Predictors of Emergency Department Observation Unit Outcomes

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Abstract

Background: Acute decompensated heart failure (adHF) is the cause of approximately 1 million annual hospital admissions. In some of these, the use of a short-stay emergency department observation unit (EDOU) decreases 90-day ED revisits and 90-day rehospitalizations and, if subsequent hospitalization is required, results in shorter stays. **Objectives:** To determine whether laboratory and clinical parameters, available at ED arrival, predict successful EDOU discharge. **Methods:** This was a 19-month retrospective analysis of adHF EDOU admissions. Details of medical history, clinical course, patient management, laboratory data, and disposition destination were gathered through review of electronic medical records. Recorded laboratory data included measurements of sodium, creatinine, blood urea nitrogen (BUN), hemoglobin, b-type natriuretic peptide, and initial ED systolic blood pressure. Data were analyzed for ability to predict the requirement of hospital admission after EDOU management. **Results:** There were 385 patients were enrolled. The mean (± standard deviation) age was 69.7 (±13.6) years, and 50.1% were female. On ED admission chest radiograph, 69.0% had evidence of pulmonary edema. Elevations in creatinine and BUN levels had statistically significant associations with admission; however, on multivariable analysis, only a BUN value >30 mg/dL significantly predicted EDOU management failure, and subsequent inpatient admission. **Conclusions:** These results demonstrate that a BUN level >30 mg/dL is associated with an increased likelihood of admission in patients with adHF. This provides the emergency physician with a practical prognostic tool for disposition planning in congestive heart failure patients.
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With annual estimates approaching $30 billion, heart failure (HF) is currently the single greatest expense for the U.S. medical system. Inpatient costs, driven primarily by excessive length of stay and high rates of 30-day hospital readmissions, account for half of all HF expenditures.[1,2] Recent research has identified the important impact of coexistent renal failure on both the morbidity and the mortality of the HF patient.[3] HF patients who have elevated BUN and creatinine levels have much higher mortality rates compared with HF patients who do not have renal insufficiency.[4]

The emergency department observation unit (EDOU) has been successfully used to treat acute decompensated heart failure (adHF). Patients admitted to an EDOU may undergo intensive diagnostic and therapeutic interventions within a 24-hour limit. However, after 24 hours, discharge from the EDOU must occur, and patients may be hospitalized or returned to their usual care environment. EDOU patients represent a subset of the overall adHF population, and are selected by the physician based on the impression that successful management can occur within this time frame. Protocols suggesting entry and exclusion criteria, diagnostic and therapeutic algorithms, educational suggestions, and discharge minimums have been described.[5,6] Likewise, the hospital cost implications have been reported to be lower when an EDOU management program is used.[7] The results of an EDOU strategy for the treatment of adHF have been marked decreases in ED HF visits and 90-day HF readmissions.[6] Because of these clinical benefits, and advantageous financial outcomes, the Centers for Medicare & Medicaid Services (CMS) instituted a specific billing code for the observation unit management of adHF on April 1, 2003.

Successful treatment requires appropriate selection of the candidate patients. Accurate patient selection ensures that those most likely to benefit from an intense EDOU management protocol are admitted to the unit, while promptly hospitalizing the patients whose needs exceed the EDOU's ability to effect a 24-hour discharge. There are very limited data on the prediction of which patients will meet these goals. Our previous work determined that inadequate diuresis, and the coexistence of chest pain, predicts a

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hospital admission from the observation unit.[8] The purpose of this study was to identify other factors, determined at the time of the ED visit, that would predict the requirement for a hospital admission from the EDOU.

METHODS

Study Design. This study was an institutional review board-approved retrospective examination of all HF admissions to the Cleveland Clinic EDOU.

Study Setting and Population. The study was conducted during 19 months, from January 1, 2002, to July 1, 2003. The Cleveland Clinic is a university-affiliated, tertiary care facility, located within an urban area. The annual ED census is about 50,000 patients. The EDOU is a 20-bed unit, managed by emergency physicians, and with dedicated nursing staff. Admission to the EDOU is predicated by the emergency physician's prospective estimate that a patient will be discharged within 24 hours. During the time of this analysis, nearly 2% of ED patients received a primary diagnosis of HF; of these, 7% were discharged to home, 28% were admitted to the EDOU, and 65% were admitted for inpatient care. The EDOU annual census is about 7,000 patients, of whom HF is the primary diagnosis in approximately 250.

