HHS Public Access

Author manuscript

Clin Biochem. Author manuscript; available in PMC 2018 June 01.

Published in final edited form as:

Clin Biochem. 2017 June ; 50(9): 491–495. doi:10.1016/j.clinbiochem.2017.02.014.

Circulating Intestinal Fatty Acid-binding Protein (I-FABP) Levels in Acute Decompensated Heart Failure

Takeshi Kitai, MD, PhD[*], **Yong-Hyun Kim, MD, PhD**[*], **Kathryn Kiefer, MS**[†], **Rommel Morales, MS**[†], **Allen G. Borowski, RDCS**[*], **Justin L Grodin, MD, MPH**[‡], and **W. H. Wilson Tang, MD**[*,†]

[*]Kaufman Center for Heart Failure, Department of Cardiovascular Medicine, Heart and Vascular Institute, Cleveland Clinic, Cleveland, OH

[†]Department of Cellular and Molecular Medicine, Lerner Research Institute, Cleveland, OH

[‡]Division of Cardiology, Department of Internal Medicine, University of Texas Southwestern Medical Center, Dallas, TX

Abstract

Background—Venous congestion has become increasingly recognized as a potential contributor to end-organ dysfunction in heart failure. Elevated I-FABP, which is excreted specifically from damaged intestinal epithelial cells, has been found in patients with abdominal hypertension and intestinal ischemia. We hypothesize that elevated intestinal fatty acid-binding protein (I-FABP) levels would identify patients with more advanced heart failure who have venous and intestinal congestion.

Methods—Baseline serum I-FABP levels were measured in 69 acute decompensated heart failure (ADHF) patients admitted to the intensive care unit for invasive hemodynamic monitoring and tailored medical therapy. Comprehensive echocardiography examinations were performed in all study patients, and clinical outcomes (death, cardiac transplant or left ventricular assist device placement) were assessed.

Results—The median circulating I-FABP level was 853 pg/ml (interquartile range: 533 to 1448 pg/ml). Age, gender, race, and baseline comorbidities were comparable between patients with low and high I-FABP levels. Although there were no significant correlations between I-FABP levels and invasively-measured hemodynamic parameters nor echocardiographic parameters, patients with higher I-FABP levels (≥853 g/ml) had significantly worse clinical outcomes compared to those with lower I-FABP levels (<853 pg/ml, P=0.025).

Conclusion—Circulating I-FABP levels had no association with invasively-measured hemodynamic parameters, but were associated with adverse clinical outcomes in patients with ADHF with systolic dysfunction.

Address for correspondence: W. H. Wilson Tang, M.D., Heat and Vascular Institute, Cleveland Clinic, 9500 Euclid Avenue, Desk J3-4, Cleveland, OH 44195, Tel: (216) 444-2121 / Fax: (216) 445-6165, tangw@ccf.org.

DISCLOSURES The authors report that they have no disclosures relevant to the contents of this paper.

Keywords

Acute Heart Failure; Cardiorenal; I-FABP; Biomarker

1. INTRODUCTION

Heart failure (HF) is a systemic clinical syndrome characterized by the involvement of multiple organ systems. Both reduced cardiac output (forward failure) and increased central venous pressure (backward failure) are important in describing the organ-to-organ crosstalk between the diseased heart and other organs. Cardiorenal syndrome specifically exemplifies this pathology between the heart and kidneys and is widely recognized in cardiology. Furthermore, intestinal congestion is a common clinical entity that has been thought to be the result from venous congestion due to right-sided, backward HF. While accumulating evidence indicates that organ crosstalk and interaction occur between the heart and the gut, the pathophysiology underlying this interaction is not well understood. There are no typical biochemical abnormalities observed in patients with intestinal congestion, whereas patients often complain of unspecified symptoms, such as feeling of fullness or constipation.

