# 30-day readmissions associated with persistent congestion or anemia at discharge in the first heart failure (HF) cohort (n=47) to receive blood volume analysis (BVA) at Lankenau Medical Center

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## Abstract [updated]

**Introduction:** Decongestion strategy in hospitalized HF patients (pts) must be individualized due to the heterogeneity of HF. Volume evaluation by clinical assessment and/or indirect metrics using Echo Doppler or direct hemodynamic measurement is unsatisfactory, and anemia is difficult to identify ,as volume overload confounds serum tests. BVA directly quantifies excess or deficit in total blood volume (TBV) and red blood cell volume (RBCV) and is currently being integrated into HF management at Lankenau Medical Center (LMC).

**Methods:** Exploratory analysis was performed to analyze risk factors at discharge for 30-day readmission among the first 50 patients to undergo BVA on admission or during the hospital stay for signs or symptoms of HF. Since BVA was not routinely performed at discharge, imputed TBV and RBCV at discharge were calculated based on normalized hematocrit (nHct) per BVA and discharge serum Hct assuming stable RBCV status. Strict/severe risk thresholds were set for congestion (TBV excess >+22%) and anemia (nHct <30% F/<33% M).

**Results:** Among 47 analyzable patients, heterogeneity in imputed TBV at discharge was high, with 30% of patients congested (>+22% excess), 30% having a less severe (+8%-+22%) excess, 34% normovolemic, and 10% hypovolemic (<−8% deficit) (range: −27.9% to +73.7%). 27% were anemic and 17% polycythemic (nHct range: 16.3% to 62.4%). Among 17 patients who had 30-day readmissions, 15 were found to have had persistent congestion (n=7) or anemia (n=8) at discharge. 30-day readmissions rates (RR) were 62% and 50% for those with anemia and congestion at discharge, respectively; 56% for those with either; and 11% for patients with near normal RBCV and normal TBV or only a less severe volume excess at discharge. Due to small subset n numbers risk factor analysis was not attempted for polycythemia or hypovolemia.

**Conclusions:** In this first cohort of HF patients to be evaluated by BVA at Lankenau Medical Center we identified a strong association of severe persistent congestion and/or anemia with 30-day readmission risk. Best practices are currently being established for optimal utilization of BVA in the HF setting, and strategies to reduce readmissions may include direct assessment of decongestion adequacy prior to discharge, more proactive management of anemia, and targeting those with greater TBV and RCBV derangement for more intense post-discharge follow-up. Variance in TBV and RBCV was higher than expected, suggesting an unmet need for accurate TBV and RBCV quantification to enable individualized management.

## Background

Congestive heart failure (HF) is associated with significant morbidity and mortality. According to the Centers for Disease Control and Prevention, more than 5 million people in the United States have HF, and about half die within 5 years of diagnosis.[1]

In acute decompensated HF, volume status historically is evaluated and monitored by clinical assessment, body weight change, intake/output, and pressures. Signs and symptoms of congestion, or excess TBV, are neither sensitive nor specific and inter-observer variability is high.[2-4] Due to refilling, weight change during diuresis is unrepresentative of the intravascular decongestion progress.[5,6] Pressures are at best moderately correlated with volume status.[3,4] Treatment strategy, then, must steer between inadequate decongestion and overdiuresis on the basis of qualitative and/or indirect metrics. RBCV assessment in HF likewise is challenging, since routine tests like hematocrit are serum ratios confounded by plasma expansion: differentiating true from dilutional anemia is a challenge and the risk of overtreatment is strongly felt. Though it is common in HF and is associated with increased all-cause and cardiovascular mortality,[7] anemia is infrequently targeted in the treatment plans for these patients.

BVA directly measures intravascular TBV, RBCV, and PV and quantifies the degree of excess or deficit vs calculated patient-specific ideals. Prior research has shown that directly quantifying TBV, RBCV, and PV by BVA in order to guide individualized care for hospitalized HF patients results in low 30-day mortality and readmissions rates.[8] LMC began the process of integrating BVA into HF care in 2015. This exploratory analysis of the first cohort of patients to receive the test at LMC illuminates emerging best practices in the clinical utilization of the data provided by BVA.

