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Original Research Article

A clinical study on single-dose intravenous iron therapy's impact on hemoglobin and its outcomes in hospitalized chronic kidney disease patients

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ABSTRACT

Background: Anemia is a common complication in Chronic Kidney Disease (CKD) due to reduced erythropoietin production and iron deficiency, leading to poor patient outcomes. Intravenous (IV) iron therapy is preferred over oral supplements for its efficacy in rapidly improving hemoglobin levels and replenishing iron stores. Single-dose IV iron formulations like Ferric Carboxymaltose offer a convenient and effective option for anemia management in Chronic Kidney Disease (CKD) patients.
Aim: Study on single-dose intravenous iron therapy's impact on hemoglobin and its outcomes in hospitalized chronic kidney disease patients.
Materials and methods: A cross-sectional study was conducted on 200 hospitalized Chronic Kidney Disease (CKD) patients receiving single-dose IV iron therapy (Ferric Carboxymaltose, Iron Sucrose, or Monoferric). Outcomes including hemoglobin improvement, iron parameters, adverse events, and cost-effectiveness were analyzed pre- and post-treatment.
Results: The majority of patients (59%) were over 50 years old, with males accounting for 55% of the study group. The most prevalent comorbidities were Hypertension (91.5%) and type 2 diabetes (51%). The average Body Mass Index (BMI) reduced from 22.8 to 21.2 after the intervention. The most commonly provided iron formulation was Ferric Carboxymaltose (69.5%), followed by iron sucrose (16.5%) and Monoferric (14%). Hemoglobin levels rose by an average of 2.3 units in 51.5% of patients, with a mean time to target of 5.1 days. Ferritin levels increased by 41.4% after therapy, whereas TIBC and transferrin saturation remained stable. Hypertension was the most common side effect, with 74 cases documented (23 mild, 43 moderate, and 8 severe).
Conclusion: The study found that Single-Dose Intravenous Iron therapy increases hemoglobin levels and Iron parameters in CKD patients, with Ferric Carboxymaltose being the most effective formulation. The medication also reduced post-hemodialysis BMI and was cost-effective for anemia management. The most common comorbidity was hypertension, and while there were some adverse events, they were largely controlled. Overall, Intravenous Iron therapy reduced anemia and its associated hazards, leading to better patient outcomes in Chronic Kidney Disease (CKD) care.

1. Introduction

1.1. Intravenous iron

Intravenous infusions of Iron have evolved from a poorly effective and dangerous intervention to a safe cornerstone for the treatment of Iron deficiency. Iron formulations

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today, are composed of composite nanoparticles of Carbohydrate Ferric Oxyhydroxides. Depending on the particular formulation, total Iron deficit can be corrected with single or multiple doses of Iron Dextran, Iron Derisomaltose (formerly known as Iron Isomaltoside 1000), Ferric Carboxymaltose, Ferumoxytol, Iron Sucrose, and Sodium Ferric Gluconate in 1-2 weeks.[1]

Iron deficiency commonly contributes to anemia affecting individuals with Chronic Kidney Disease. In addition to the mechanisms of functional and absolute Iron deficiency and general treatment principles outlined in the KDIGO (Kidney Disease: Improving Global Outcomes) guideline, this review describes the diagnostic criteria for Iron deficiency in Chronic Kidney Disease.[2] The process of replenishing absolute Iron deficit has advance since well-tolerated and potent oral agents such as Ferric Citrate, Ferric Maltol, and Sucrosomial Iron have been developed over time.[3,4].

2. Chronic Kidney Disease

Chronic Kidney Disease (CKD) is a condition where kidney function gradually declines over time. The major risk factors for Chronic Kidney Disease (CKD) are diabetes, hypertension, heart disease, obesity, age over sixty, a family history of renal failure, acute kidney injury, and tobacco use or smoking. It is important to detect CKD early because a variety of physical, environmental, and social factors can cause it.[5] In addition, other conditions or illnesses like HIV Nephropathy, Glomerulonephritis, IgA Nephropathy, Polycystic Kidney disease, Autoimmune diseases, severe infections, Hydronephrosis, abnormalities of the kidneys and urinary tract, kidney cancer, kidney stones, recurrent untreated UTIs, and prolonged UTIs can cause Chronic Kidney Disease (CKD). A build-up of urea causes hypophosphatemia, hypocalcemia, azotemia, uremia, potassium accumulation, fluid overload, and cachexia. Abnormalities in Calcium, Phosphorus, Parathyroid hormone, or Vitamin D metabolism, as well as bone turnover, mineralization, volume, linear growth, or strength, as well as vascular or other soft-tissue calcification, can all result from changes in mineral and bone metabolism. A new symptom of CKD is Cognitive decline, with a 35–40% increased risk of Dementia or Cognitive decline in these patients. Sexual dysfunction is prevalent in both male and female CKD patients.[6,7]