Fatty acid binding proteins (FABPs) comprise a group of cytoplasmic, small molecular mass proteins with high organ specificity. Uniquely located in mature intestinal enterocytes, intestinal FABP (I-FABP) is a member of the FABP family involved in the uptake and transport of long chain fatty acids from the intestinal lumen. [1, 2] Because I-FABP is mainly expressed in the villi where ischemic injury first occurs, and not in the crypt, I-FABP might be an early and useful marker for mucosal compromise or injury. [1, 3, 4] Recently, elevated I-FABP levels have been found in patients suffering from intestinal disease and systemic inflammatory response syndrome and have been reported as a promising sensitive marker for intestinal injury. [5–10]

Therefore, we aimed to investigate the relationship between serum I-FABP levels and the severity of heart failure, to examine I-FABP as a non-invasive biomarker to detect intestinal congestion.

2. METHODS

2.1. Study Population

This was a prospective, observational cohort study in patients hospitalized with acute decompensated HF (ADHF) who underwent pulmonary artery catheter-guided therapy. [11] Patients were eligible if they were admitted with a primary diagnosis of ADHF with New York Heart Association (NYHA) class III or IV symptoms, a left ventricular ejection fraction (LVEF) ≤35%, and elevated filling pressures defined by a pulmonary capillary wedge pressure (PCWP) > 18 mmHg and/or a right atrial pressure (RAP) > 8 mmHg. Patients who underwent mechanical ventilation or renal replacement therapy were excluded.

The hemodynamic goals were to achieve a decrease in PCWP to ≤18 mmHg, decrease in RAP to ≤8 mmHg and improvement in cardiac index to ≤2.2 l/min/m^2, while maintaining mean arterial pressure >65mmHg. The pharmacologic approach to intravenous therapy in

the specialized heart failure intensive care unit has been previously described. [12] A pre-specified endpoint was defined as the composite of all-cause mortality, heart transplantation, and HF re-hospitalization. This study was approved by the Cleveland Clinic Institutional Review Board. All patients provided written informed consent.

2.2. I-FABP Measurements

Blood samples were collected in serum separating tubes, and were clotted at room temperature for 30 minutes. Samples were then centrifuged for 20 minutes at 2000 x g and serum was collected in 2.0 ml tubes and stored at −80°C until analysis. Serum I-FABP levels were determined with a human FABP2/I-FABP enzyme-liked immunosorbent assay (ELISA), commercially available from R&D Systems (Minneapolis, MN). The assay was performed according to the manufacturer's recommendations, with serum samples diluted 1:5 in calibrator diluent provided. Concentration was determined via standard curve from absorbance read at 450nm and corrected at 570nm.

2.3. Statistical Analyses

Categorical variables, represented as numbers and percentages, were compared using either the chi-square test or the Fisher's exact test. Continuous variables were summarized as mean and standard deviation or median and interquartile range (IQR) where appropriate. Based on the distribution, continuous variables were compared using the Student's t test or Wilcoxon rank sum test. Two-sided p-values <0.05 were considered statistically significant. Spearman's correlation was used to assess the association between I-FABP levels and hemodynamic or other clinical parameters. The Kaplan Meier method was used to estimate cumulative event-free survival, and differences in the survival curves were compared via the log-rank test. A multivariable Cox proportional hazards model with risk adjusting variables was constructed to estimate the adjusted hazard ratio. These risk adjusting variables included age, gender, LVEF, serum creatinine, beta-blocker, angiotensin converting enzyme inhibitor or angiotensin receptor blocker, mineralocorticoid receptor antagonist medication, hypertension, diabetes mellitus, and hyperlipidemia. All variables were selected *a priori* as they were either predictors of risk in HF or because of their ability to confound the I-FABP-risk relationship. All statistical analyses were performed with JMP Pro 10.0.0 (SAS Institute Inc., Cary, North Carolina) and R v3.2.1 software (R Foundation for Statistical Computing, Vienna, Austria).