Eligible patients were identified by computerized search of hospital records using International Classification of Diseases, Ninth Revision (ICD-9) codes, as well as text word search. The study entry criteria were a primary EDOU admission diagnosis of HF and availability of medical records for review. Patients receiving dialysis of any kind were excluded from this analysis. EDOU entry and exclusion criteria, validated EDOU therapeutic algorithms, and EDOU discharge criteria have been previously described, and were in place during the time that this analysis was performed.[5–9]

Study Protocol. Diagnoses were defined by the attending emergency physicians, and were based on their clinical judgment, including radiographic studies and laboratory work. No reassignment of diagnosis was made retrospectively. Point-of-care B-type natriuretic peptide (BNP) testing was available throughout the study period. The assay platform had an upper limit of reporting of 1,300 pg/mL at the beginning of the study period; however, midway through the study, the manufacturer increased the upper limit of reporting to 5,000 pg/mL. During the time when the test had an upper limit of 1,300 pg/mL, any patients with a value of greater than 1,300 pg/mL were coded as having a value of 1,300 pg/mL.

All charts were examined and abstracted by a single reviewer, and all are included within the database. The chart review included all notes from the ED and EDOU, along with all discharge summaries when applicable. Each note was reviewed to provide both clinical information and disposition of the patient, as well as pertinent laboratory data. Recorded data included demographic information, basic metabolic chemistries, specific physical signs and historical symptoms, treatment plan, and final disposition. Demographic data included age and gender, along with encounter date for each episode. Initial vital signs, laboratory measurements of sodium, creatinine, and BUN, and the first measurement of hemoglobin in the ED were recorded. Acute pulmonary edema was defined to be present when either the ED chest radiograph interpretation by a board-certified radiologist was acute pulmonary edema, or the attending emergency physician documented the presence of acute pulmonary edema as a result of his or her examination. Absence of positive information in these criteria resulted in designation of the patient as not having pulmonary edema.

Measurements. The chart review was performed so that parameters were entered as ''present,'' ''absent'' when their specific absence was noted in the chart, or ''missing'' when the chart did not indicate the presence or absence of the parameter.

Data Analysis. Statistical analysis was performed using the SAS statistical package (Cary, NC), which adjusts for missing data. Both t-test and chi-square test were performed, and logistic regression was used in all cases where univariate procedure resulted in a statistically significant result. Statistical significance was defined as $p < 0.05$.

RESULTS

Three hundred eighty-five patients meeting all the entry criteria were included in the database for this study. Females comprised 50.13% (193 of 385), and the average age was 69.76 years (22–94; standard deviation [SD] ±13.63). Overall, most patients were successfully discharged from the EDOU. Only 102 of the 385 study patients (26.49%) required hospital admission after EDOU management. There was no association between gender and subsequent hospitalization following EDOU management ($p = 0.82$), nor did the initial vital signs predict subsequent hospitalization. The average systolic blood pressure was 141 mm Hg (77–245; SD ± 29) and did not predict admission ($p = 0.14$).

The chest radiograph results found that a majority of the patients (69%) presented to the ED with evidence of pulmonary edema. However, there was a nonsignificant association between the presence or absence of pulmonary edema and subsequent admission to the hospital from the EDOU. Twenty-nine percent of the patients with acute pulmonary edema

TABLE 1. Mean Variables and Associated Emergency Department Observation Unit (EDOU) Outcomes

	EDOU Failure* (95% CI)	EDOU Success† (95% CI)	p-value
Sodium (mmol/L)	139.6 (139.1, 140.0)	138.9 (138.0, 139.7)	0.1543
BUN (mg/dL)	26.4 (24.6, 28.2)	35.4 (31.4, 39.4)	<0.0001
Creatinine (mg/dL)	1.4 (1.3, 1.5)	1.6 (1.4, 1.8)	0.0404
Hemoglobin (g/dL)	12.2 (12.0, 12.4)	12.3 (11.9, 12.8)	0.7471
BNP (pg/mL)	1,397.5 (1,250.3, 1,544.7)	1,262.6 (1,058.3, 1,466.9)	0.2897
sBP (mm Hg)	143.0 (139.5, 146.5)	137.9 (132.1, 143.7)	0.1384
Age (years)	69.3 (67.7, 71.0)	71.1 (68.8, 73.5)	0.2114

