Published in final edited form as:

Am J Gastroenterol. 2012 February ; 107(2): 247–252. doi:10.1038/ajg.2011.314.

Hospital Re-Admissions among Patients with Decompensated Cirrhosis

Michael L. Volk¹, Rachel S. Tocco¹, Jessica Bazick², Mina O. Rakoski¹, and Anna S. Lok

¹Division of Gastroenterology and Hepatology, University of Michigan, Ann Arbor MI

²Department of Internal Medicine, University of Michigan, Ann Arbor MI

Abstract

OBJECTIVES—Early re-hospitalizations have been well characterized in many disease states, but not among patients with cirrhosis. The aims of this study were to identify the frequency, costs, predictors, and preventable causes of hospital re-admissions among patients with decompensated cirrhosis.

METHODS—Rates of re-admission were calculated for 402 patients discharged after one of the following complications of cirrhosis: ascites, spontaneous bacterial peritonitis, renal failure, hepatic encephalopathy or variceal hemorrhage. Costs of re-admissions were calculated using the hospital accounting system. Predictors of time to first re-admission were determined using Cox regression, and predictors of hospitalization rate/person-years using negative binomial regression. The independent association between re-admission rate and mortality was determined using Cox regression. Admissions within 30 days of discharge were assessed by two reviewers to determine if preventable.

RESULTS—276 (69%) subjects had at least one non-elective re-admission, with a median time to first re-admission of 67 days. By one week after discharge 14% of subjects had been re-admitted, and 37% were re-admitted within one month. The mean costs for re-admissions within one week and between weeks 1–4 were \$28,898 and \$20,581, respectively. During a median follow-up of 203 days, the median number of re-admissions was 2 (range 0–40), with an overall rate of 3 hospitalizations/person-years. Patients with more frequent re-admissions had higher risk of subsequent mortality, despite adjustment for confounders including the Model for End-stage Liver Disease score. Predictors of time to first re-admission included MELD score, serum sodium, and number of medications on discharge; predictors of hospitalization rate included these variables as well as the number of cirrhosis complications and being on the transplant list at discharge. Among 165 re-admissions within 30 days, 22% were possibly preventable.

CONCLUSIONS—Hospital re-admissions among patients with decompensated cirrhosis are common, costly, moderately predictable, in some cases possibly preventable, and independently associated with mortality. These findings support the development of disease management interventions to prevent re-hospitalization.

Corresponding author: Michael L. Volk, MD, MSc, Division of Gastroenterology and Hepatology, University of Michigan Health System, 300 N Ingalls, 7C27, Ann Arbor, MI 48109, mvolk@med.umich.edu.

Specific author contributions: all authors participated in data interpretation and approved the final version of the manuscript. Michael Volk was responsible for study design and drafting of the manuscript, Rachel Tocco was responsible for data analysis, Jessica Bazick and Mina Rakoski were responsible for data acquisition, and Anna Lok was responsible for critical review of the study design and manuscript revision.

Conflicts of interest: none of the authors has any conflict of interest for this study.

Background

Cirrhosis is the final common pathway for the majority of liver diseases. More than 40,000 deaths in the United States each year can be attributed to complications of cirrhosis, nearly as many as attributable to diabetes and more than that attributable to kidney diseases(1). Cirrhosis is also responsible for significant morbidity and health-care costs. It leads to more than 150,000 hospitalizations costing nearly \$4 billion dollars each year(2), and the incidence of hospitalizations due to complications of cirrhosis is increasing(3).

For patients with cirrhosis who survive their hospitalization, the period immediately after discharge is a high risk one. They often carry new diagnoses, are on new medications or received changes in the dosages of existing medications, and are de-conditioned from their hospital stay. Furthermore, responsibility for their care is typically being transitioned from the inpatient team to outpatient physicians, and communication between providers is not always optimal(4). For these reasons, clinical experience suggests that many patients are re-admitted within the first month.