3. RESULTS

3.1. Patient characteristics

The mean patient age was 55.8±12.6 years, 80% were male, and the mean LVEF was 28.0±9.2%. The median I-FABP level was 853 pg/ml (IQR: 533 to 1448 pg/ml). Baseline characteristics that were stratified by the I-FABP levels are provided in Table 1. Although age, gender, race and other baseline characteristics were comparable between the groups, higher I-FABP levels were associated with baseline markers of worse renal function, including elevated levels of blood urea nitrogen (28.6±18.0 vs 43.0±28.4 mg/dl, P=0.03), serum creatinine (1.24±0.63 vs 1.63±0.74 mg/dl, P=0.04), Cystatin-C (1.73±0.78 vs

2.21±1.00 mg/l, P=0.03), and neutrophil gelatinase-associated lipocalin (NGAL, 120.5±58.8 vs 172.3±113.4 ng/ml, P=0.02).

3.2. Relationship of I-FABP Levels to Invasively-Measured Hemodynamics, Echocardiographic Indices and Other Biomarkers

Patients' vital signs and invasively-measured hemodynamic parameters, stratified by I-FABP levels, are shown in Table 2. There were no significant differences in hemodynamic parameters between patients with low and high I-FABP levels. Similarly, there were no significant differences between patients with low and high I-FABP levels in echocardiographic indices, including LVEF, estimated LV filling pressure (E/e'), and estimated RV function (tricuspid annular plane systolic excursion, right ventricular fractional area change, and right atrial volume index) (Table 3). In addition, I-FABP levels are not correlated with hemodynamic parameters, including RAP (ρ=0.08, P=0.52), PCWP (ρ=0.05, P=0.69) and cardiac output (ρ=0.07, P=0.59); and echocardiographic indices such as LVEF (ρ=0.19, P=0.40), RA volume index (ρ=0.23, P=0.07) and IVC diameter (ρ=0.01, P=0.93, Table 4).

3.3. I-FABP Levels and Post-discharge Clinical Outcomes

Overall, there were 21 deaths (30.4%), 20 heart transplantations (29.0%) and 8 left ventricular assist device (LVAD) placements (11.6%) during a median follow-up of 2.9 (IQR: 1.7 to 7.8) years. Patients with higher I-FABP levels had significantly worse clinical outcomes measured as a composite of death from all cause, heart transplantation or LVAD placement compared to those with lower I-FABP levels (Figure 1, P=0.025). However, after adjusting for confounders, the risk of the composite outcomes for the higher I-FABP group relative to the lower group was neutral (adjusted hazard ratio: 1.71, 95% confidence interval: 0.64 to 4.56, P=0.29).

4. DISCUSSION

In the present study, although there were no significant correlations between serum I-FABP levels and invasively measured hemodynamic parameters or echocardiography indices, we found that the I-FABP levels were elevated in ADHF patients, and patients with higher I-FABP had worse outcomes than those with lower I-FABP levels.

Increased RAP is a known risk factor for worse prognosis in patients with HF. [13, 14] Intestinal problems in the setting of HF are common because both passive venous congestion and decreased cardiac output could develop intestinal edema, leading to loss of function. [15] Further, constipation is a common complaint in advanced HF, and ADHF patients often present with abdominal symptoms, such as nausea and vomiting. [16, 17] Peripheral edema and jugular vein distension, which reflect varying degrees of venous congestion, still have significant roles in the management of HF, despite diversity of the factors driving these signs. Given these diagnostic challenges, invasively-measured central venous pressure remains the ideal standard for diagnosing venous congestion. [18] Thus, identifying and evaluating the extent of intestinal congestion in HF remains a challenge. A specific

biomarker to detect intestinal congestion and to predict the necessity to intervene more aggressively is in high demand.

