Dynamic iron status after acute heart failure

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Summary

Background. – Iron deficiency (ID) is common in heart failure (HF), and is associated with unfavourable clinical outcomes. Although it is recommended to screen for ID in HF, there is no clear consensus on the optimal timing of its assessment.

Aim. – To analyse changes in iron status during a short-term follow-up in patients admitted for acute HF.

Methods. – Iron status (serum ferritin concentration and transferrin saturation) was determined in 110 consecutive patients (median age: 81 years) admitted to a referral centre for acute HF, at three timepoints (admission, discharge and 1 month after discharge). ID was defined according to the guidelines.

Results. – The prevalence rates of ID at admission, discharge and 1 month were, respectively, 75% (95% confidence interval [CI] 67–83%), 61% (95% CI 52–70%), and 70% (95% CI 61–79%) (P = 0.008). Changes in prevalence were significant between admission and discharge (P = 0.0018). Despite a similar ID prevalence at admission and 1 month (P = 0.34), iron status changed in 25% of patients. Between admission and discharge, variation in C-reactive protein correlated significantly with that of ferritin (ρ = 0.30; P = 0.001). Advanced age, anaemia, low ferritin concentration and low creatinine clearance were associated with the persistence of ID from admission to 1 month.

Conclusions. – Iron status is dynamic in patients admitted for acute HF. Although ID was as frequent at admission as at 1 month after discharge, iron status varied in 25% of patients.

KEYWORDS

Iron deficiency;

Acute heart failure;

Co-morbidity

Abbreviations: BNP, B-type natriuretic peptide; CI, confidence interval; CRP, C-reactive protein; HF, heart failure; ID, iron deficiency; LVEF, left ventricular ejection fraction; TS, transferrin saturation.

Background

Heart failure (HF) is a severe condition associated with a poor prognosis. Outcome depends on the severity of the heart disease and co-morbidities [1, 2]. Among these co-morbidities, iron deficiency (ID), with or without anaemia, is present in 30–50% of patients with chronic HF, as a consequence of a depletion of iron stores, defective iron absorption and reduced availability of iron recycled in the reticuloendothelial system [3-6]. Even in the absence of anaemia, ID is associated with worse symptoms and unfavourable clinical outcomes, regardless of left ventricular ejection fraction (LVEF) [4, 6-10]. Recent clinical trials and meta-analyses have shown that intravenous iron therapy in patients with HF with reduced LVEF and ID improves outcomes, exercise capacity and quality of life [11-15]. Thus, screening for ID is recommended in all patients with HF, using serum ferritin concentration and transferrin saturation (TS) [2, 16]. However, the timing of ID screening varies greatly across studies, and it is suggested that the prevalence of ID would be higher in patients admitted for acute HF because of multiple factors, including exacerbation of inflammatory phenomena [17-19]. Thus, we hypothesized that iron status could vary during periods of decompensated HF, leading to issues in the optimal prescription of iron therapy. We analysed changes in iron status during a short-term follow-up in patients admitted for acute HF.

Methods

Study design and patients

From 1 January until 1 June 2017, all consecutive adults hospitalized with acute HF not related to an acute ST-segment elevation myocardial infarction in the Department of Cardiology of Hôpital Nord (University Health Centre of Marseille, France) were eligible for study entry. Acute HF was defined as the rapid onset or acute worsening of symptoms and signs of HF associated with a B-type natriuretic peptide (BNP) plasma concentration ≥ 100 pg/mL [20]. Iron status, haemoglobin, haematocrit, albumin, BNP, creatinine clearance estimated using the Cockcroft formula and C-reactive protein (CRP) were determined by blood samples at three timepoints, defined as follows: (1) ”admission”: within 24–48 hours after admission to the Department of Cardiology; (2) “discharge”: within 48 hours before hospital discharge, when haemodynamic status was stable and intravenous diuretic therapy was stopped; and (3) “1-month”: 1 month after hospital discharge.

Patients who did not have evaluation of their iron status at one of these three timepoints were

excluded, as were patients who had received a blood transfusion, iron therapy or erythropoietin therapy within the 3 months before admission, during hospitalization and within 1 month after hospital discharge. Patients readmitted for another episode of acute HF within 1 month after hospital discharge were also excluded. Informed consent was obtained from each patient. The protocol was approved by the local ethics committee (number: 2017-08-11-003).

Definition of ID

ID was defined as serum ferritin < 100 µg/mL (absolute ID) or serum ferritin between 100 and 299 µg/mL with TS < 20% (functional ID), according to the guidelines [2, 16]. Anaemia was defined as haemoglobin < 130 g/L for men and < 120 g/L for women.

Data collection and patient management

Clinical, laboratory, electrocardiogram and therapeutic data were examined at admission. All patients underwent transthoracic echocardiography within the first day of admission. The variables of left ventricular morphology, diastolic function, systolic function and right ventricular function were reviewed and measured by a single senior echocardiologist (J. C.), according to the guidelines [21]. LVEF was classified as altered (< 40%), mid-range (40–49%) or preserved (≥ 50%), according to recent recommendations [2]. The management of HF was not modified by the protocol, and was left to the physician's discretion. For patients with ID, screening for any potentially treatable/reversible causes of bleeding was performed by a clinical assessment, and sometimes by digestive endoscopy after a gastroenterologist consultation.

Statistical analysis

A sample size of 100 patients needed for inclusion was calculated to achieve 80% power using a two-sided McNemar test with a significance level of 0.05 to detect that the proportion of discordant pairs ("with ID at admission and without ID at discharge" pairs or "without ID at admission and with ID at discharge" pairs) is 15%, with 13% of "with ID at admission and without ID at discharge" pairs and 2% of "without ID at admission and with ID at discharge" pairs.