In other chronic disease states, early hospital re-admissions are widely recognized as being costly, associated with worse patient outcomes, and partially preventable(5). For example, in the field of congestive heart failure there have been multiple successful randomized trials of interventions to prevent hospital re-admissions(6). In cirrhosis, however, hospital re-admissions have not been well characterized, and further information will be needed to design appropriate interventions. We hypothesized that early re-hospitalizations among patients with cirrhosis are common and partially preventable. Therefore, the aims of this study were to identify the frequency, cost, predictors, and preventable causes of hospital re-admissions among patients with decompensated cirrhosis.

Methods

Study sample

This was a retrospective study of adult (age ≥ 18) patients discharged from our institution between July 1, 2006 and July 1, 2009, and followed until liver transplant, death, lost to follow-up, or the end of the study period in August 2010. Potential subjects were initially identified by discharge diagnoses including any of the following ICD-9 or CPT codes: alcoholic cirrhosis (571.2), cirrhosis not due to alcohol (571.5), biliary cirrhosis (571.6), hepatic encephalopathy (572.2), ascites (789.59), hepatorenal syndrome (572.4), spontaneous bacterial peritonitis (567.23), esophageal varices with bleeding (456.0, 456.2), portal hypertension (572.3), hepatocellular carcinoma (155.0), other sequelae of chronic liver disease (572.8), or paracentesis (54.91). 1,926 individual patient charts were reviewed, and subjects included if they had cirrhosis diagnosed by an attending hepatologist, along with any of the following complications as part of their hospital admission:

1. hepatic encephalopathy, defined as altered mental status diagnosed as hepatic encephalopathy by an attending hepatologist and improved after treatment with lactulose,
2. variceal hemorrhage, defined as a clinically significant gastrointestinal bleed (tachycardia, hypotension, requirement for blood transfusion, or >2g drop in hemoglobin) and varices seen on endoscopy,
3. spontaneous bacterial peritonitis (SBP), defined as >250 polymorphonuclear cells per high power field and/or monomicrobial culture in the ascitic fluid,

4. renal failure in the presence of ascites, defined as a rise in the serum creatinine by 0.5 mg/dL (to >1.5 mg/dL), with ascites documented on physical examination or ultrasound, or admitted on diuretics for the treatment of ascites, or
5. ascites requiring paracentesis during the hospitalization.

Exclusion criteria were 1) discharge with hospice care, and 2) liver transplantation prior to or during the index hospitalization. Approval from the Institutional Review Board was obtained for the conduct of this study.

Institutional structure

This study was conducted at a single academic transplant center with nine hepatologists who see outpatients in a dedicated liver clinic, a core group of hepatology nursing staff, physician assistants available to see sick patients for urgent add-on visits, and a call center for patient calls. Procedures such as paracentesis are performed Monday through Friday, and can typically be scheduled with 24 hour notice. The catchment area is large, and many patients live up to 8 hours' drive away. On the inpatient side, patients with liver disease are either admitted to the dedicated liver service or are admitted to a general medicine service with hepatology consultation. Upon discharge, each patient is given a copy of the discharge summary. This document includes a summary of events during the hospitalization, pertinent test results, changes made to medications, medications on discharge, follow-up appointments, and list of warning symptoms which should prompt them to seek medical attention.

Endpoints and statistical analysis

Subsequent hospital admissions were recorded after the index hospitalization by examining the computerized medical record at our institution for each patient. This record includes both inpatient (history and physical, daily notes, test results, discharge summary) and outpatient documents. In order to capture episodes of hospitalization at other institutions, we examined all outpatient clinic and telephone notes which record hospital admissions (to any hospital) since the last clinic visit and notifications by patients, family members or physicians at outside hospitals of any hospitalizations at other institutions. Follow-up time was censored at death, "elective" admissions such as transplant or post-procedure observation, or the date of the last clinic note. Admissions were categorized as elective if they were planned for a procedure or surgery. The primary endpoints included 1) time to first re-admission, and 2) overall rate of re-admissions during the study period. Statistical analysis was performed using Stata v.11 (StataCorp, College Station TX).

