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UNSOLICITED REVIEW

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Iron deficiency in heart failure: Efficacy and safety of intravenous iron therapy

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Summary

Aim: To discuss the pathophysiology of iron metabolism in chronic heart failure (CHF) and the current knowledge of the efficacy of intravenous (IV) iron therapy in patients with CHF and identify points of controversy as well as highlight areas for future research.

Discussion: Iron deficiency is a recognized complication of many chronic conditions. Numerous studies have reported that iron deficiency is highly prevalent in patients with CHF and is associated with exercise intolerance, reduced quality of life, and increased risk of hospitalization and mortality. Several small studies have demonstrated IV iron to be associated with improvements in symptoms, exercise capacity, quality of life, renal function, New York Heart Association (NYHA) functional class and left ventricular ejection fraction (LVEF), and reduction in NT-pro-brain natriuretic peptide (NT-proBNP) in patients with CHF and iron deficiency. Two larger-scale trials confirming these results (FAIR-HF and CONFIRM-HF) have led to guideline recommendations that IV iron therapy should be considered in patients with CHF with reduced ejection fraction and iron deficiency (serum ferritin <100 μg/L, or ferritin between 100 and 299 μg/L with transferrin saturation <20%) to provide symptomatic relief and improve exercise capacity and quality of life.

Conclusion: Intravenous iron therapy improves symptoms, exercise capacity, and quality of life, at least in the short-to-intermediate time. However, there are still currently no standardized criteria used to define iron deficiency and the underlying mechanism of iron deficiency in CHF remains incompletely understood. Further work is required to improve the ability to identify iron deficiency in patients with CHF and evaluate the effect of iron repletion on hard endpoints including hospitalization and mortality.

KEYWORDS

Anemia, Heart failure, Iron deficiency, Iron therapy

1 | INTRODUCTION

Worldwide, approximately one-third of the general population is affected by iron deficiency, making it the most common nutritional disorder.[1-3] Iron deficiency is a recognized complication of chronic conditions such as inflammatory bowel, rheumatoid, and chronic kidney disease.[4-6] As an essential micronutrient, iron has a central role in many metabolic processes. Due to its ability to switch between two oxidative states, ferrous (Fe^{2+}) and ferric (Fe^{3+}), iron is an efficient cofactor for several enzymes which help catalyze numerous

Chan-Keat Kang and Michael Pope contributed equally to this work.

biochemical reactions.[7,8] Iron is a component of hemoglobin, which is crucial for oxygen transport to tissues. It also plays a role in oxygen storage (myoglobin) and oxidative metabolism (component of oxidative enzymes and respiratory chain proteins) and is involved in the synthesis and breakdown of carbohydrates, lipids, and nucleic acids.[7-10]

It is increasingly recognized that many patients with chronic heart failure (CHF) have associated iron deficiency. These patients experience worse symptoms compared to those who are iron-replete and are at a higher risk of morbidity and mortality. This article discusses the prevalence of iron deficiency in heart failure and its underlying pathophysiology and examines current clinical practice in the management of iron-deficient CHF patients. This article also identifies points of controversy and highlights areas for future research.

2 | IRON METABOLISM AND ETIOLOGY OF IRON DEFICIENCY IN CHRONIC HEART FAILURE

Although iron plays an important physiological role, an excess leads to significant toxicity and end-organ damage as seen in disease states of iron overload and inherited defects in iron metabolism such as hereditary hemochromatosis. As there is no specific mechanism for iron excretion, iron absorption and subsequent metabolism are tightly regulated. Homeostasis is then maintained by loss of iron through the turnover of skin and gut epithelial cells and bleeding.[11]

Iron is primarily absorbed in the duodenum and jejunum via the divalent metal transporter protein on the luminal cell membrane. Ferric iron is reduced to its ferrous form by the enzyme ferric reductase, and cytoplasmic ferrous iron is either packaged as ferritin for intracellular storage or transported across the basolateral membrane into the circulation. This process involves oxidization back to its ferric form by the enzyme hephaestin oxidase and export through ferroportin iron channels allowing absorbed iron to be transported through the circulation bound to transferrin.[11]