2.1. Hemodialysis

Hemodialysis is an incredibly efficient way to get rid of extra fluid and waste from your blood. However, advanced chronic kidney disease (CKD) and kidney failure cannot be completely cured by it, as it does not replace all of the functions of the kidney. Hemodialysis might just be needed temporarily while the kidneys heal in certain cases of AKI. Nevertheless, your kidneys will not get better if renal disease advances gradually to renal failure. Either a kidney transplant or dialysis for a lifetime is needed. Hemodialysis can be performed in a hospital, a dialysis center, or at home. Each dialysis session lasts three to four hours and is usually conducted three times a week. Hemodialysis treatments at home usually take place five or six days a week. You should choose the treatment location in consultation with your healthcare provider.[8]

3. Methods and Materials

3.1. Sources of data and materials

1. Patient case sheet.
2. Hemodialysis record.
3. ADR forms.

3.2. Method of data collection

Hospitalized patients' electronic or paper-based chronic kidney disease (CKD) medical records were Accessed and examined. Pertinent data such as patient characteristics, stage of chronic kidney disease, co-occurring conditions, and specifics of iron treatment, hemoglobin levels, Blood pressure, Body Mass Index (BMI), Iron, TIBC (Total Iron Binding Capacity), Erythropoietin-stimulating agent (ESA) use and treatment results were collected.[9] Collected data to clinical outcomes and iron therapy regimens were connected and patients were observed during their hospital stay. Any hemoglobin level changes, adverse iron therapy events, and therapeutic improvements were recorded.[10]

3.3. Statistical analysis

1. The data was collected and entered in Microsoft Excel software 2024 and interpreted by descriptive statistics that were presented to analyze and express the report as counts and percentages in the form of tables, charts, and graphs.
2. The Statistical analysis of collected data was performed using IBM SPSS version 26 statistical software.

4. Results

4.1. Patient age distribution

Out of 200 cases, the patients are divided into six categories according to their age. Patients who are aged between 51 to 60 have a high percentage at 37.5% of being admitted to the hospital diagnosed with CKD. A total of 82 patients were below 50 years of age while 128 were above 50 years of age.

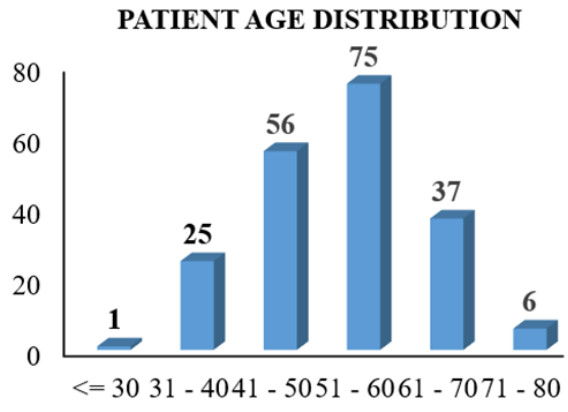

Figure 1: Patient age distribution

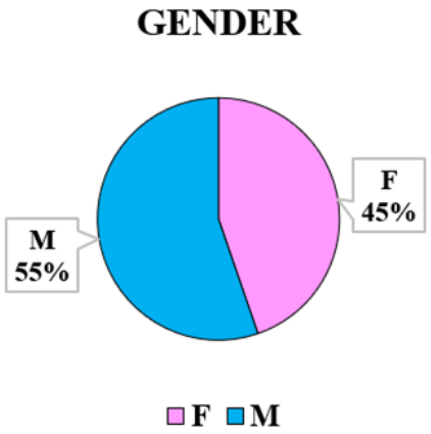

Figure 2: Gender distribution

5. Descriptive Statistics of Patient Age

The age distribution of 200 patients has a mean of 52.52 years and a median of 55.55 years, indicating that the average age is in the middle 50s. The standard deviation is 10.17, indicating moderate diversity in patient ages. The age range is from 30 to 75.5 years, for a total of 45.5 years.