*EDOU failure = patient required hospitalization after EDOU management.
†EDOU success = patient did not require subsequent hospitalization.
BUN = blood urea nitrogen; BNP = B-type natriuretic peptide.

ultimately required hospitalization from the EDOU ($p = 0.0573$). The average BNP value was 1,356 pg/mL (10–5000; SD ± 1,070), but this did not vary significantly with patient requirement for hospital admission ($p = 0.32$).

Most laboratory results did not predict hospitalization following EDOU management (Table 1). The mean sodium level was 142 mmol/L (range 124–154, SD ±29), and there was no statistically significant association between sodium levels and hospital admission requirement ($p = 0.11$). The mean hemoglobin level was 12.3 g/dL (range 6.4–17.9; SD ±1.9), and was not associated with an admission disposition ($p = 0.74$).

Renal function was evaluated by BUN and creatinine measurements. No patient developed renal failure during the study period. The mean creatinine concentration was 1.43 (±0.84) mg/dL (range 0.4–9.9). Patients requiring admission after EDOU management had a higher creatinine level (1.58 ± 0.8 mg/dL) than those not requiring admission (1.38 ± 0.8 mg/dL; $p = 0.03$). However, on multivariate logistic regression, this did not reach statistical significance (odds ratio [OR] 1.113; 95% CI = 0.730 to 1.698). The mean BUN was 28.8 (±17.2) mg/dL (range 7–126). Patients requiring hospital admission following EDOU management had an elevated BUN (35.5 ± 17.9 mg/dL), compared with those not requiring admission (26.4 ± 14.1 mg/dL; $p < 0.001$). On multivariate analysis, BUN was the only variable that predicted hospital admission after EDOU management (OR 0.97; 95% CI = 0.95 to 0.98). The likelihood of admission rose with increasing BUN value (Figure 1). Patients with a BUN value of 30 mg/dL or more had a 2.6 times higher admission rate than those with a lower BUN value (95% CI = 1.6 to 4.2). The area under the receiver-operating characteristic (ROC) curve for BUN's prediction of failure of adHF management in the EDOU was 0.6629 (±0.0326) (Figure 2).

DISCUSSION

The major finding in this study is the association between an elevated BUN value and the ultimate requirement of patients with HF for inpatient admission from the EDOU. However, the absence of any other association is also a potentially significant outcome. This study is a complement to previous inquiries that demonstrated the role of an elevated BUN value and increased mortality in the progression of HF.[4,10]

We have demonstrated that a BUN level in excess of 30 mg/dL is associated with a 2.6-fold increase in the likelihood of hospital admission. Beyond statistical significance, the absolute magnitude of the association between an increased admission rate and a moderately elevated BUN level suggests a relationship between an elevated BUN level and more severe disease. Additionally, there may exist a threshold where the probability of admission dramatically increases once a certain BUN level is reached. Other trials have indicated that an initially elevated creatinine level is an important predictor of outcomes, and is associated with increased six-month mortality, rate of readmissions, and functional decline.[3] However, even more predictive of adverse outcomes was the extent of creatinine increase that occurred as a consequence of therapy during hospitalization.[3] It is unlikely that the EDOU patients in our study were hospitalized for a sufficient length of time to document clinically relevant increases in the level of creatinine.