Circulating iron is avidly taken up by hepatocytes, splenic cells, and bone marrow. Iron is incorporated into heme for bone marrow hematopoiesis or packaged as ferritin for iron storage particularly within the liver and spleen. Senescent erythrocytes are broken down by reticuloendothelial macrophages in the liver and spleen releasing further iron for either storage or circulation.[11,12]

Distinguishing between stored and circulating iron is key to characterizing iron deficiency, which can be classified as either absolute or functional.[12,13] Absolute deficiency represents a depletion of iron stores, while functional deficiency includes:

1. Normal iron stores but impaired mobilization of iron into the circulation thereby restricting iron availability for cell metabolism and erythropoiesis.
2. An insufficient supply of iron to meet the demands of enhanced erythropoiesis brought about by either anemia of another cause or excessive endogenous erythropoietin production.

Although ferritin is the predominant form of intracellular stored iron, a proportion of this enters the circulation. Serum ferritin levels can therefore serve as a surrogate marker of iron stores. Systemic inflammation, however, results in the release of acute-phase reactants, including ferritin, therefore limiting the validity of the relationship between serum ferritin levels and levels of stored iron in many chronic conditions. Perhaps more important is the amount of circulating iron available for cell metabolism. This can be estimated as a percentage of circulating transferrin saturated with iron (T_{SAT}).[13]

Many proinflammatory cytokines have been implicated in the progression of CHF. Of these, the most important ones appear to be tumor necrosis factor-α (TNF-α), interleukin (IL)-1, and IL-6.[14] In mouse models, both TNF-α and IL-1 induce the synthesis of ferritin by macrophages and hepatocytes.[15,16] Divalent metal transporter 1 (DMT1), a transmembrane iron transport protein, is involved in the uptake of iron by macrophages and is upregulated in the presence of TNF-α, interferon-γ, and lipopolysaccharide.[17,18] These proinflammatory cytokines also stimulate retention of iron in macrophages by downregulating the expression of ferroportin.[18] Ferroportin is therefore involved in the release of iron from macrophages as well as the transfer of absorbed iron to the systemic circulation.[19] The discovery of hepcidin, an acute-phase protein, furthered the understanding of the relationship between the inflammatory immune response and iron homeostasis. Both IL-6 and lipopolysaccharide induce hepcidin expression and production in the liver. Results from mouse models suggest that hepcidin may be centrally involved in the diversion of iron traffic by reducing duodenal iron absorption across the basolateral enterocyte membrane and blocking iron release from macrophages.[20] Consequently, there is limited iron available for utilization by erythroid progenitor cells, thus resulting in iron-restricted erythropoiesis as well as adversely impacting on the other key physiological roles of iron.

However, iron metabolism has yet to be fully investigated in patients with CHF and it remains unknown to what extent data from animal models can be extrapolated and applied to the clinical setting. It is tempting to link iron deficiency in CHF with associated inflammation and to suggest that hepcidin may have a central role in the inhibition of iron absorption.[21] Recent studies, however, found rather low circulating levels of hepcidin in patients with CHF and reported no association between levels of proinflammatory cytokines (such as IL-6) and overexpression of hepcidin.[22-24] Although markers of inflammation increased with worsening functional class, the inverse was true for hepcidin despite iron deficiency and iron-restricted erythropoiesis becoming increasingly common. Importantly, circulating levels of erythropoietin are often raised in heart failure, being higher in patients with worse functional class, and are correlated with adverse prognosis.[12] Erythropoietin is a powerful suppressor of hepcidin production, and this may to some extent explain the lower levels observed in those

TABLE 1 Summary of blood tests used to diagnose iron deficiency

Test	Strengths	Limitations
Ferritin	1. Measures stored iron 2. Not affected by short-term variations in iron intake	1. Affected by inflammatory states limiting sensitivity 2. Affected by liver disease
Serum iron	1. Direct measurement	1. Does not reflect iron stores 2. Highly variable with intake and metabolic requirements
Serum transferrin	1. Reflects varying metabolic requirements 2. Not affected by inflammatory states	1. Falsely low in liver disease 2. Not a direct measurement of iron levels
Transferrin saturations	1. Not affected by inflammatory states 2. Measures transported iron available for cell uptake	1. Does not directly measure iron stores

with worse symptoms. The underlying mechanism of iron deficiency in CHF remains incompletely understood and further work is needed to fully elucidate the precise pathophysiology, and this in turn may influence treatment strategies.