Time to first re-admission was calculated using the Kaplan-Meier method, and predictors of time to re-admission were determined using Cox regression. The following candidate predictors were first analyzed individually: type of cirrhosis complication as described above, number of complications, being on the transplant list at discharge, length of hospital stay, discharge day of the week (weekday vs weekend), number of medications on the discharge summary, discharge location (home versus nursing facility), age, gender, race/ethnicity, marital status, insurance type (Medicaid or charity care versus other), etiology of liver disease, presence of hepatocellular carcinoma, Charlson comorbidity index (calculated using the Deyo adaptation(7)), and most recent laboratory values on discharge including Model for End-stage Liver Disease (MELD) score and serum sodium (both treated as continuous variables). Variables with p-value <0.1 were subsequently included in the multivariable model. The type of cirrhosis complication and number of complications were collinear, and neither was clearly superior in predictive power (by chi-square statistic), so number of complications was used in the final model for simplicity. The final multivariable

model was then used to divide subjects into two equal groups based on their risk for early re-admission, using the linear prediction of the fitted model.

We hypothesized that factors influencing the first re-admission might be different from those influencing multiple subsequent re-admissions. Therefore, negative binomial regression was used to determine which variables predicted hospitalization rate (hospitalizations/person-years at risk). As with the above analysis, elective admissions and those occurring after the time of transplantation were excluded.

In order to determine whether frequent re-hospitalization was independently associated with mortality, we performed Cox regression on the hospitalization rate (re-admissions/person-years), with censoring at the time of liver transplantation, lost to follow-up, or end of the study period. Potential confounders included in the model were the MELD score, age, number of medications, serum sodium, comorbidity index, and whether the patient was listed for transplant.

Costs were determined for re-admissions within one week, and between weeks one to four. Elective re-admissions (including for transplant) were excluded. Costs were assessed using the University of Michigan cost accounting system (Transition Systems Inc., TSI, Chicago, IL), and included both fixed and variable costs. The TSI system tracks the use of all resources and assigns costs based upon direct acquisition costs for supplies and time-and-motion studies for labor(8).

Readmissions within thirty days were then assessed independently by two subspecialist physicians (MLV, MOR) and categorized as “possibly preventable” versus “not preventable.” This determination was made by reviewing each discharge summary as well as the subsequent admission history and physical document, and any intervening clinic or phone notes. Re-admissions were categorized as possibly preventable if there was evidence that a modification to the health care delivery system such as improved patient education, adherence to medications, or closer follow-up could have avoided that hospitalization. In order to avoid overestimating preventable re-admissions, those that were unable to be accurately categorized (such as re-admissions to an outside hospital) were categorized as not preventable. Concordance between the two reviewers was 83%; discrepancies were resolved by consensus and by categorizing admissions as not preventable when differences of opinion persisted. The most common discrepancy involved situations where the patient did not receive the care intended by the medical team, not because of miscommunication or inadequate education, but rather because the patient chose to be noncompliant or had inadequate social support to enact the care plan. Because these situations are not always necessarily modifiable, they were ultimately categorized as not preventable in the consensus results.

Results

Four hundred and twenty-three subjects met eligibility criteria during the study period, but 21 were excluded from further analysis due to lack of follow up at our institution after discharge. Clinical and demographic data from the index admission is displayed in Table 1 for the remaining 402 subjects who formed our study sample. The median time from hospital discharge to end of the study period was 398 days, during which time 70 patients (17%) received a liver transplant and 83 (21%) others died.

Three hundred and fourteen or 78% of subjects were re-admitted during the follow-up period, with 38 of them being elective in nature. After censoring these elective re-admissions, the median time to first re-admission was 67 days, as shown in Figure 1, with 14% of subjects re-admitted within one week and 37% re-admitted within one month.

Eighty-three percent of first re-admissions occurred at our institution, while 17% were re-admitted elsewhere. The median number of non-elective re-admissions during the study period was 2 (range 0–40) during a median time at risk of 203 days, yielding a median hospitalization rate of 3 hospitalizations/person-years. Among the 55 re-admissions that occurred within one week, the mean cost per re-admission was \$25,898; among the 85 re-admissions that occurred between weeks one to four, the mean cost was \$20,581.