I-FABP is a member of the FABP family, which consists of 15 kD cytoplasmic proteins involved in the intracellular buffering and transport of hydrophobic fatty acids within the cell cytoplasm. [2] I-FABP is expressed in the enterocytes at the tip of the villi and makes up 2% of intracellular protein. [1, 19] Since the gut is a blood-demanding organ and villi are most vulnerable during ischemia, I-FABP has been demonstrated to be released into systemic circulation due to enterocyte membrane integrity loss by intestinal ischemia. [2, 4] Elevated serum concentrations of I-FABP were found in patients suffering from necrotizing enterocolitis, intestinal ischemia due to abdominal sepsis, systemic inflammatory response syndrome, and intestinal injury due to mesenteric infarction. [4, 5, 20] Results from these reports suggest I-FABP could be a promising sensitive marker for intestinal injury. [9, 10] In addition, Derikx *et al.*, reported that elevated serum I-FABP was associated with poor outcomes in patients with abdominal sepsis. [5] In HF, both reduced intestinal perfusion (forward failure) and bowel wall edema due to venous congestion (backward failure) can cause intestinal epithelial ischemia. [21, 22]

In the current study, however, serum I-FABP levels were not correlated with hemodynamic and echocardiographic parameters, reflecting reduced cardiac output or elevated filling pressure. Since observed median I-FABP levels (843 pg/ml) were high in this study, even the lower I-FABP group had higher levels as compared to previous reports. This may be an indication of the advanced HF present in the patients enrolled in this study (1-year rate of death, LVAD or heart transplantation was 46.5 %). Derikx *et al.*, reported that higher serum I-FABP was associated with poor outcomes, and the mean I-FABP levels were 406 pg/ml in patients with in-hospital death versus 85 pg/ml in those discharged alive. [5] Likewise, Haan *et al.*, reported that I-FABP levels were associated with intestinal epithelial damage and inflammatory response, with mean I-FABP levels of 455 pg/ml in the high-risk group and 259 pg/ml in the low-risk group. [7] However, further study is needed to investigate whether I-FABP can detect intestinal congestion in less severe HF patients. Nevertheless, the lack of associations between I-FABP and hemodynamic values implies that venous congestion itself is not a major determinant of circulating I-FABP values. In the current analysis, I-FABP was associated with increased incidence of death, LVAD, or heart transplantation. However, patients with higher I-FABP had significantly worse renal function than those with lower I-FABP, and the impact of I-FABP on the outcomes was neutral after multivariable adjustment. As I-FABP is primarily excreted by the kidney, serum concentration of I-FABP might be affected by patients' renal function in this study. Recent studies have demonstrated that I-FABP levels in urine, not serum, were useful as a marker of intestinal mucosal damage in the early diagnosis of necrotic enterocolitis.[23] Further investigations into the prognostic value of urinary I-FABP are therefore warranted.

Our study has several limitations. First, this was a single-center study that recruited patients admitted to our HF intensive care unit. Hence, selection bias that may have identified that only patients with advanced HF (NYHA III or IV) were included. Therefore, these results may not apply to other patient populations with ADHF. Second, only a single time-point blood draw was analyzed, and we did not have any information regarding gastrointestinal

symptoms, intra-abdominal pressure and composition of gut microbiota. These could be insightful to assess venous and/or intestinal congestion.[15, 24] Third, ELISA-based assays are needed to measure I-FABP, which forms a major limitation for practical, daily clinical practice. Finally, the small sample size may be insufficient to assess the relationships between I-FABP levels and post-discharge outcomes. Despite these limitations, our study is the first to demonstrate I-FABP levels in patients with ADHF, encompassing a unique dataset that enabled us to assess the relationship between I-FABP levels, and hemodynamic and echocardiographic parameters in detail. Further studies are needed to confirm the link between I-FABP and other clinical parameters suggesting venous and/or intestinal congestion, such as intra-abdominal pressure and gut microbiota composition.

5. CONCLUSIONS

Circulating I-FABP levels had no association with invasively-measured hemodynamic parameters, but were associated with adverse clinical outcomes in patients with ADHF with systolic dysfunction.

Acknowledgments

FUNDING Dr. Tang has received funding support from the National Institutes of Health (R01HL103931).