## Methods

Exploratory analysis sought to illuminate 30-day readmissions risk factors at discharge among the first 50 patients to undergo BVA testing using the Daxor BVA-100 Blood Volume Analyzer (Daxor Corporation) on admission or at any other time during hospitalization for HF at LMC. Pre-discharge BVA was not routinely performed, so an imputed TBV status (% deviation from ideal) at discharge was calculated based on normalized Hct (nHct: a hematocrit adjusted for actual blood volume; automatically calculated and reported by BVA) and discharge serum Hct, utilizing a proprietary developmental methodology. Any change in RBCV status during hospital stay, eg transfusion or bleeding, would confound the imputation, so 2 patients (1 readmitted) noted to have received a transfusion were excluded from the analysis, as was 1 other patient (readmitted) for whom nHct was not recorded, for an analyzable cohort of n=47. The variables analyzed for risk were hypervolemia and anemia at discharge; too few patients had hypovolemia and polycythemia at discharge (n=3, n=4, respectively) to attempt analysis for these subsets. Given the small cohort, the potential imprecision of imputed discharge TBV status, and the goal of defining a meaningfully heightened risk for readmission, a strict risk threshold of >+22% imputed TBV (severe excess) at discharge was set. Those with less severe excess (+8%–≤+22%) did not meet the defined threshold and were not considered hypervolemic at discharge for risk analysis purposes. For anemia, risk thresholds were set at nHct <33% for men and <30% for women.

As a still novel metric at LMC during this period (May-October 2015), BVA was not routine for all HF inpatients but rather was performed on an ad hoc basis. No guidance was in place for treatment planning in the event BVA results were perceived by healthcare providers as discordant with clinical impressions or other findings.

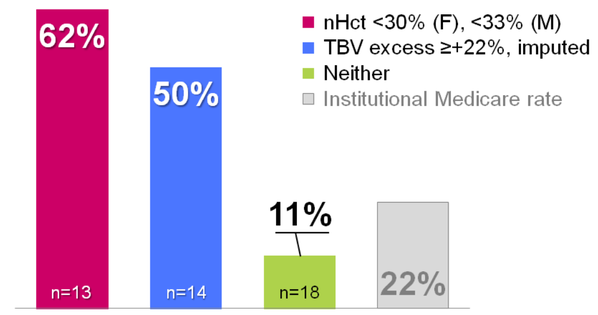
## Results

High heterogeneity was observed at discharge both in imputed TBV status (range -27.9 to +73.7%) and RBCV status (nHct range 16.3% to 62.4%). 30% of patients were congested at the >+22% TBV risk threshold at time of discharge; 30% had a less severe overload that did not meet the defined threshold and so were not counted as hypervolemic for risk factor analysis purposes; 34% were normovolemic; and 10% were hypovolemic. 28% of patients were discharged with anemia. None were identified as both anemic and hypervolemic at discharge by the defined thresholds, although 2 anemic patients had congestion less severe than the defined threshold, while 1 patient with hypervolemia and 1 patient with less severe volume excess also had polycythemia.

Among patients who were anemic or hypervolemic at discharge, the 30-day readmission rate was 56%. Among patients whose TBV and RBC status were normal or did not exceed defined thresholds at discharge, the 30-day readmission rate was 11%. Per Medicare, LMC's institutional 30-day readmissions rate for HF is 22%.[8]

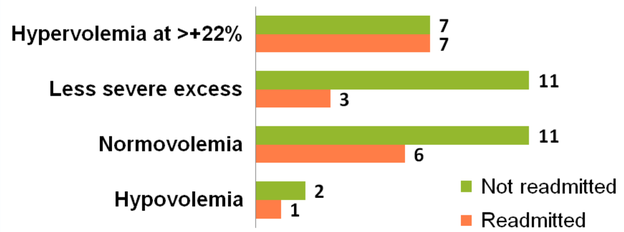
Among patients who were readmitted within 30 days (n=17), 88% had an identifiable risk factor at discharge: 47% were anemic and 41% hypervolemic. Anemia at discharge appeared to correlate especially strongly with 30-day readmission risk. 62% of those anemic at discharge and 50% of those hypervolemic at discharge were readmitted within 30 days. Among those not readmitted within 30 days (n=31), 16% were anemic at discharge, 22% hypervolemic, 26% were discharged in a normovolemic state, and 35% with a less severe TBV excess that fell below the defined threshold.

Figure 1. Impact of anemia or hypervolemia at discharge on 30-day readmissions rate in hospitalized HF patients.



