/ CIRCHEARTFAILURE. 115.002845

Testani, J., Chen, J., McCauley, B., Kimmel, S., & Shannon, R. (2010). Potential effects of aggressive decongestion during the treatment of decompensated heart failure on renal function and survival. Circulation, 122(3), 265-272. doi: 10.1161/CIRCULATIONAHA.109.933275

Testani, J., Brisco, M., Chen, J., Mccauley, B., Parikh, C., & Tang, W. (2013). Timing of hemoconcentration during treatment of acute decompensated heart failure and subsequent survival: Importance of sustained decongestion. Journal of the American College of Cardiology, 62(6), 516-524. doi: 10.1016/j.jacc.2013.05.027

Yancy, C., Jessup, M., Bozkurt, B., Butler, J., Casey, D., Drazner, M., . . . Wilkoff, B. (2013). 2013 ACCF/AHA guideline for the management of heart failure: Executive summary: A report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. Circulation, 128(16), 1810-1852. doi: 10.1161/CIR.0b013e31829e8807

Yancy, C., Jessup, M., Bozkurt, B., Butler, J., Casey, D., Colvin, M., . . . Westlake, C. (2017). 2017 ACC/AHA/HFSA focused update of the 2013 ACCF/AHA guideline for the management of heart failure: A report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines and the Heart Failure Society of America. Circulation, 136(6), e137-e161. doi: 10.1161/CIR.0000000000000509

Appendix

Inclusion and Exclusion Flow Diagram