References

1. Ockner RK, Manning JA. Fatty acid-binding protein in small intestine. Identification, isolation, and evidence for its role in cellular fatty acid transport. J Clin Invest. 1974; 54:326–338. [PubMed: 4211161]
2. Veerkamp JH, Peeters RA, Maatman RG. Structural and functional features of different types of cytoplasmic fatty acid-binding proteins. Biochim Biophys Acta. 1991; 1081:1–24. [PubMed: 1991151]
3. Robinson JW, Mirkovitch V. The recovery of function and microcirculation in small intestinal loops following ischaemia. Gut. 1972; 13:784–789. [PubMed: 4263959]
4. Lieberman JM, Sacchettini J, Marks C, Marks WH. Human intestinal fatty acid binding protein: Report of an assay with studies in normal volunteers and intestinal ischemia. Surgery. 1997; 121:335–342. [PubMed: 9068676]
5. Derikx JP, Poeze M, van Bijnen AA, Buurman WA, Heineman E. Evidence for intestinal and liver epithelial cell injury in the early phase of sepsis. Shock. 2007; 28:544–548. [PubMed: 17607153]
6. Derikx JP, van Waardenburg DA, Thuijls G, Willigers HM, Koenraads M, van Bijnen AA, Heineman E, Poeze M, Ambergen T, van Ooij A, van Rhijn LW, Buurman WA. New insight in loss of gut barrier during major non-abdominal surgery. PLoS One. 2008; 3:e3954. [PubMed: 19088854]
7. de Haan JJ, Lubbers T, Derikx JP, Relja B, Henrich D, Greve JW, Marzi I, Buurman WA. Rapid development of intestinal cell damage following severe trauma: A prospective observational cohort study. Crit Care. 2009; 13:R86. [PubMed: 19505335]
8. Relja B, Szermutzky M, Henrich D, Maier M, de Haan JJ, Lubbers T, Buurman WA, Marzi I. Intestinal-fabp and liver-fabp: Novel markers for severe abdominal injury. Acad Emerg Med. 2010; 17:729–735. [PubMed: 20653587]
9. Guthmann F, Borchers T, Wolfrum C, Wustrack T, Bartholomaus S, Spener F. Plasma concentration of intestinal- and liver-fabp in neonates suffering from necrotizing enterocolitis and in healthy preterm neonates. Mol Cell Biochem. 2002; 239:227–234. [PubMed: 12479590]
10. Pelsers MM, Namiot Z, Kisielewski W, Namiot A, Januszkiewicz M, Hermens WT, Glatz JF. Intestinal-type and liver-type fatty acid-binding protein in the intestine. Tissue distribution and clinical utility. Clin Biochem. 2003; 36:529–535. [PubMed: 14563446]