Patients with more frequent re-admissions had higher risk of subsequent mortality (hazard ratio 1.08 per unit increase in hospitalization rate, $p < 0.001$), despite adjustment for MELD score, serum sodium, number of medications, age, comorbidity index, and being listed for transplant.

Independent predictors of time to first non-elective re-admission were MELD score, serum sodium, and number of medications on discharge, as shown in Table 2. The multivariable Cox model had a c-statistic of 0.65, indicating moderate predictive ability. The linear prediction of the fitted model was then used to divide the subject population into two groups of equal size, based on their risk for early non-elective re-admission, as shown in Figure 2. For example, a patient with MELD score of 12, serum sodium of 140 mMol/L, and 6 medications on discharge would have a 22% predicted risk of re-admission by one month, while a patient with MELD score of 20, serum sodium of 125 mMol/L, and 14 medications on discharge would have a 60% predicted risk of re-admission by one month.

Independent predictors of hospitalization rate (hospitalizations/person-years) were similar, and included MELD score, serum sodium, number of medications on discharge, number of cirrhosis complications, and being on the transplant list at discharge, as shown in Table 3.

Of the 165 re-admissions within one month, 36 (22%) were judged to be possibly preventable. The most common causes for possibly preventable re-admissions were hepatic encephalopathy and fluid imbalance (hyper- and hypovolemia). Reasons why these admissions were judged to be possibly preventable were as follows. 1) Failure to appropriately titrate lactulose – numerous chart examples were seen where the patient was not having adequate number of bowel movements, was not aware of the need to adjust the dose, did not notify the clinic for worsening symptoms, and was subsequently admitted for encephalopathy. 2) Failure to plan ahead for paracentesis – patients would wait until severely symptomatic to call for paracentesis, and when this could not be scheduled right away, they would present to the emergency room and be admitted for treatment of tense ascites. 3) Failure to recognize warning signs indicating over-diuresis – patients would be discharged on a new dose of diuretics, would experience rapid weight loss and present to the emergency room with hypovolemia and acute kidney injury. These and other examples were judged to be possibly preventable because improved patient education, telephone management, or other disease management intervention could theoretically have prevented at least some of these admissions.

Discussion

This study found that early re-hospitalizations among patients with decompensated cirrhosis are extremely common, with 37% of patients being re-admitted within one month of discharge at a cost of over \$20,000 per admission. By comparison, this rate is higher than in the Medicare population (20%)(9) or the elderly heart failure population (25%)(10). Not only were hospital re-admissions common and costly, they were also moderately predictable and partially preventable. Risk factors for re-admission included severity of liver disease as measured by the MELD score and serum sodium, as well as complexity of medical regimen as measured by the number of medications. These variables permitted stratification of the

patients into two equally-sized groups at high risk (55% re-admitted within 30 days) and lower risk (22% re-admitted within 30 days). Among the 165 admissions within 30 days of discharge, nearly one quarter could have been prevented by better patient understanding of their medication regimen or by more intensive outpatient monitoring. Finally, frequent re-hospitalizations were associated with higher risk of mortality, independent of measures of disease severity such as the MELD score.

Cirrhosis is a complex disease, and the multiple complications can be overwhelming for patients and their caregivers. They must adjust medications frequently, often with unclear instruction or conflicting advice from multiple physicians. Among other tasks, they must obtain the necessary laboratory follow-up, deal with side effects of diuretics such as muscle cramps, and titrate their lactulose medication to the number of desired bowel movements per day. They are required to know what prescription and over-the counter medications to avoid, and to follow the proper diet despite minimal education on how to do so. Finally, they must know when and how to seek medical attention for warning signs of impending complications. Our current episodic and uncoordinated system of healthcare delivery is poorly structured for such patients with chronic disease(11). For example, the use of structured discharge summaries has long been known to be associated with improved communication between hospital providers and outpatient physicians, yet these simple interventions are not always utilized(12). This fact has been recognized in other disease states such as congestive heart failure, where chronic disease management is included as a Class 1 recommendation in practice guidelines(13). The findings in this study suggest that similar efforts should be made for the cirrhosis population.