3 | DIAGNOSING IRON DEFICIENCY

As outlined above, iron exists in stored intracellular, circulating, and utilized forms, the latter predominantly within erythrocyte hemoglobin. The levels of all forms vary considerably and movement between them involves complex regulation in response to changing metabolic requirements and various pathophysiological processes. An optimal diagnostic test would simply and accurately measure all forms of iron as well as total body iron levels. Unfortunately, no such test exists. Table 1 summarizes the various blood tests used to diagnose iron deficiency.

Bone marrow biopsy is considered the "gold standard" for evaluating iron status. This has the advantage of directly measuring iron stored within bone marrow and available for hematopoiesis. However, it is an invasive, uncomfortable, and relatively complicated test to perform, therefore significantly limiting its clinical applicability. In the absence of a single diagnostic test, we rely on a combination of serum biomarkers. The most widely used of these is ferritin. Intracellular iron is stored as a protein-bound complex known as ferritin. Although intracellular levels cannot be measured, a proportion crosses the cell membrane and enters the circulation. Quantification of circulating levels serves as a surrogate measure of iron stores. A low ferritin indicates iron deficiency. Ferritin however is also an acute-phase protein released from the liver in response to inflammation, thereby significantly reducing its diagnostic accuracy—in particular, a "normal" ferritin does not exclude iron deficiency in the context of coexisting inflammatory immune activation. Circulating iron is also measurable. However, this has a number of limitations. Serum iron levels vary considerably depending on intake and physiological requirements and may be maintained even as iron stores become significantly depleted. Circulating iron is found predominantly bound to its specific carrier protein, transferrin. The levels of circulating iron are therefore strongly influenced by levels of serum transferrin. Furthermore, transferrin is produced in response to low iron stores and increasing demands. Measurements of either serum iron or circulating transferrin alone therefore poorly reflect iron levels. The percentage of transferrin saturated with iron can also be measured. In iron deficiency, iron levels fall while transferrin increases, resulting in fewer binding sites occupied and lower percentage transferrin saturation.

The major studies of iron deficiency in heart failure adopt a definition combining ferritin and transferrin saturations. Although in physiological circumstances, a ferritin above 30 ng/L is considered normal, in an inflammatory state this cutoff results in poor sensitivity. Instead, a ferritin of <100 ng/L or a value of between 100 and 300 ng/L with transferrin saturations <20% has been deemed to suggest iron deficiency.

4 | PREVALENCE AND PROGNOSIS OF IRON DEFICIENCY IN HEART FAILURE

In recent years, there has been increased focus on the clinical importance of iron deficiency in patients with CHF. It is a frequent comorbidity with varying prevalence depending on study criteria and the definition of iron deficiency used. For example, in one study of 1506 stable CHF patients with both preserved and reduced left ventricular systolic function, 50% were reported to be iron-deficient.[25] When analyzed according to hemoglobin level, 46% of those without anemia and 61% of those with anemia were iron-deficient.[25] These results are similar to a recently published study of 4456 patients referred to a single outpatient heart failure service, which identified iron deficiency in 43%-68% of patients with anemia and 14%-35% of those with a normal hemoglobin depending on the definition of iron deficiency used.[26] There has only been one published study using the gold standard technique of bone marrow analysis, which examined 37 anemic patients with advanced severe heart failure and demonstrated iron deficiency in 73%.[27]

Many studies have shown that iron deficiency is associated with exercise intolerance, reduced quality of life, and increased risk of hospitalization and mortality in CHF patients.[28-30] Although iron deficiency is frequently related to anemia, it is an independent predictor of symptom severity, exercise tolerance, and quality of life irrespective of hemoglobin status.[25,29,30] One study analyzed 3 years of follow-up