11. Verhaert D, Mullens W, Borowski A, Popovic ZB, Curtin RJ, Thomas JD, Tang WH. Right ventricular response to intensive medical therapy in advanced decompensated heart failure. Circ Heart Fail. 2010; 3:340–346. [PubMed: 20176715]
12. Mullens W, Abrahams Z, Francis GS, Skouri HN, Starling RC, Young JB, Taylor DO, Tang WH. Sodium nitroprusside for advanced low-output heart failure. J Am Coll Cardiol. 2008; 52:200–207. [PubMed: 18617068]
13. Drazner MH, Rame JE, Stevenson LW, Dries DL. Prognostic importance of elevated jugular venous pressure and a third heart sound in patients with heart failure. N Engl J Med. 2001; 345:574–581. [PubMed: 11529211]
14. Setoguchi S, Stevenson LW, Schneeweiss S. Repeated hospitalizations predict mortality in the community population with heart failure. Am Heart J. 2007; 154:260–266. [PubMed: 17643574]
15. Mullens W, Abrahams Z, Skouri HN, Francis GS, Taylor DO, Starling RC, Paganini E, Tang WH. Elevated intra-abdominal pressure in acute decompensated heart failure: A potential contributor to worsening renal function? J Am Coll Cardiol. 2008; 51:300–306. [PubMed: 18206740]
16. Opasich C, Gualco A. The complex symptom burden of the aged heart failure population. Curr Opin Support Palliat Care. 2007; 1:255–259. [PubMed: 18685371]
17. Gavazzi A, De Maria R, Manzoli L, Bocconcelli P, Di Leonardo A, Frigerio M, Gasparini S, Humar F, Perna G, Pozzi R, Svanoni F, Ugolini M, Deales A. Palliative needs for heart failure or chronic obstructive pulmonary disease: Results of a multicenter observational registry. Int J Cardiol. 2015; 184:552–558. [PubMed: 25767016]
18. Vincent JL, Pelosi P, Pearse R, Payen D, Perel A, Hoeft A, Romagnoli S, Ranieri VM, Ichai C, Forget P, Della Rocca G, Rhodes A. Perioperative cardiovascular monitoring of high-risk patients: A consensus of 12. Crit Care. 2015; 19:224. [PubMed: 25953531]
19. Sacchettini JC, Hauft SM, Van Camp SL, Cistola DP, Gordon JI. Developmental and structural studies of an intracellular lipid binding protein expressed in the ileal epithelium. J Biol Chem. 1990; 265:19199–19207. [PubMed: 1699943]
20. Kanda T, Fujii H, Tani T, Murakami H, Suda T, Sakai Y, Ono T, Hatakeyama K. Intestinal fatty acid-binding protein is a useful diagnostic marker for mesenteric infarction in humans. Gastroenterology. 1996; 110:339–343. [PubMed: 8566578]
21. Sandek A, Bauditz J, Swidsinski A, Buhner S, Weber-Eibel J, von Haehling S, Schroedl W, Karhausen T, Doehner W, Rauchhaus M, Poole-Wilson P, Volk HD, Lochs H, Anker SD. Altered intestinal function in patients with chronic heart failure. J Am Coll Cardiol. 2007; 50:1561–1569. [PubMed: 17936155]
22. Sandek A, Bjarnason I, Volk HD, Crane R, Meddings JB, Niebauer J, Kalra PR, Buhner S, Herrmann R, Springer J, Doehner W, von Haehling S, Anker SD, Rauchhaus M. Studies on bacterial endotoxin and intestinal absorption function in patients with chronic heart failure. Int J Cardiol. 2012; 157:80–85. [PubMed: 21190739]
23. Heida FH, Hulscher JB, Schurink M, Timmer A, Kooi EM, Bos AF, Bruggink JL, Kasper DC, Pones M, Benkoe T. Intestinal fatty acid-binding protein levels in necrotizing enterocolitis correlate with extent of necrotic bowel: Results from a multicenter study. J Pediatr Surg. 2015; 50:1115–1118. [PubMed: 25783297]
24. Pasini E, Aquilani R, Testa C, Baiardi P, Angioletti S, Boschi F, Verri M, Dioguardi F. Pathogenic gut flora in patients with chronic heart failure. JACC Heart Fail. 2016; 4:220–227. [PubMed: 26682791]

HIGHLIGHTS

- Elevated I-FABP was associated with adverse clinical events in heart failure patients.
- Serum I-FABP levels had no association with right-side filling pressure in heart failure patients.
- Serum I-FABP was not associated with echocardiographic parameters suggesting venous congestion.