Limitations of this study include its single center and retrospective nature. Factors influencing re-admissions such as patient education and social support will need to be assessed in future prospective studies. Additionally, re-admissions at other hospitals were captured by reviewing subsequent chart documentation in our system, and thus some could have been missed. The fact that we reviewed charts to capture outside hospital admissions may partially explain our findings of a relatively high 37% one-month re-admission rate. By comparison, a recent study in patients with advanced liver disease found a one-month re-admission rate of 20%, but did not include re-admissions at other institutions(14). Finally, our classification of early re-admissions as preventable was entirely subjective, though agreement between independent reviewers was 83%. The true test of whether re-admissions among patients with cirrhosis are preventable will be if implementation of disease management interventions can successfully decrease their frequency.

In conclusion, hospital re-admissions among patients with decompensated cirrhosis are common, costly, moderately predictable, in some cases possibly preventable, and independently associated with mortality. These findings support the development of disease management interventions to prevent re-hospitalization.

Acknowledgments

Guarantor of the article: Michael Volk

Financial support: this study was funded in part by a Research Scholar Award from the American Gastroenterology Association, as well as K23DK085304 from the National Institutes of Health (both to MLV).

References

1. Kim WR, Brown RS Jr, Terrault NA, et al. Burden of liver disease in the United States: summary of a workshop. *Hepatology*. 2002; 36:227–242. [PubMed: 12085369]

2. Talwalkar JA. Prophylaxis with beta blockers as a performance measure of quality health care in cirrhosis. *Gastroenterology*. 2006; 130:1005–1007. [PubMed: 16530542]
3. Nguyen GC, Segev DL, Thuluvath PJ. Nationwide increase in hospitalizations and hepatitis C among inpatients with cirrhosis and sequelae of portal hypertension. *Clin Gastroenterol Hepatol*. 2007; 5:1092–1099. [PubMed: 17625983]
4. Coleman EA, Min SJ, Chomiak A, et al. Posthospital care transitions: patterns, complications, and risk identification. *Health Serv Res*. 2004; 39:1449–1465. [PubMed: 15333117]
5. Institute of Medicine (U.S.). *Crossing the quality chasm : a new health system for the 21st century*. Washington, D.C.: National Academy Press; 2001. Committee on Quality of Health Care in America.
6. Phillips CO, Wright SM, Kern DE, et al. Comprehensive discharge planning with postdischarge support for older patients with congestive heart failure: a meta-analysis. *JAMA*. 2004; 291:1358–1367. [PubMed: 15026403]
7. Deyo RA, Cherkin DC, Ciol MA. Adapting a clinical comorbidity index for use with ICD-9-CM administrative databases. *J Clin Epidemiol*. 1992; 45:613–619. [PubMed: 1607900]
8. Englesbe MJ, Ads Y, Cohn JA, et al. The effects of donor and recipient practices on transplant center finances. *Am J Transplant*. 2008; 8:586–592. [PubMed: 18294154]
9. Jencks SF, Williams MV, Coleman EA. Rehospitalizations among patients in the Medicare fee-for-service program. *N Engl J Med*. 2009; 360:1418–1428. [PubMed: 19339721]
10. Rich MW, Beckham V, Wittenberg C, et al. A multidisciplinary intervention to prevent the readmission of elderly patients with congestive heart failure. *N Engl J Med*. 1995; 333:1190–1195. [PubMed: 7565975]
11. Volk ML, Piette JD, Singal AS, et al. Chronic disease management for patients with cirrhosis. *Gastroenterology*. 139:14–16. e1. [PubMed: 20553725]
12. Rawal J, Barnett P, Lloyd BW. Use of structured letters to improve communication between hospital doctors and general practitioners. *BMJ*. 1993; 307:1044. [PubMed: 8251779]
13. Hunt SA, Abraham WT, Chin MH, et al. ACC/AHA 2005 Guideline Update for the Diagnosis and Management of Chronic Heart Failure in the Adult: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to Update the 2001 Guidelines for the Evaluation and Management of Heart Failure): developed in collaboration with the American College of Chest Physicians and the International Society for Heart and Lung Transplantation: endorsed by the Heart Rhythm Society. *Circulation*. 2005; 112:e154–e235. [PubMed: 16160202]
14. Berman K, Tandra S, Forssell K, et al. Incidence and Predictors of 30-Day Readmission Among Patients Hospitalized for Advanced Liver Disease. *Clinical Gastroenterology and Hepatology*. 2011; 9:254–259. [PubMed: 21092762]