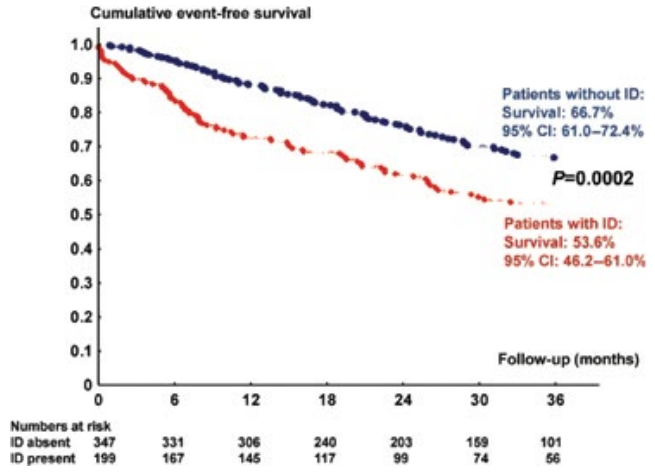

FIGURE 1 Three-year event-free survival (all-cause death and transplantation) in 546 patients with chronic heart failure secondary to left ventricular systolic dysfunction with versus without iron deficiency. (From Jankowska et al[29] used with permission)

of 546 patients with CHF secondary to left ventricular systolic dysfunction (LVEF ≤ 45%) attending outpatient clinics or admitted to a tertiary referral cardiology center.[29] Event-free survival (event defined as all-cause death and transplantation) was 54% in those with iron deficiency versus 67% in those without (Figure 1).[29] Analysis of a cohort of patients with both preserved and reduced left ventricular systolic function demonstrated an association between both anemia and iron deficiency with higher New York Heart Association (NYHA) functional class. As shown in Figure 2, iron deficiency was associated with increased mortality, with an even stronger relationship when associated with anemia.[25]

5 | THERAPEUTIC INTERVENTIONS

Prior to considering specific treatment of iron deficiency, it is worth discussing the role of erythropoiesis-stimulating agents (ESAs) in patients with CHF. Recognizing the association of anemia with adverse outcomes in CHF, several small studies evaluated the potential benefit of ESAs with encouraging results that suggested improvement in symptoms and reduction in hospital admissions.[31-35] These led to the RED-HF trial,[36] a randomized, double-blind study designed to ascertain whether treatment with the ESA darbepoetin alfa improves clinical outcomes in CHF patients with anemia. In this double-blind study, 2278 patients with CHF (LVEF ≤ 40%) and mild-to-moderate anemia (defined as hemoglobin between 9.0 and 12.0 g/dL) were recruited and assigned to receive either darbepoetin alfa or placebo. Participants in the active treatment arm were given the drug to achieve a hemoglobin target of 13.0 g/dL. The primary endpoint was a composite of death from any cause or first hospitalization for worsening heart failure. The primary endpoint occurred in 576 patients (50.7%) of 1136 patients in the active treatment arm and in 565 (49.5%) in the placebo group (P = .87). A total of 42 patients (3.7%) in the darbepoetin alfa group experienced a fatal or nonfatal stroke as opposed to 31 patients (2.7%)