In the edematous patient, diuretic resistance is defined as a condition in which diuretic response is diminished or lost before the therapeutic goal of edema relief is reached.[11] From a physiologic perspective, azotemia is a marker of diuretic resistance[11] and predicts increased adverse outcomes in HF patients.[3,4]

In the majority of HF patients, the rate-limiting step preventing hospital discharge is the attainment of a decongested state. The ability to attain and maintain a decongested state is critical, not just in the short term with its impact on length of stay in hospitalized patients, but also in the longer term as it impacts the quality of life and is a significant mortality predictor.[12] Ultimately, the presence of diuretic resistance significantly complicates the ability to reach and maintain a decongested state, and the presence of diuretic resistance predicts higher rates of adverse outcomes.[13]

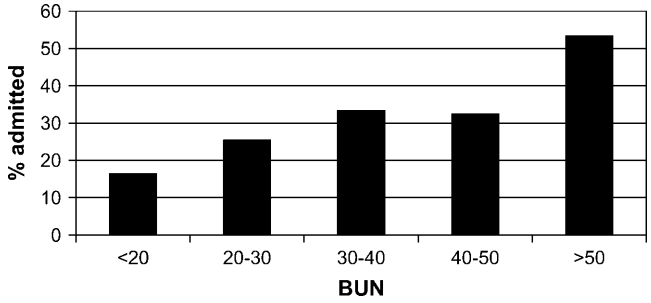

Figure 1. Relationship between blood urea nitrogen (BUN, in mg/dL) and admission from the emergency department observation unit.

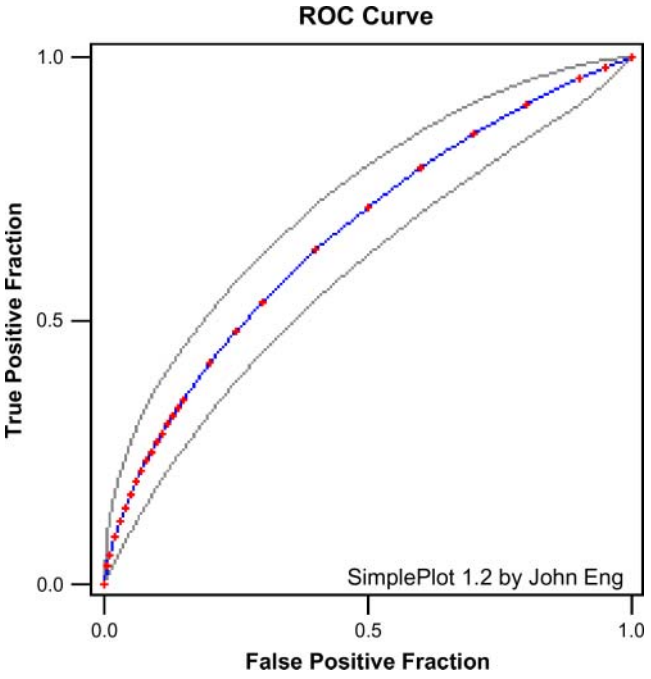

Figure 2. Receiver-operating characteristic (ROC) curve: blood urea nitrogen (BUN) predicting emergency department observation unit management failure.

Consequently, it is not unexpected that the presence of diuretic resistance will be a critical determinant in the response to therapy. An inability to attain urine output with diuretics will increase length of stay, and patients with therapeutic requirements exceeding 24 hours will fail EDOU management. This is consistent with prior studies reporting that a low urine output (<1.2 L) during the observation unit admission is associated with an increased need for hospitalization.[8]

In this study, in addition to an elevated BUN value, initial creatinine levels were associated with increased admission rates. However, after multivariate analysis, creatinine level no longer maintained a statistically significant relationship with admission necessity. The most likely explanation for this finding may involve the general relation between elevations in creatinine and BUN levels. Patients with markedly elevated BUN level, in relation to their creatinine levels, can represent a population with intravascular depletion (e.g., dehydration from diuretic use) manifesting as prerenal azotemia. In this setting, both renal blood flow and glomerular filtration rates (GFRs)[14] are decreased. Decreasing renal perfusion contributes to diuretic resistance by impeding the delivery of volume, solute, and decreasing the delivery of the diuretic to the renal tubules. In fact, loop diuretics can contribute to this downward spiral by decreasing the GFR,[14] and increasing the levels of neurohormones whose function is to decrease the GFR and retain sodium and water.[15]

In prospective trials, impaired renal function, manifest by a decreased GFR, was the strongest predictor of mortality, exceeding even measures of cardiac function.[4] By this method, once begun, diuretic resistance can rapidly amplify its clinical impact. By increasing diuretic resistance, the probability of longer hospitalization requirements would be predicted. This is reflected in our results, since in prerenal azotemia the BUN level is increased to a much greater extent, as compared with the increase in creatinine level.