Continuous variables are expressed as medians (interquartile ranges). The unpaired Student's *t* test or the Mann-Whitney test were used for unpaired comparisons. The Friedman test followed by the

Dunn post hoc test were used for repeated measures. Spearman's correlation coefficient was used to analyse the association between two continuous variables. Categorical variables are described as counts and percentages with 95% confidence intervals (CIs). The χ^2 test or Fisher's test was used for unpaired comparisons, and the McNemar test or Cochran's Q test was used for repeated comparisons. The Benjamini and Hochberg procedure was used to take multiplicity of comparisons into account.

Finally, we analysed the characteristics at admission associated with persistence and occurrence of ID 1 month after discharge. The following relevant variables were tested in a single-variable analysis: age, sex, body mass index, diabetes, oral anticoagulant or antiplatelet therapy, anaemia, haemoglobin, ferritin, TS, CRP, creatinine clearance and BNP.

A *P* value < 0.05 was considered to indicate statistical significance. Statistical analysis was performed using R, version 2.14.0 (R Foundation for Statistical Computing, Vienna, Austria).

Results

Patient characteristics at admission

During the inclusion period, 178 patients were assessed for eligibility. Sixty-eight patients were excluded, leaving 110 patients in the final population (Fig. A.1). The median age was 81 (70, 86) years, and 55% of the patients were men. The median LVEF was 44% (31%, 59%), and 45% of patients had an LVEF < 40%.

ID was present at admission in 82 patients, corresponding to a prevalence of 75% (95% CI 67–83%). There was no significant difference in the baseline characteristics of the acute HF episode between patients with or without ID at admission (Table 1). Absolute ID was present in 55 patients (50%) and functional ID in 27 patients (25%), which corresponded to 67% and 33% of all patients with ID, respectively. The prevalence rates of ID in patients with reduced, mid-range and preserved LVEF were 69%, 77% and 79%, respectively (*P* = 0.53). Fifty-four patients (49%) had anaemia, including 30 (55%) with concomitant absolute ID, eight (15%) with functional ID and 16 (30%) without ID.

The median serum ferritin concentration at admission was 100 (47, 226) µg/L, and the median TS was 13% (8%, 18%). There was no significant difference in ferritin concentration (*P* = 0.15) and TS (*P* = 0.09), according to the three LVEF groups.

Two patients with ID underwent digestive endoscopy during hospitalization, which revealed small intestinal telangiectasia and adenomatous polyps of the colon.

The 68 excluded patients had a median age of 80 (71, 86) years, and a median LVEF of 43% (33%, 55%). In this group, ID was present in 79% of cases (59% absolute ID; 20% functional ID).

Changes in iron status after admission

The median duration of hospital stay was 9 (7, 12) days. The ID prevalence rates at admission, discharge and 1 month changed significantly (P = 0.008 for global comparison), and were 75% (95% CI 67–83%), 61% (95% CI 52–70%) and 70% (95% CI 61–79%), respectively. The changes in prevalence were significant between admission and discharge (P = 0.0018), but not between admission and 1 month (P = 0.34) (Fig. 1A). Absolute ID predominated at the three timepoints (Fig. 1B). Between admission and discharge, we observed a relative decrease of 24% in the prevalence of absolute ID (P = 0.015), and a relative decrease of 16% in the prevalence of functional ID (P = 0.28). Despite a non-significant change in the prevalence of ID between admission and 1 month, iron status changed in 27 patients (25%). Sixteen patients (15%) shifted in status from ID at admission (five patients with absolute ID and 11 patients with functional ID) to no-ID at 1 month, and 11 patients (10%) shifted from no-ID at admission to ID at 1 month (three patients with absolute ID and eight patients with functional ID) (Fig. 2). At 1 month, ID was observed less frequently in patients receiving angiotensin converting-enzyme inhibitors/angiotensin receptor blockers than in patients without these drugs (61% vs 90%; P = 0.002). At this timepoint, there was no significant association between the other treatments and ID.

The serum ferritin concentration and TS changed significantly between the three timepoints (P < 0.0001 for global comparison). At admission, the median ferritin concentration was 100 (47, 222) µg/L, and the median TS was 13% (8%, 18%). At discharge, the median ferritin concentration was 148 (66, 297) µg/L, and the median TS was 16% (11%, 22%). At 1 month, the median ferritin concentration was 109 (52, 200) µg/L, and the median TS was 16% (11%, 21%). These changes were significant between admission and discharge for ferritin and TS, and between admission and 1 month only for TS (Fig. 3).

The changes in ID prevalence and iron variables remained the same after exclusion of 12 patients with an infectious precipitating episode (Fig. A.2).