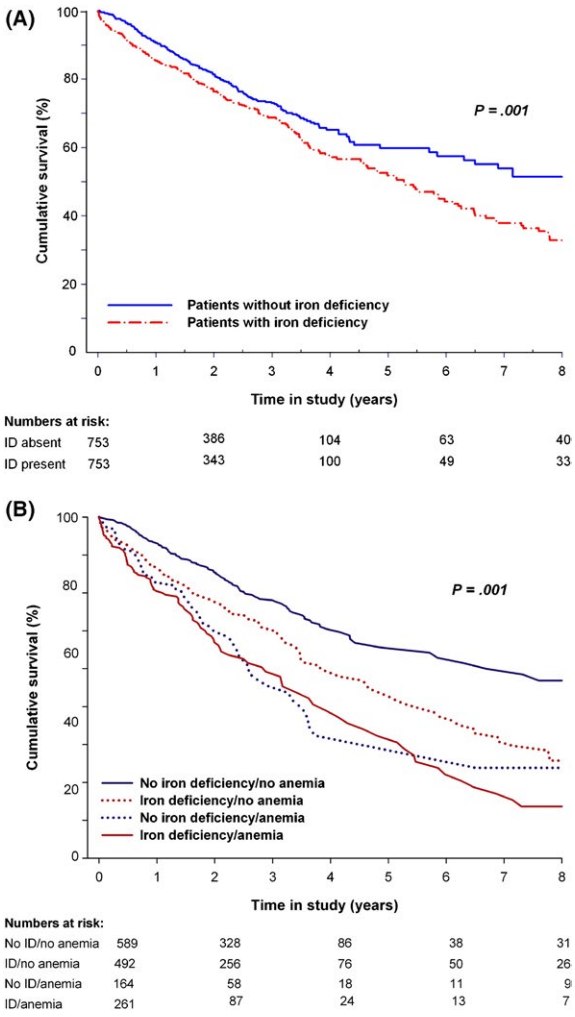

FIGURE 2 (A) The presence of iron deficiency is associated with reduced survival in chronic heart failure patients with both preserved and impaired left ventricular systolic function. (B) Iron deficiency and anaemia are cumulatively associated with reduced survival with iron deficiency appearing to have greater significance to anaemia alone. (From Klip, et al[25] used with permission)

in the placebo group (P = .23). Reports of thromboembolic adverse events were received from 153 patients (13.5%) and 114 patients (10.0%) from the darbepoetin alfa group and placebo group, respectively (P = .01). Darbepoetin alfa therefore did not reduce the rate of mortality or hospitalization among patients with CHF and associated anemia but conferred a significant increase in the risk of thromboembolic events. This study served to eliminate erythropoietin as a standard treatment for anemia in patients with CHF.

6 | IRON REPLACEMENT

Several small studies reported that intravenous (IV) iron was associated with improvements in symptoms, exercise capacity, quality of life, renal function, NYHA functional class and LVEF, and reduction in NT-proBNP in CHF patients with iron deficiency

TABLE 2 Summary of results of the meta-analysis of iron therapy in heart failure by Jankowska et al[43]

	Toblli[38]	FERRIC-HF[39]	FAIR-HF[42]	IRON-HF[44]	CONFIRM-HF[21]	Meta-analysis[43]
Number randomized (n=)	40	35	459	16	301	851
Follow-up period	5 mos after treatment	2 wks after treatment	24-26 wks	3 mos	52 wks	-
Outcome	**OR, 95% CI**	**OR, 95% CI**	**OR, 95% CI**	**OR, 95% CI**	**OR, 95% CI**	**OR, 95% CI**
All-cause death	N/A	1.47 (0.06, 38.91)	0.62 (0.17;2.36)	1.25 (0.09;17.65)	0.85 (0.38;1.91)	0.83 (0.43;1.59) *P* = .5671
Cardiovascular death	N/A	1.47 (0.06; 38.91	0.50 (0.12; 2.02	N/A	0.92 (0.39; 2.15)	0.80 (0.39; 1.63) *P* = .5405
All-cause death or cardiovascular hospitalization	N/A	0.24 (0.03; 1.73)	0.44 (0.24; 0.84)	N/A	0.45 (0.28; 0.73)	0.44 (0.30; 0.54) *P* < .0001
Cardiovascular death or hospitalization for worsening heart failure	N/A	N/A	0.41 (0.18; 0.93)	N/A	0.38 (0.21; 0.68)	0.39 (0.24; 0.63) *P* = .0001
HF hospitalization	0.07 (0.000; 1.34)	0.20 (0.02; 2.43)	0.38 (0.14; 1.04)	N/A	0.27 (0.13; 0.56)	0.28 (0.16; 0.50) *P* < .0001
	Mean difference between groups (95% CI)	**Mean difference between groups (95% CI)**	**Mean difference between groups (95% CI)**	**Mean difference between groups (95% CI)**	**Mean difference between groups (95% CI)**	**Mean difference between groups (95% CI)**
6MWT distance	N/A	N/A	28.4 (13.95; 42.85)	N/A	38.40 (12.80; 64.00)	30.82 (18.23; 43.40), *P* < .0001
NYHA class	−1.30 (−1.77; −0.83)	−0.60 (−0.96; −0.24)	−0.25 (−0.37; −0.13)	N/A	−0.28 (−0.49; −0.06)	−0.54 (−0.87; −0.21), *P* = .0013
LVEF	−6.4 (−9.32; −3.48)	1.0 (−2.80; 4.80)	N/A	N/A	N/A	−2.8 (−10.05; 4.45), *P* = .4485
EQ-5D score	N/A	N/A	5.70 (2.04; 9.36)	N/A	2.4 (−1.34; 6.14)	4.07 90.84; 7.310, *P* = .0136
KCCQ score	N/A	N/A	6.60 (2.72; 10.48)	N/A	4.40 (0.45; 8.35)	5.52 (2.75; 8.29), *P* = .0001
PGA	N/A	1.70 (0.58; 2.82)	0.63 (0.35; 0.91)	N/A	0.52 (0.06; 0.98)	0.70 (0.31; 1.09), *P* = .0004
MLHFQ score	−20.00 (−24.04; −15.96)	13.00 (−27.17; 1.17)	N/A	N/A	N/A	−19.47 (−23.36; −15.59), *P* < .0001