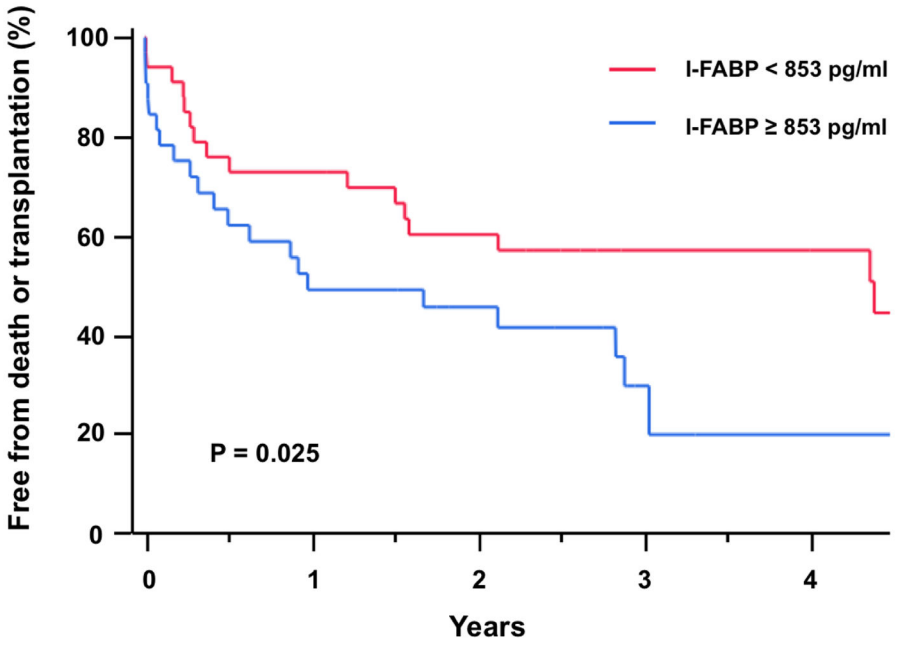

Figure 1.

Kaplan-Meier survival curves for freedom from the composite endpoint of all-cause death, heart transplantation, and LVAD placement between patients with higher (≥853 pg/ml) and lower (<853 pg/ml) serum I-FABP levels.

Table 1

Baseline Patient Characteristics Stratified by I-FABP Levels

	I-FABP <853 pg/ml (N=34)	I-FABP≥853 pg/ml (N=35)	P
Age, years	54 ± 12	57 ± 13	0.38
Male	30 (88)	25 (71)	0.08
Caucasian	29 (85)	31 (89)	0.69
Body weight, kg	92.0 ± 23.9	83.9 ± 19.3	0.13
Body surface area, m^2	2.10 ± 0.29	1.98 ± 0.25	0.06
Ischemic etiology	16 (48)	20 (59)	0.40
Hypertension	17 (50)	22 (63)	0.28
Diabetes mellitus	24 (71)	18 (51)	0.10
Hyperlipidemia	19 (58)	18 (53)	0.15
Prior stroke	7 (21)	4 (11)	0.30
Baseline medication			
Beta blocker	27 (79)	25 (71)	0.44
ACEI or ARB	27 (79)	25 (71)	0.44
MRA	17 (50)	16 (46)	0.72
Baseline laboratory measures			
Sodium, mEq/l	136.0 ± 4.1	133.8 ± 5.5	0.12
Glucose, mg/dl	105.2 ± 25.7	119.3 ± 48.5	0.25
Hemoglobin, g/dl	11.9 ± 2.2	11.8 ± 1.9	0.82
Blood urea nitrogen, mg/dl	28.6 ± 18.0	43.0 ± 28.4	0.03
Creatinine, mg/dl	1.24 ± 0.63	1.63 ± 0.74	0.04
Cystatin-C, mg/l	1.73 ± 0.78	2.21 ± 1.00	0.03
NGAL, ng/ml	120.5 ± 58.8	172.3 ± 113.4	0.02
Albumin, g/dl	3.6 ± 0.5	3.9 ± 0.5	0.17
NT-pro BNP, pg/ml	7720 ± 8969	7402 ± 4924	0.86
BNP, pg/ml	1691 ± 2045	1613 ± 1012	0.84

Values are n (%), or mean ± SD. ACEI = angiotensin converting enzyme inhibitor; ARB = angiotensin receptor blocker; MRA = mineralocorticoid receptor antagonist; NGAL = neutrophil gelatinase-associated lipocalin; NT-pro BNP = n-terminal brain natriuretic peptide.

Table 2

Hemodynamics parameters stratified by I-FABP levels.