Factors associated with changes in iron status between admission and discharge

To explain the changes in ferritin and TS between admission and discharge (Δferritin and ΔTS), we analysed the concomitant changes in haemodynamic status by BNP, haemodilution by haematocrit and inflammatory status by CRP. The median serum BNP concentration decreased significantly between admission and discharge, from 684 (310, 1249) pg/mL to 323 (180, 515) pg/mL ($P < 0.0001$), but ΔBNP was not correlated with Δferritin ($\rho = 0.10$; $P = 0.28$) or ΔTS ($\rho = –0.02$; $P = 0.87$). The median haematocrit did not significantly differ between admission and discharge (39% (34%, 43%) vs 38% (35%, 43%); $P = 0.36$) and Δhaematocrit was not correlated with Δferritin ($\rho = 0.12$; $P = 0.23$) or ΔTS ($\rho = –0.03$; $P = 0.79$). The median serum CRP concentration did not differ significantly between admission and discharge (12 (4, 34) mg/L vs 14 (7, 41) mg/L; $P = 0.13$), but ΔCRP correlated significantly with Δferritin ($\rho = 0.30$; $P = 0.001$) and ΔTS ($\rho = –0.25$; $P = 0.04$) (Fig. 4). The serum CRP concentration increased in 40 patients (36%) between admission and discharge. In these patients, the median serum ferritin concentration increased greatly, from 116 (55, 239) µg/L to 177 (89, 356) µg/L ($P < 0.0001$), while TS remained stable (16% (10%, 20%) vs 16% (11%, 22%); $P = 0.14$). Among the 70 patients without increased CRP, the median serum ferritin concentration did not increase significantly (82 (44, 232) µg/L vs 105 (58, 278) µg/L; $P = 0.07$), unlike the median TS (12% (7%, 17%) vs 15% (11%, 22%); $P < 0.0001$).

Factors associated with changes in iron status between admission and 1 month

The characteristics at admission that were associated with the persistence of ID at 1 month were advanced age, the presence of anaemia, a lower haemoglobin value, a lower serum ferritin concentration and lower creatinine clearance (Table 2). The lower the ferritin concentration at admission, the greater the probability that ID persisted at 1 month. The probability of ID persisting at 1 month was 91% when the ferritin concentration at admission was ≤ 100 µg/L (Fig. 5). No significant characteristics associated with the occurrence of ID between admission and 1 month could be identified (Table A.1).

Discussion

This study specifically analysed changes in iron status over time in patients admitted for an acute episode of HF. The results showed that iron status changed through the period between admission and 1 month after discharge. Moreover, although the prevalence of ID was not significantly different between admission and 1 month after discharge timepoints, iron status changed in a quarter of patients.

Prevalence of ID at admission for acute HF

ID is a common co-morbidity in patients with HF, and is more prevalent than in the general population [22]. While it is recommended to screen for ID in these patients, there is no clear consensus on the optimal timing of its assessment. Thus, ID is diagnosed in 30–50% of ambulatory patients with chronic HF, i.e. when their haemodynamic state is stable [3-5, 8, 23]. However, ID seems to be more frequent when it is assessed within the first few days after admission for an episode of acute HF. In our study, the prevalence of ID at admission was 75%, similar to the prevalence rates described in previous works, which varied between 65% and 83%, when blood samples were taken at the same time [5, 6, 17-19, 24]. As in previous works, ID predominated in women, but we found more absolute ID, as it accounted for 67% of cases of ID in our study and 57–66% in others [6, 10, 18]. We found an ID prevalence of 70% 1 month after discharge from the hospital, which was, again, higher than the 30–50% described in chronic HF studies [3-6, 8]. The median age of 81 years in our population was much older than that of patients included in these previous works. This difference could explain why ID was more frequent in our work, even well after the episode of decompensation. Indeed, the risk of ID has been shown to increase with age in the general population [25].

Changes in iron status after admission for acute HF

After acute decompensation, we observed short-term variations in iron status. Compared with admission, there was a significant decrease in the proportion of patients with ID after a median hospitalization time of 9 days, resulting mainly in a decrease in absolute ID prevalence, which fell by 24%. Although the timing of ID evaluation differed slightly, a similar observation was recently reported in a small study of 47 patients, where iron status was assessed at admission and 30 days after admission [19]. However, the population analysed in this work was derived from a previous study that

was not designed to explore ID as a primary endpoint [26]. Our results were corroborated by a significant increase in serum ferritin concentration at discharge. Although the reasons for this variation are not known, several mechanisms may be suggested. During an inflammatory syndrome, the plasma concentration of ferritin increases while the TS decreases [27]. In the present study, CRP increased in 36% of patients between admission and discharge from the hospital, and CRP variation correlated strongly with ferritin variation; this correlation was much lower with TS variation. Thus, in patients with absolute ID at admission, an increase in inflammation status at discharge may have increased ferritin concentrations above the 100 µg/L threshold without a significant decrease in TS. In this case, by definition, patients no longer had ID. This phenomenon was observed in 60% of our patients whose CRP concentrations increased between admission and discharge. Cohen-Solal et al. also found an inverse association between CRP concentration and the presence of ID [18]. The increasing CRP concentration observed in some patients at the end of hospitalization may have several explanations, such as those related to inflammation caused by healthcare procedures (venous or urinary catheters) or nosocomial infections. Nevertheless, similar variations in iron status were observed even after exclusion of patients with a concurrent infectious episode. Thus, other mechanisms are probably also involved in changes of ID status, and will have to be analysed by further specific studies.

According to the results of the present study, we can suggest that ID screening may not be recommended at hospital discharge after an episode of acute HF. If we now consider the timepoint of 1 month after hospital discharge as the time of reference for ID screening, then our study shows that the prevalence of ID is not significantly different within the 24–48 hours after admission for an episode of acute HF. This result suggests that ID screening might be performed at admission. However, despite similar prevalence rates of ID, iron status changed in 25% of patients between admission and discharge. Therefore, if we considered iron therapy based on the results of an ID screening performed at admission, this treatment would have been unjustified or wrongly omitted in 15% and 10% of our patients, respectively. Therefore, we suggest that the assessment of the iron status should be performed in a stable haemodynamic state, and at least 1 month after hospitalization for acute HF. Nevertheless, if the ID screening is conducted at admission, our study identified a group of patients in whom ID had a high probability of persisting in stable haemodynamic conditions, at least 1 month after discharge. This group accounted for 60% of patients in our work, similar to the findings of Van Aelst et

al. [19]. These patients were probably older (aged > 80 years), with anaemia, renal insufficiency (creatinine clearance < 50 mL/min) and very low ferritin concentrations (≤ 100 µg/L). This result suggests that ID may persist in patients whose intrinsic ability to regenerate their iron stocks is probably impaired, and in those with severe ID resulting in anaemia.