EQ-5D, European Quality of Life; HF, heart failure; KCCQ, Kansas City Cardiomyopathy Questionnaire; LVEF, left ventricular ejection fraction; MLHFQ, Minnesota Living with Heart Failure Questionnaire; 6MWT, 6-minute walking test; N/A, not applicable; PGA, patient global assessment.

anemia.[37-39] Further data supporting benefit on exercise capacity have come from a recent study which demonstrated a significant improvement in peak oxygen uptake (VO_2) among symptomatic patients with stable heart failure treated with IV iron for 24 weeks as compared with placebo ($P = .02$).[40] In contrast, oral iron appears to have little effect on oxygen consumption or iron stores in patients with CHF.[41] This is likely due to the impaired duodenal absorption of iron in the context of the chronic inflammatory state described above.

To date, there have been two larger-scale clinical trials which reported the beneficial effects of IV iron therapy in CHF patients with iron deficiency.[21,42] The FAIR-HF trial[42] was a randomized, double-blind study designed to determine whether the administration of IV iron (ferric carboxymaltose) conferred symptomatic benefit in iron-deficient CHF patients, either with or without anemia. In this study, 459 patients with CHF and NYHA functional class II or III were enrolled. Cutoff points for LVEF were ≤ 40% and ≤ 45% for NYHA class II and III, respectively. Iron deficiency was defined as ferritin < 100 μg/L, or between 100 and 299 μg/L with transferrin saturation < 20%. The subjects were randomly assigned to receive either IV ferric carboxymaltose or saline (placebo). The primary endpoints were the self-reported patient global assessment and NYHA functional class, both recorded at week 24. Among the patients who were given ferric carboxymaltose, 50% reported being much or moderately improved, and 47% were in NYHA functional class I or II. In comparison, 28% of patients in the placebo arm reported being much or moderately improved, and 30% were in NYHA functional class I or II ($P < .001$). No significant differences were found between anemic and nonanemic patients (anemia defined as hemoglobin < 12.0 g/dL for both men and women). The second study, known as CONFIRM-HF trial,[21] was a multicenter, double-blind, placebo-controlled trial designed to evaluate the effects and safety (to one year) of IV iron therapy in iron-deficient CHF patients. A total of 304 CHF patients with LVEF ≤ 45% were recruited with the same definitions of iron deficiency as in FAIR-HF. Patients were randomized in a 1:1 ratio to receive either IV ferric carboxymaltose or saline (placebo) for 52 weeks. The primary endpoint was the change in 6-minute-walk-test (6MWT) distance from baseline to week 24. IV ferric carboxymaltose was associated with significantly greater improvement in 6MWT distance at week 24 of 33 ± 11 m over the placebo group ($P = .002$). The beneficial effects of iron therapy were sustained throughout the period of study. Furthermore, although it was not powered to evaluate this, IV iron was associated with a reduction in the risk of hospitalization for worsening heart failure (HR 0.39, 95% CI 0.19-0.82, $P = .009$).

A recent meta-analysis by Jankowska et al[43] examined evidence from five randomized controlled trials,[21,38,39,42,44] involving a total of 851 patients—the majority being from FAIR-HF and CONFIRM-HF. IV iron therapy improved symptoms, exercise capacity, quality of life, and clinical outcomes, regardless of concomitant anemia. Interestingly, the risk of cardiovascular hospitalization, heart failure hospitalization, cardiovascular death, and all-cause death appeared to be significantly reduced by IV iron therapy. Table 2 summarizes the key results from the meta-analysis.