Table 1: Descriptive statistics of patient age

Age	Value
	200
Mean	52.52
Median	55.55
Std. Deviation	10.17
Range	45.5
Minimum	30
Maximum	75.5

5.1. Gender distribution

In the current study, the dominant gender was male (110), and the remaining was filled by female gender (90). This data represents the distribution of genders in a sample of 200 individuals. Females make up 45% of the sample, while males constitute 55%.

6. Total Patients with Co-Morbidities

This data shows the prevalence of various comorbidities among the population. Hypertension is the most common condition, with 183 cases, followed by Type 2 Diabetes Mellitus at 102 cases. Anemia is present in 53 individuals, while ischemic heart disease is less common in 13 cases. Acute Pulmonary Edema is rare with only 6 cases, and there are 50 cases categorized under "others," indicating a variety of less common conditions.

Table 2: Total comorbiditie

Co-morbidities	Enumeration
HTN	183
Anemia	53
T2DM	102
IHD	13
Acute pulmonary edema	6
Others	50

7. Intravenous Iron Therapy Used

This figure lists the distribution of iron treatments among 200 patients: 139 received Inj. Ferric Carboxy Maltose (FCM), 33 received Inj. Iron Sucrose and 28 were treated with Inj. Monoferric (Iron Isomaltoside).

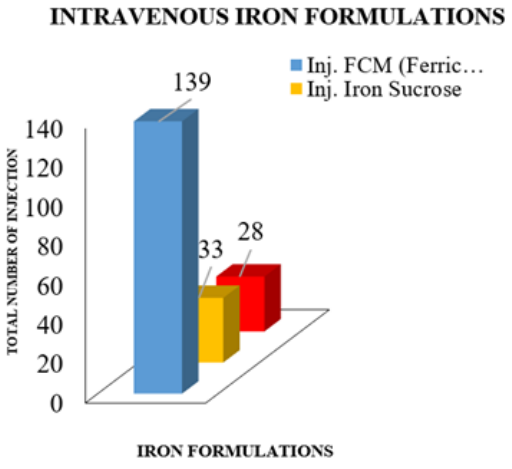

Figure 3: Intravenous iron formulations

8. Hemoglobin Level Changes

The figure summarizes the results of a study involving 200 patients. Out of these, 103 patients achieved a change in hemoglobin levels, with an average increase of 2.3 units. The target percentage of patients who met this goal was 51.5%.

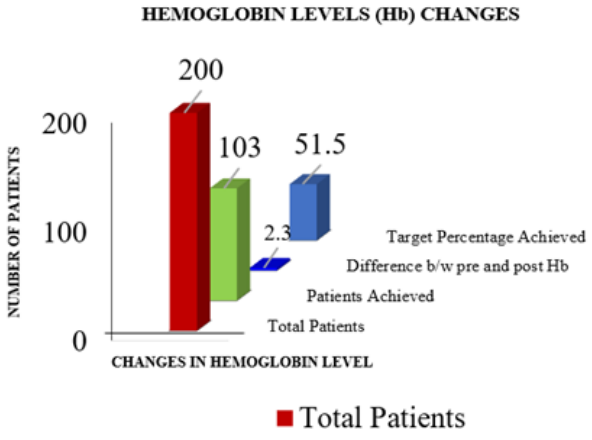

Figure 4: Hemoglobin level changes

9. Time to Reach Target Hemoglobin

This figure details the time required for patients to reach their target. The maximum time observed was 5.6 days, while the median was 4 days and the average time was 5.1 days. The standard deviation of 6.4 days indicates variability in the time taken among patients.