Study limitations

Our study has several limitations. Firstly, it was subject to a referral bias, because only patients admitted to the cardiology department of a university hospital were included.

The time between admission and discharge from the hospital varied from one patient to another, depending on the response to the HF therapy. Thus, ID screening at discharge was not performed at the same time for all patients. However, it was more relevant for us to assess patients in a stable haemodynamic state, rather than at a fixed timepoint during hospitalization.

The 1-month timepoint chosen for the evaluation of ID after discharge may be considered as relatively short. However, given the potentially large number of early rehospitalizations (within 6 months) for cardiac decompensation in this population, the 1-month period seemed relevant to us. Iron status at 1 month was established by measurements performed at different laboratories out of the hospital. Thus, we cannot exclude that variations related to the method used influenced our results.

The sample size was calculated to determine the prevalence of ID in acute HF, regardless of LVEF. Thus, the power of the study was low to precisely analyse the changes in ID prevalence according to the different LVEF groups, knowing that the benefits of iron therapy were only demonstrated for patients with LVEF ≤ 45% [11]. The power was also too low to precisely analyse the risk factors for ID emergence or persistence.

Conclusions

ID is a very common co-morbidity in patients hospitalized for acute HF. However, after admission, iron status is dynamic, and varies according to the time of its evaluation. Although ID was as frequent at admission as at 1 month after discharge, iron status varied in 25% of patients. Some variables at admission, such as ferritin concentration < 100 µg/L, might predict ID persistence at 1 month, suggesting that iron supplementation could be given to these patients during their hospitalization.

Sources of funding

This work was supported by Vifor Pharma. Vifor Pharma provided support for investigators' publication charges. Neither Vifor Pharma nor any other commercial entity had a role in the design of the trial, the enrolment or care of the patients, the collection, storage, analysis or interpretation of the data, the writing of the manuscript or the decision to submit the manuscript for publication. All of the authors approved the final article, and take responsibility for all aspects of the reliability and freedom from bias of the data presented, and their discussed interpretation.

Disclosure of interest

J. C. Modest consultancy and lecture fees from the companies **MSD**, **Janssen**, **Merck**, **Novartis**, **AstraZeneca** and **Vifor Pharma**.

J. B. Modest consultancy fees from the company **Bayer**.

M. P. Modest fees for teaching and proctoring purposes from the company **Medtronic**.

L. B. Modest fees from the companies **Medicine Company**, **Eli Lilly**, **Abbott**, **Medtronic**, **Boston Scientific** and **AstraZeneca**. Grants from the company **AstraZeneca**.

M.L. Modest consultancy and lecture fees from the companies **AstraZeneca** and **Sanofi**.

F. P. Modest consultancy and lecture fees from the companies **Abbott**, **AstraZeneca**, **Biotronik**, **Boston Scientific**, **Cordis**, **Daichi-Sankyo**, **Edwards**, **Eli Lilly**, **Hexacath**, **Iroko Cardio**, **Medtronic**, **Servier** and **Terumo**.

F. T. Modest consultancy and lecture fees from the companies **AstraZeneca**, **Novartis**, **Sanofi**, **Boston Scientific** and **Bristol-Myers Squibb**.

The other authors declare that they have no conflicts of interest concerning this article.

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Figure legends

Figure 1. Changes in the prevalence of (A) iron deficiency and (B) iron status, according to the three evaluation timepoints. ID: iron deficiency.

Figure 2. Distribution of the changes in iron status of patients between admission and 1 month. ID: iron deficiency.

Figure 3. Variations in (A) the serum ferritin concentration and (B) transferrin saturation, according to the three evaluation timepoints.

Figure 4. Correlation between changes in C-reactive protein (ΔCRP) and changes in ferritin (Δferritin) and transferrin saturation (ΔTS).

Figure 5. Distribution of patients with iron deficiency (ID) persistence or no ID persistence between admission and 1 month, according to ferritin concentration at admission.

Table 1 Characteristics of patients at admission.

	ID (*n* = 82)	No ID (*n* = 28)	*P*
Age (years)	81 (71, 86)	81 (70, 86)	0.93
Male sex	41 (50)	20 (71)	0.05
Black race	21 (26)	5 (18)	0.40
NYHA class III–IV	76 (93)	25 (89)	0.69
Acute pulmonary oedema	26 (32)	7 (25)	0.50
Cardiogenic shock	4 (5)	3 (11)	0.28
LVEF (%)	46 (32, 60)	39 (30, 56)	0.66
LVEF class			0.58
< 40%	34 (41)	15 (54)	
40–49%	10 (12)	3 (11)	
≥ 50%	38 (46)	10 (36)	
Body mass index (kg/m^2)	27 (24, 29)	26 (23, 29)	0.36
Blood pressure (mmHg)			
Systolic	135 (121, 151)	128 (116, 144)	0.99
Diastolic	74 (64, 89)	75 (63, 85)	0.78
Pulse (beats/min)	85 (74, 102)	85 (70, 100)	0.52
Cardiovascular risk factors			
Diabetes	26 (32)	9 (32)	0.97
Hypertension	67 (82)	18 (64)	0.06
Atrial fibrillation/flutter	41 (50)	9 (32)	0.10
Dyslipidaemia	34 (41)	9 (32)	0.38
Medical history			
Ischaemic heart disease	49 (60)	19 (68)	0.45
COPD	21 (26)	7 (25)	0.95
Chronic renal insufficiency	48 (59)	20 (71)	0.23
Cancer	22 (27)	6 (21)	0.94
Precipitating factor			