7 | CURRENT GUIDELINES

In the latest clinical guideline published by the Scottish Intercollegiate Guidelines Network (SIGN) on management of CHF,[45] patients with reduced ejection fraction, NYHA class III with an LVEF ≤ 45%, or NYHA class II, LVEF ≤ 40%, with a hemoglobin level of 9.5-13.5 g/dL and iron deficiency (defined as ferritin < 100 μg/L, or transferrin saturation < 20% with ferritin 100-300 μg/L) should be *considered* for IV iron therapy. IV ferric carboxymaltose is also shown to be cost-effective (£12,482 per QALY gained).[46] In addition, the SIGN guidelines state that erythropoietin is not recommended for CHF patients with reduced ejection fraction and anemia, mainly due to the absence of beneficial effects and the increased risk of thromboembolic adverse events.[45]

The European Society of Cardiology (ESC) has also recently recommended that IV iron be considered in symptomatic patients with heart failure with reduced ejection fraction and iron deficiency (the same definitions applied as the SIGN guidelines)—Class IIa recommendation and Level A evidence. The primary purpose of this recommendation is for symptom alleviation and to improve exercise capacity and quality of life.[47]

The latest update published by the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines and the Heart Failure Society of America (ACC/AHA/HFSA) recommended that IV iron *may be considered* in patients with NYHA class II and III and iron deficiency (ferritin < 100 ng/mL, or 100-300 ng/mL if transferrin saturation < 20%) to improve functional status and quality of life (Class IIb recommendation and Level B-R evidence).[48] However, the report also stated that a strong recommendation for IV iron replacement can only be made once results from a well-designed trial evaluating its effects on morbidity and mortality are available.

8 | FUTURE CHALLENGES

Major gaps of knowledge still exist. Although serum ferritin has been used in several of the studies, increasing amounts of data suggest that serum ferritin is not a robust indicator of iron deficiency.[26] Patients with CHF are less likely to have a low serum ferritin compared to patients without CHF. This may be attributed to the fact that ferritin is an acute-phase reactant which may be elevated in response to the underlying inflammatory process in CHF.[14-20] Consequently, iron deficiency may be missed if based on serum ferritin concentration as high levels of serum ferritin may reflect inflammation rather than iron repletion. Many patients with serum ferritin < 100 μg/L were also found not to have anemia, thus suggesting a poor correlation between serum ferritin levels and prevalence of anemia.[26] Therefore, the validity of serum ferritin as a tool used to define iron deficiency is questionable and further work is

needed to evaluate other hematinic factors which may potentially be a better indicator of iron deficiency.

In addition, the longer-term impact of iron repletion on CHF hospitalization, overall hospitalization (used as an index of both morbidity and cost-effectiveness), cardiovascular mortality, and safety is still poorly understood. An ongoing UK-based study, IRONMAN,[49] is a prospective, randomized open-label, blinded endpoint trial aiming to evaluate these issues. The primary objective is to compare the additional effect of an IV iron regimen (iron isomaltoside-1000) when added to standard guideline-indicated therapy on cardiovascular mortality and recurrent hospitalizations due to heart failure in patients with CHF secondary to left ventricular systolic dysfunction and iron deficiency. A total of 1300 patients will be recruited with the study period planned to last for approximately 4.5 years. Further outcome studies are planned in Germany and the United States.

9 | CONCLUSION

Iron deficiency is very common in CHF and associated with an increased morbidity and mortality. IV iron therapy improves symptoms, exercise capacity, and quality of life, at least in the short-to-intermediate time. However, there are still currently no standardized criteria used to define iron deficiency and the underlying mechanism of iron deficiency in CHF remains incompletely understood. Further work is required to improve the ability to identify iron deficiency in patients with CHF and evaluate the effect of iron repletion on hard endpoints including hospitalization and mortality.

CONFLICT OF INTEREST

CCL reports having received speaker fees from, or being a member of advisory boards for, Novartis, MSD, Astra Zeneca, and Servier. PRK reports having received research grants from Alere, Medtronic, Pharmacosmos, and Servier. PRK also reports having received speaker fees from, or being a member of advisory boards for, Alere, Amgen, BMS, Janssen, Novartis, Pfizer, Pharmacosmos, Servier, and Vifor. Remaining authors have declared no conflict of interest.

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