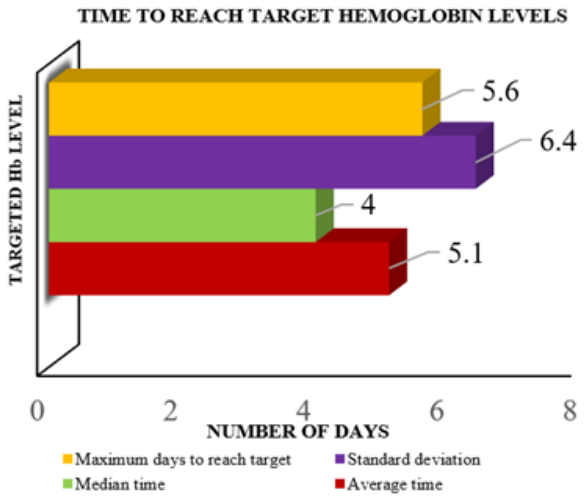

Figure 5: Time to reach target Hemoglobin

10. Iron-Related Parameters

This data shows iron-related parameters before and after therapy. Baseline ferritin averaged 530.5 ng/mL, increasing to 750.2 ng/mL post-therapy. Total iron-binding capacity (TIBC) was 236.2 μg/dL at baseline, slightly decreasing to 231.6 μg/dL after therapy. Transferrin saturation had a mean of 27.8%, ranging from 10.4% to 60%.

Table 3: Iron-related parameters

Iron related Parameters	Mean	Median	Std. Deviation	Min. Value	Max. Value
Baseline Ferritin (ng/mL)	530.5	405	268.4	118	1229
Post-therapy ferritin (ng/mL)	750.2	775.4	212	500	950
Baseline TIBC (μg/dL)	236.2	232	40.3	126	328
Post-therapy TIBC (μg/dL)	231.6	228	40	117	318
Transferrin Saturation (%)	27.8	24	11	10.4	60

11. Iron-Related Parameters Mean and Percentage Change

This figure shows changes in iron-related parameters from baseline to post-therapy. Ferritin levels increased by a mean of 219.7 ng/mL, representing a 41.4% rise. In contrast, TIBC decreased by 4.4 μg/dL, reflecting a -1.9% change.

Table 4: Iron-related parameters mean and percentage change

	Change In Mean	% Change
Ferritin	219.7	41.4
TIBC	-4.4	-1.9

11.1. Correlation between Iron markers

Post-therapy ferritin and TIBC are strongly correlated (0.99). Hemoglobin improvement is strongly linked to ferritin (0.86), but less so to TIBC (0.38) and transferrin saturation (0.22).

11.2. BMI of patient

The data shows a decrease in BMI from an average of 22.8 pre-intervention to 21.2 post-intervention, reflecting a reduction of 1.5 in body mass.

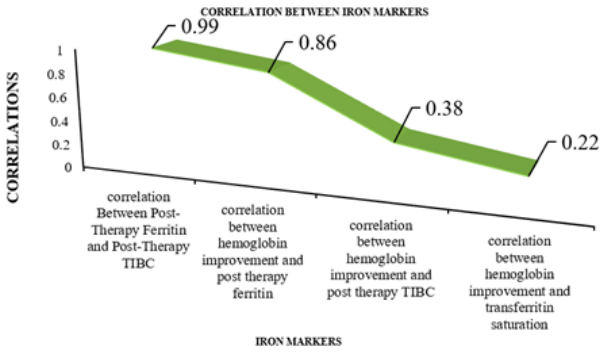

Figure 6: Correlation between ironmarkers

Table 5: BMI distribution

Data	Average
Pre BMI	22.8
Post BMI	21.2
BMI change	1.5

12. Cost-Effectiveness Analysis

According to the cost-effectiveness study, each unit increase in hemoglobin levels costs Rs. 1,138.30. The intervention's total cost was Rs. 226,523, or an average of Rs. 1,921.30 per patient.

Table 6: Cost-effective analysis

Cost-Effective Analysis	Inr.
Total cost	226523.0
Cost per patient	1921.3
Cost per Hemoglobin increase	1138.3

13. Clinical Observations

The clinical observations of adverse events reveal that, out of 93 cases, 74 patients had hypertension, 15 had hypotension, 3 experienced fever and chills, and 1 had hypothermia, with hypertension being the most common adverse event.

Table 7: BMI distribution

Data	Average
Pre BMI	22.8
Post BMI	21.2
BMI change	1.5

14. Cost-Effectiveness Analysis

According to the cost-effectiveness study, each unit increase in hemoglobin levels costs Rs. 1,138.30. The intervention's total cost was Rs. 226,523, or an average of Rs. 1,921.30 per patient.