Infection	8 (10)	4 (14)	0.50
Uncontrolled hypertension	16 (20)	5 (18)	0.55
Supraventricular arrhythmia	19 (23)	6 (21)	0.85
Ventricular arrhythmia	1 (1)	0 (0)	0.75
Atrioventricular conduction abnormalities	3 (4)	4 (14)	0.07
Poor treatment adherence	17 (21)	9 (32)	0.23
Fluid inflation treatment	2 (2)	2 (7)	0.27
Non-STE acute coronary syndrome	4 (5)	4 (14)	0.11
Unknown	39 (48)	13 (46)	0.55
Electrocardiogram with atrial fibrillation/flutter	34 (41)	9 (32)	0.38
Laboratory measurements			
Haemoglobin (g/L)	126 (112, 137)	123 (107, 142)	0.86
Haematocrit (%)	39 (35, 43)	37 (34, 43)	0.73
Serum ferritin (µg/L)	61 (42, 135)	341 (245, 495)	< 0.001
Transferrin saturation (%)	11 (7, 16)	21 (17, 26)	< 0.001
CRP (mg/L)	11 (4, 29)	14 (3, 50)	0.13
Sodium (mmol/L)	139 (137, 141)	139 (137, 140)	0.75
Albumin (g/L)	40 (37, 42)	39 (36, 41)	0.13
Anaemia[a]	38 (46)	16 (57)	0.32
Urea (mmol/L)	46 (33, 67)	55 (38, 74)	0.39
Creatinine clearance (mL/min)	99 (78, 125)	114 (102, 148)	0.09
Concomitant treatments			
ACE inhibitor or ARB	42 (51)	14 (50)	0.91
Beta-blocker	37 (45)	9 (32)	0.23
MR inhibitors	7 (9)	1 (4)	0.38
Sacubitril/valsartan	2 (2)	1 (4)	1.0
Diuretics	53 (64)	15 (54)	0.30
Antiplatelet therapy	43 (59)	11 (39)	0.23
Anticoagulant therapy	39 (48)	9 (32)	0.16

Data are expressed as median (interquartile range) or number (%). ACE: angiotensin-converting

enzyme; ARB: angiotensin receptor blocker; COPD: chronic obstructive pulmonary disease; CRP: C-reactive protein; ID: iron deficiency; LVEF: left ventricular ejection fraction; MR: mineralocorticoid receptor; NYHA: New York Heart Association; STE: ST-segment elevation.

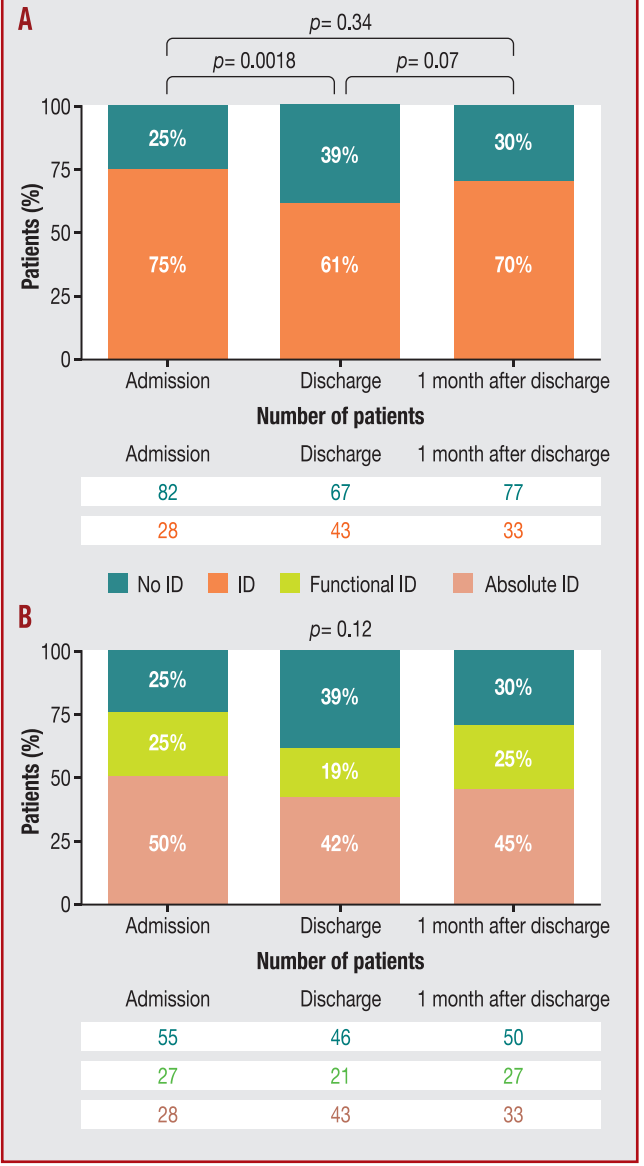
[a] Anaemia was defined as haemoglobin < 130 g/L for men and < 120 g/L for women.