1. WHAT IS CURRENT KNOWLEDGE?

- Cirrhosis is a complex chronic disease with high morbidity and mortality
- In other diseases, early re-hospitalizations are known to be costly and partially preventable

2. WHAT IS NEW HERE?

- Rates of hospital re-admission among patients with decompensated cirrhosis are higher than other diseases such as congestive heart failure
- Predictors of re-admission include MELD score, serum sodium, and the number of medications
- Frequent re-admissions are independently associated with increased mortality
- Nearly one quarter of early re-admissions are possibly preventable

Figure 1.
Time to first re-admission in the overall sample (n=402)

Figure 2.

Time to first-readmission according to risk factors on the index hospital admission. Low risk (n=201) and high risk (n=201) groups were determined by the linear prediction of the multivariable model including MELD score, serum sodium, and number of medications. The shaded areas represent 95% confidence intervals (CI).

Table 1

Demographic and clinical data on index admission (n=402).

Median Age	54 (range 19–88)
Gender	57% male
Married	55%
Race/Ethnicity	
White	82%
Black	9%
Hispanic	3%
Other	6%
Cirrhosis complications during index hospitalization	
Ascites requiring paracentesis	54%
Hepatic encephalopathy	34%
Renal failure with ascites	24%
Variceal hemorrhage	20%
Spontaneous Bacterial Peritonitis	13%
Hepatocellular Carcinoma	8%
On transplant list at discharge	16%
Median MELD at discharge	15 (range 6–40)
Median sodium at discharge	135 mMol/L (range 119–145)
Median Charlson comorbidity index	5 (range 0–36)
Median length of stay	5 days (range 1–60)
Discharge Location	
Home/Self care	67%
Home/Health service	24%
Nursing home/rehab facility	9%
Median # medications on discharge	9 (range 1–32)
Insurance type	17% Medicaid/charity care

Table 2

Multivariable analysis of predictors of time to first re-admission. Hazard ratios are expressed as risk of re-admission per unit increase in the variable.

Variable	Hazard ratio (95% CI)	P-value
MELD score	1.05 (1.03, 1.07)	<0.001
Serum sodium	0.97 (0.94, 0.99)	0.02
# medications	1.05 (1.02, 1.08)	0.001
Female gender	1.27 (0.99, 1.62)	0.05
# of cirrhosis complications	1.13 (0.94, 1.35)	0.21
On transplant list at discharge	1.35 (0.97, 1.86)	0.07
Discharge location	0.96 (0.72, 1.29)	0.79
Home health (vs self-care)	0.76 (0.48, 1.21)	0.24
Skilled nursing (vs self-care)		

Table 3

Multivariable analysis of predictors of hospitalization rate. Coefficients are expressed as hospitalizations/person-years per unit increase in the variable.

Variable	Coefficient (95% CI)	P-value
MELD score	0.06 (0.04, 0.08)	<0.001
Serum sodium	-0.05 (-0.02, -0.08)	0.001
# medications on discharge	0.04 (0.01-0.07)	0.003
# cirrhosis complications	0.20 (0.02-0.4)	0.03
On transplant list at discharge	0.42 (0.07, 0.8)	0.02