Other studies have supported the importance of an elevated BUN level in predicting subsequent outcomes.[10,16] In an inpatient cohort, representing a group with a greater severity of illness than those in our study, it was reported that an elevated BUN level was associated with increased risk of acute mortality. An analysis of hospitalized HF patients also implicated an elevated BUN level as a marker for mortality.[16] In addition to an elevated BUN level, elevated creatinine level, older age, lower systolic blood pressure, higher respiratory rate, and hyponatremia were all predictive of an increased mortality.[10,16] However, these data originate from an inpatient population, and represent a cohort of individuals expected to manifest greater severity of illness, based on the fact that they required immediate hospitalization, rather than a trial of EDOU management. Ultimately, their results cannot be directly applied to the outpatient EDOU cohort, a population predicted to have less severe disease.

B-type natriuretic peptide is a proven marker of HF exacerbation,[17] and in our study population the average BNP exceeded 1,300 pg/mL. While this suggests accurate inclusion criteria, we did not find a correlation between the absolute value of BNP and disposition. Other studies have found BNP to be a marker of poor prognosis in patients with moderate HF, and have suggested that it can be used as a noninvasive hemodynamic monitor.[18] Our study is limited here by the change in test reporting during the time period of our analysis. A subsequent analysis with the new extended range of the test may demonstrate BNP to be a useful tool for predicting hospital admission.

Serum sodium level has also been reported to predict outcome in HF patients,[19] with hyponatremia adversely affecting mortality rates in hospitalized HF patients. Other studies have reported that sodium

level is predictive of 30-day and one-year mortality rates.[16] While we did not corroborate these findings, we did not evaluate long-term outcomes. In terms of EDOU disposition, we found no evidence that presentation sodium levels predicted an EDOU management failure.

Similarly, anemia is associated with adverse HF outcomes,[16] but in our study population, we found no association between EDOU disposition and anemia. Last, although socioeconomic status and race predict outcomes in many cardiovascular conditions, they were not examined in these patients.

LIMITATIONS

Because of the retrospective nature of the investigation, patient data were limited to the information gathered and documented by the emergency team at the time of the patient's visit. While we reviewed more than a year and a half of Cleveland Clinic Foundation OU admissions, involving 385 patients, it was limited to only one site and one patient population. We suggest validation using multiple sites, and a prospective methodology that may provide insight into additional predictors of success in EDOU management. Follow-up studies could address many of these problems by involving more sites, standardizing laboratory reports, and developing a standard information form. The platform for the BNP diagnostic test changed during the conduct of this study. It is possible that the newer test with an expanded range may demonstrate prognostic value that was not determined here.

Another limitation involves the variables of nonstandardized entry and exclusion habits for admission to the EDOU, differing levels of therapeutic intensity as ordered by the emergency physician, and variability in disposition decisions. These were addressed by having in place previously established EDOU entry and exclusion criteria to decrease population heterogeneity, validated therapeutic algorithms in an attempt to standardize intensity of care, and established discharge criteria to decrease variation in disposition decisions.[5–9] While these processes have been in place historically, and prior quality assurance data have indicated that physician compliance exceeds 90%, compliance documentation was not included in this analysis. Consequently, the above variables may have influenced outcomes.

A final limitation is that a retrospective methodology does not provide definitive information on how treatment may be improved with this new information. This study only provides information as to the likely course within the ED and does not provide any insight as to how one might be able to limit hospitalizations using its conclusions in a proactive, treatment-oriented manner. A prospective study will be required.

CONCLUSIONS

Management of heart failure in an emergency department observation unit is a recognized treatment option. In this study, we have found that 74% of patients are discharged after EDOU treatment. An elevation in BUN level suggests a lowered likelihood of successful EDOU treatment. Whether more aggressive management of these patients would lead to an improved discharge rate would be an important subject for future studies.

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