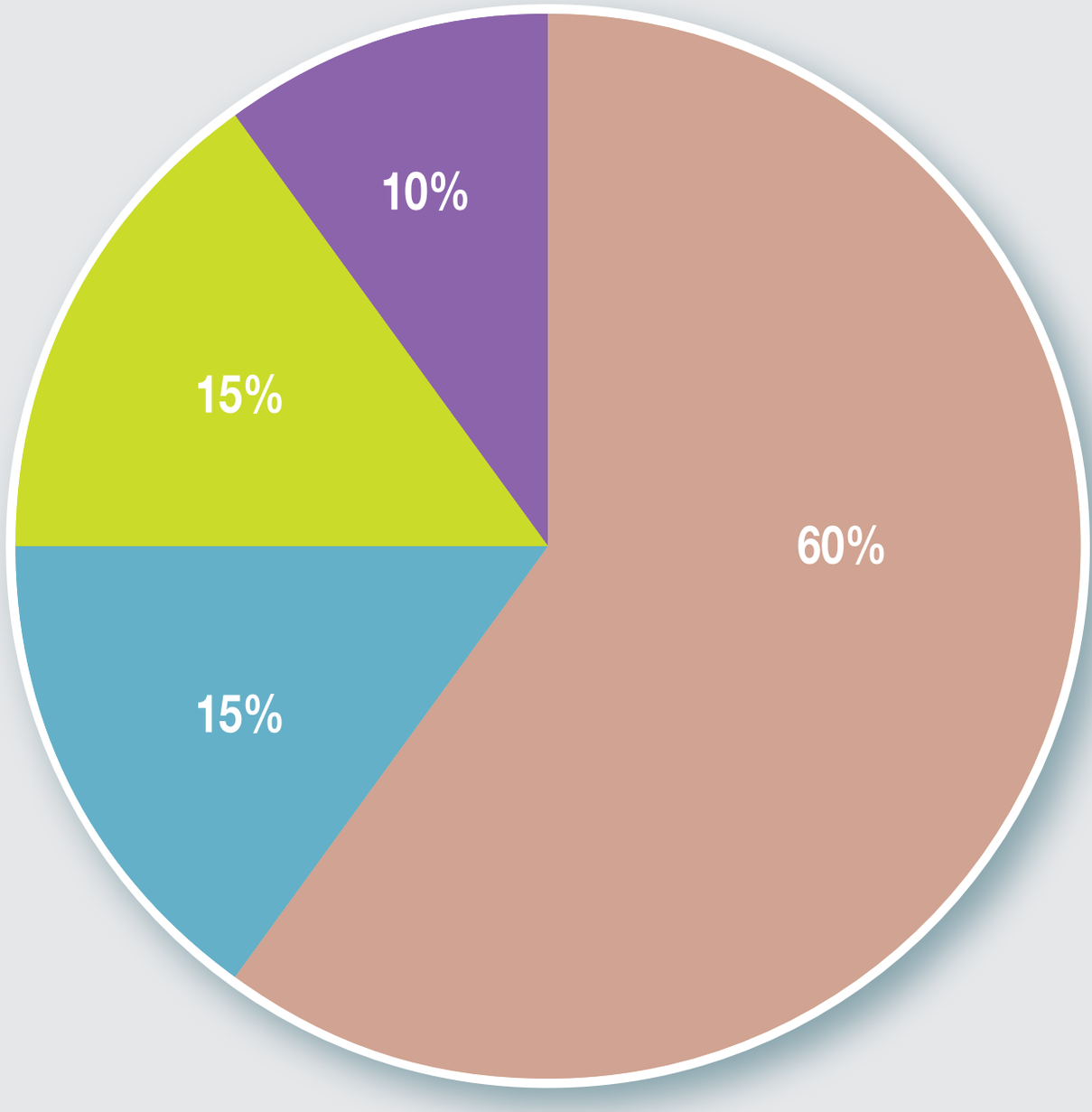
Table 2 Comparison of characteristics at admission according to the persistence of iron deficiency at 1 month.