	I-FABP <853 pg/ml (N=34)	I-FABP≥853 pg/ml (N=33)	P
Systolic blood pressure, mmHg	111 ± 17	107 ± 17	0.36
Diastolic blood pressure, mmHg	62 ± 12	57 ± 14	0.16
Heart rate, bpm	87 ± 17	78 ± 13	0.03
Right atrial pressure, mmHg	11.5 ± 6.1	13.8 ± 5.5	0.10
Systolic PA pressure, mmHg	48.0 ± 11.6	50.4 ± 16.0	0.48
Diastolic PA pressure, mmHg	23.5 ± 7.3	23.1 ± 6.4	0.81
Mean PA pressure, mmHg	34.8 ± 7.6	37.5 ± 10.4	0.27
PCWP, mmHg	20.8 ± 6.8	21.7 ± 7.5	0.63
Cardiac output, L/min	4.18 ± 1.30	4.44 ± 1.54	0.47
Cardiac index, L/min/m^2	1.99 ± 0.52	2.23 ± 0.76	0.16

Values are n (%), or mean ± SD.

PA = pulmonary artery; PCWP = pulmonary capillary wedge pressure.

Table 3

Echocardiographic indices stratified I-FABP levels.

	I-FABP <853 pg/ml (N=34)	I-FABP≥853 pg/ml (N=35)	P
LV Ejection fraction, %	26.4 ± 8.8	29.6 ± 9.6	0.23
LV EDD, mm	69 ± 12	65 ± 12	0.19
LV ESD, mm	61 ± 12	55 ± 12	0.07
LV EDV, mm	253.5 ± 107.9	214.5 ± 86.8	0.11
LV ESV, mm	193.3 ± 91.3	157.1 ± 72.9	0.08
LV mass, g	405.4 ± 160.3	378.0 ± 103.8	0.42
E/e’	20.7 ± 9.2	19.6 ± 7.6	0.61
LVOT-TVI	13.7 ± 4.3	14.5 ± 4.2	0.47
LA volume index	45.2 ± 12.3	45.5 ± 18.3	0.94
RA volume index	34.3 ± 12.8	40.0 ± 16.1	0.12
TAPSE	1.25 ± 0.25	1.15 ± 0.25	0.19
RV FAC	29.0 ± 8.8	27.3 ± 10.3	0.50

Values are n (%), or mean ± SD.

LV = left ventricular; EDD = end-diastolic dimension; ESD = end-systolic dimension; EDV = end-diastolic volume; ESV =end-systolic volume; LVOT-TVI = left ventricular outflow-tract time velocity integral; LA = left atrial; RA = right atrial; TAPSE = tricuspid annular plane systolic excursion; RV FAC = right ventricular fractional area change.

Table 4

Associations between I-FABP levels and clinical parameters.

	ρ^*	P value
Hemodynamic indices		
Right atrial pressure, mmHg	0.08	0.52
PCWP, mmHg	0.05	0.69
Cardiac output, L/min	0.07	0.59
Echocardiographic indices		
LVEF, %	0.19	0.40
E/e'	0.001	0.99
TAPSE	−0.18	0.22
RV-FAC	−0.01	0.93
RA volume index	0.23	0.07
IVC diameter, cm	0.01	0.93
Laboratory marker		
NT-pro BNP, pg/ml	0.08	0.51
BNP, pg/ml	0.12	0.31
Creatinine, mg/dl	0.22	0.07
Cystatin-C, ml/l	0.19	0.12
NGAL, mg/ml	0.09	0.48

*Spearman correlation coefficients.

PCWP = pulmonary capillary wedge pressure; LVEF = left ventricular ejection fraction; TAPSE = tricuspid annular plane systolic excursion; RV-FAC = right ventricular fractional area change; RA = right atrial; IVC = inferior vena cava; NT-pro BNP = N-terminal pro-brain natriuretic peptide; NGAL = neutrophil gelatinase-associated lipocalin.