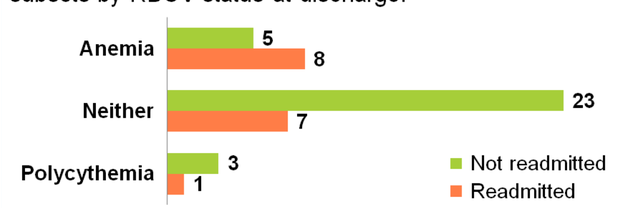

nHct, or normalized Hct, is adjusted for plasma volume to reflect true RBCV. Not shown: polycythemia (n=1), hypovolemia (n=1); neither was readmitted.

Figure 2. 30-day readmissions outcomes (n)—patient subsets by imputed volume status at discharge.



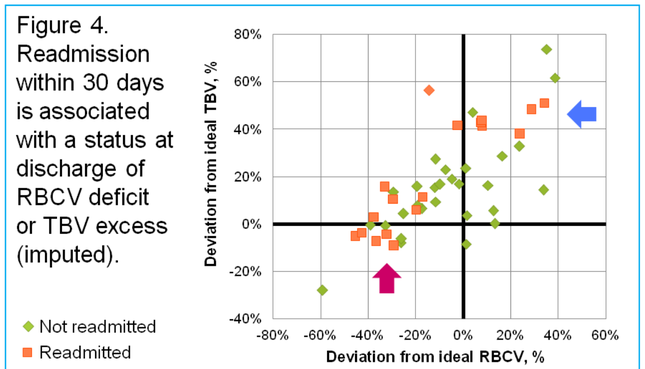

Patients with a less severe excess, ie, an imputed TBV of >+8% but ≤+22% at discharge, did not meet the risk threshold defined for this analysis.

Figure 3. 30-day readmissions outcomes (n)—patient subsets by RBCV status at discharge.




Risk threshold for anemia at discharge was set at nHct <30% (F), <33% (M).

Figure 4. Readmission within 30 days is associated with a status at discharge of RBCV deficit or TBV excess (imputed).




## Summary

- This exploratory analysis of the first cohort of HF patients to receive BVA testing at LMC (5/2015-10/2015) (n=47 analyzable) revealed a strong association between markedly anemic or hypervolemic status at discharge and readmission within 30 days
- 88% of patients who experienced a 30-day readmission had an identifiable risk factor at discharge. Among those with a 30-day readmission, 47% were anemic at discharge, 41% hypervolemic
- 62% of those who were anemic at discharge and 50% of those hypervolemic at discharge experienced a 30-day readmission
- Patients with TBV and RBCV in normal range or not exceeding the defined thresholds at discharge had a 30-day readmission rate of 11% (half the LMC institutional Medicare HF rate of 22%)

## Discussion

The main limitations of this retrospective exploratory analysis are the small cohort, whose baseline demographics, clinical status ,and prognosis are unclear, and the imputation of discharge TBV, which any unrecorded change in RBCV status would confound and which cannot be presumed to deliver the accuracy of direct measurement.

This is the second BVA dataset in HF to describe interventional patient outcomes. The 11% 30-day readmissions rate observed for patients with normal or near-normal TBV and RBCV at discharge echoes the larger dataset (n=250) presented earlier this year at ACC 2016[9] in which TBV and RBCV management guided by BVA resulted in a 30-day readmissions rate of 11.6%. This concordance of results is encouraging, and suggests that a relative reduction of roughly 50% in 30-day readmissions risk is achievable in HF when treatment plans and targets can be rationally individualized to patient needs.

In this cohort, in the ACC16 interventional cohort,[9] and in multiple historical studies,[7] HF patients with anemia have worse outcomes than others. These results underline a need to identify and address anemia in the setting of hospitalized HF. Accurate quantification of RBCV status will improve the risk:benefit of treatment and allow more proactive management of anemia in HF patients.

Severe hypervolemia at discharge was strongly associated with 30-day readmissions risk. Less severe excess at discharge was not, and this may be ascribable to the expanded venous capacitance of long-term, late-stage chronic HF. It should be noted that the high severity thresholds set for this analysis may be inappropriate when considering a broader HF population. Routine BVA prior to discharge, and/or at 7-day outpatient follow-up, could confirm the adequacy of acute treatment and help optimize transitional care.

The impact on outcomes of direct measurement of TBV and RBCV by BVA in order to drive HF treatment strategies individualized to the quantified needs of the patient should be prospectively examined.

## References

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