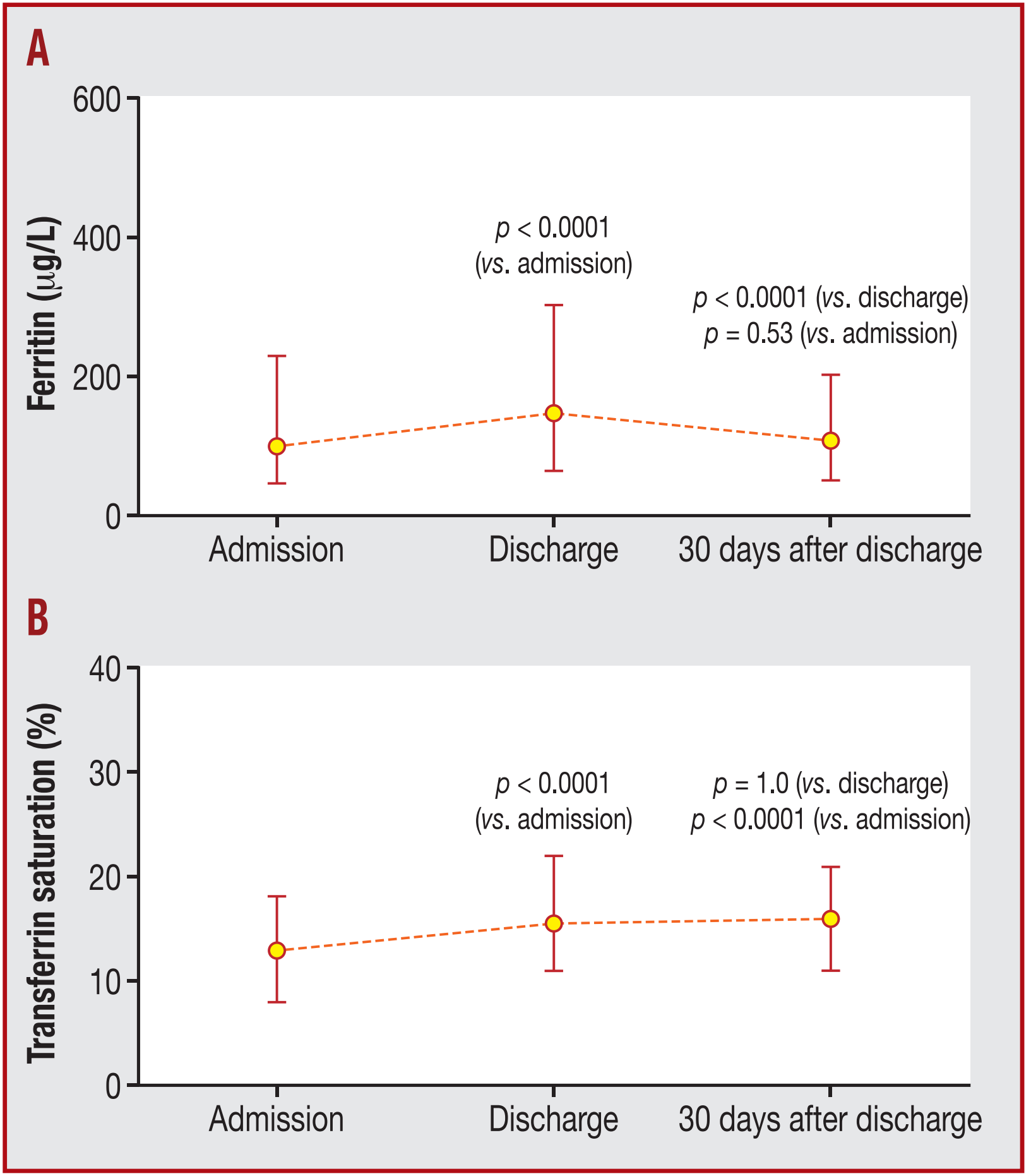
	No ID persistence at 1 month	ID persistence at 1 month	*P*
Age (years)	71 (58, 82)	81 (74, 86)	0.04
Male sex	11 (69)	30 (45)	0.09
Body mass index (kg/m^2)	27 (26, 31)	27 (24, 29)	0.20
Diabetes	4 (25)	22 (33)	0.77
Antiplatelet or anticoagulant therapy	14 (88)	59 (89)	1.0
Serum ferritin (µg/L)	199 (90, 245)	52 (35, 98)	< 0.001
Transferrin saturation (%)	15 (9, 16)	11 (7, 16)	0.39
Haemoglobin (g/L)	147 (137, 156)	123 (111, 130)	< 0.001
Anaemia[a]	1 (6)	37 (56)	< 0.001
CRP	11 (6, 23)	11 (4, 33)	0.10
Creatinine clearance (mL/min)	72 (54, 92)	50 (36, 71)	0.01
BNP (pg/mL)	625 (470, 759)	766 (326, 1288)	0.05

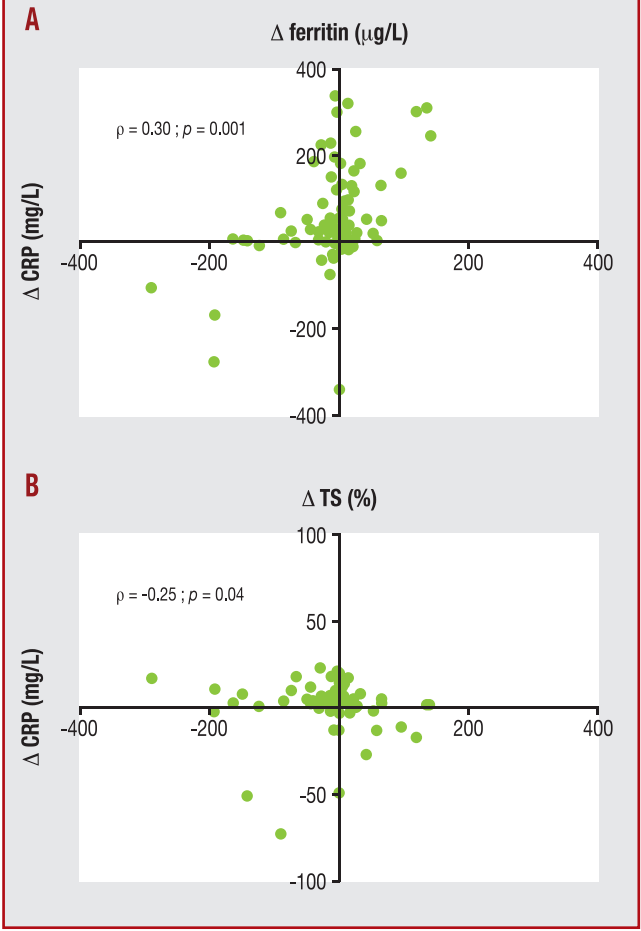
Data are expressed as median (interquartile range) or number (%). BNP: B-type natriuretic peptide; CRP: C-reactive protein.

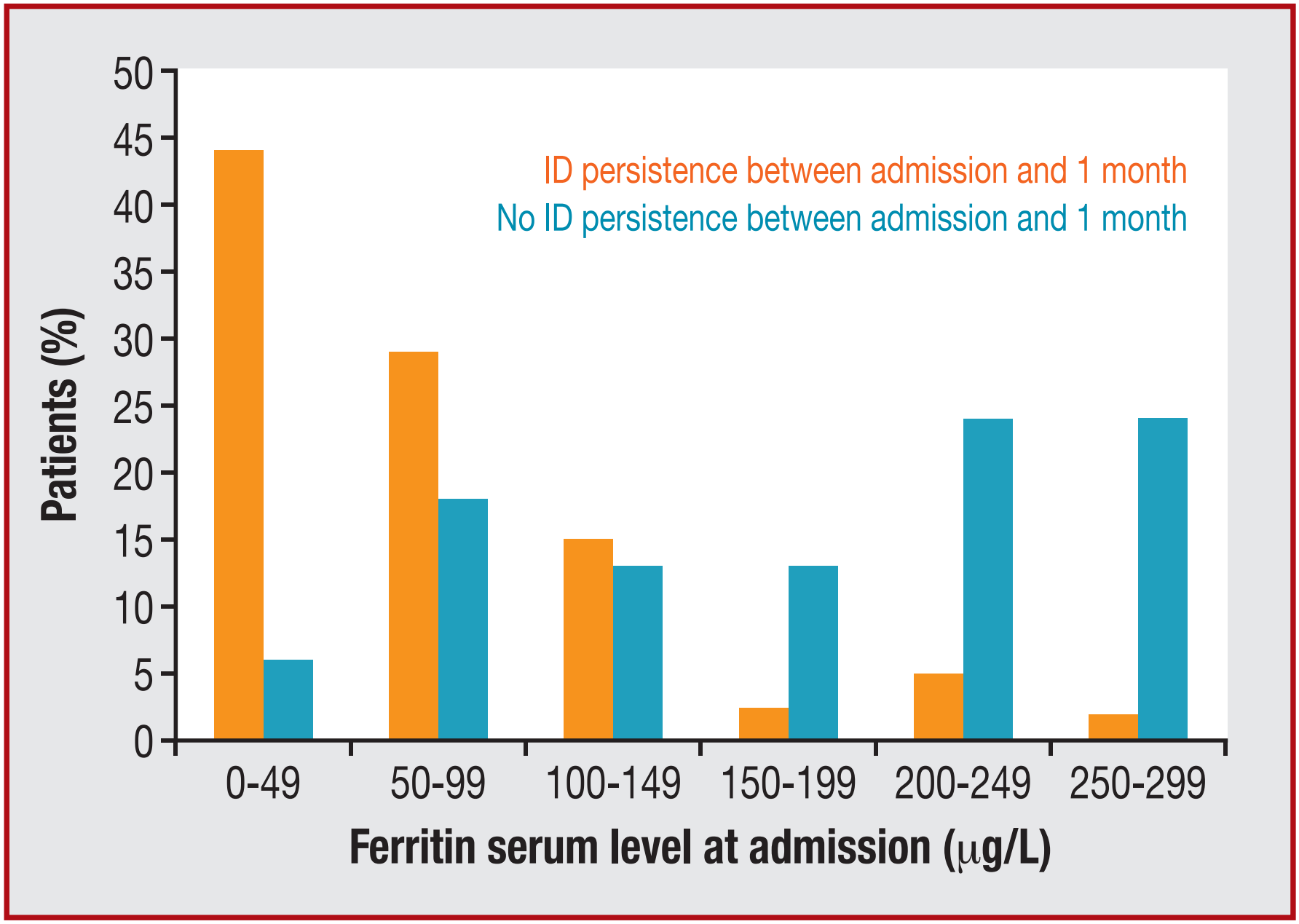
[a] Anaemia was defined as haemoglobin < 130 g/L for men and < 120 g/L for women.


A
p= 0.34
p= 0.0018
p= 0.07
Patients (%)
100
75
50
25
0
25%
75%
39%
61%
30%
70%
Admission
Discharge
1 month after discharge
Number of patients
Admission
Discharge
1 month after discharge
82
67
77
28
43
33
No ID
ID
Functional ID
Absolute ID
B
p= 0.12
Patients (%)
100
75
50
25
0
25%
25%
50%
39%
19%
42%
30%
25%
45%
Admission
Discharge
1 month after discharge
Number of patients
Admission
Discharge
1 month after discharge
55
46
50
27
21
27
28
43
33


10%
15%
60%
15%
ID at admission → ID at 1 month
ID at admission → no-ID at 1 month
No-ID at admission → no-ID at 1 month
No-ID at admission → ID at 1 month


A
600
400
200
0
Ferritin (µg/L)
p < 0.0001
(vs. admission)
p < 0.0001 (vs. discharge)
p = 0.53 (vs. admission)
Admission
Discharge
30 days after discharge
B
40
30
20
10
0
Transferrin saturation (%)
p < 0.0001
(vs. admission)
p = 1.0 (vs. discharge)
p < 0.0001 (vs. admission)
Admission
Discharge
30 days after discharge


A
Δ ferritin (μg/L)
ρ = 0.30 ; p = 0.001
Δ CRP (mg/L)
400
200
-200
-400
-400
-200
200
400
B
Δ TS (%)
ρ = -0.25 ; p = 0.04
Δ CRP (mg/L)
100
50
-50
-100
-400
-200
200
400


ID persistence between admission and 1 month
No ID persistence between admission and 1 month
Patients (%)
50
45
40
35
30
25
20
15
10
5
0
0-49
50-99
100-149
150-199
200-249
250-299
Ferritin serum level at admission (μg/L)