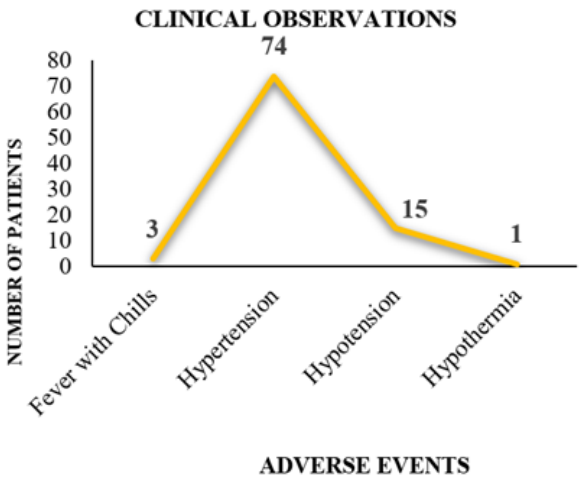

Figure 7: Clinical observations

Table 8: Cost-effective analysis

Cost-Effective Analysis	Inr.
Total cost	226523.0
Cost per patient	1921.3
Cost per Hemoglobin increase	1138.3

15. Clinical Observations

The clinical observations of adverse events reveal that, out of 93 cases, 74 patients had hypertension, 15 had hypotension, 3 experienced fever and chills, and 1 had hypothermia, with hypertension being the most common adverse event.

16. Discussion

16.1. Patient age distribution

The majority of patients (64%) were over 50 years old, with the highest percentage (37.5%) in the 51–60 age group. This supports the known prevalence of CKD in older populations, with an average age of 52.52 years (Figure 1).

16.2. Descriptive statistics of patient age

The age distribution of 200 patients shows a mean of 52.52 years, a median of 55.55 years, and a standard deviation of 10.17, with ages ranging from 30 to 75.5 years (Table 1).

16.3. Gender distribution

Males comprised 55% of the sample, indicating a higher prevalence of CKD in men, which is consistent with existing literature (Figure 2).

Co-morbidities Hypertension (183 cases) and Type 2 Diabetes Mellitus (102 cases) were the most common co-morbidities, which are well-known risk factors for CKD. Anemia was also prevalent, highlighting the need for managing anemia in CKD patients (Table 2).

On the other hand, individuals with severe anemia (Hb <10.5 g/dL) had a considerably greater risk of cardiovascular hospitalizations, death (HR 5.27; 95% CI 4.37–6.35), and end-stage renal disease (ESRD) progression, according to Anat Gafter-Gvili, *et. al*. The early iron therapy intervention that is the focus of our investigation may mitigate severe anemia and its related consequences in CKD, hence lowering these long-term risks.[11]

16.4. Intravenous iron therapy

Ferric Carboxymaltose (FCM) was the most commonly used iron therapy (139 patients), with Iron Sucrose and Monoferric used in fewer cases. This treatment improved hemoglobin levels in 51.5% of patients, with an average increase of 2.3 units (Figure 3).

16.5. Hemoglobin level changes

Out of 200 patients, 103 (51.5%) achieved a hemoglobin increase, with an average rise of 2.3 units (Figure 4).

In contrast, hemoglobin levels improved by only +0.60 g/dL in anemic patients and +0.08 g/dL in non-anemic patients at the 6-month follow-up (95% CI -0.27 to +1.48) in Davide Cesarano, *et. al*. study, with 36.4% of anemic patients showing a hemoglobin increase >1 g/dL. The higher baseline severity of anemia in our cohort and the use of intravenous iron formulations, such as ferric carboxymaltose (FCM) and iron sucrose, may have contributed to the difference between Cesarano's results and ours. These formulations may have caused anemia to be corrected more quickly than oral iron treatments.[12]

16.6. Time to reach target Hemoglobin

Patients reached their target hemoglobin in an average of 5.1 days (median: 4 days), with a maximum of 5.6 days and a standard deviation of 6.4 days, indicating variability (Figure 5).

16.7. Iron-related parameters

Ferritin levels increased by 41.4%, while TIBC slightly decreased by 1.9%. This shows that intravenous iron therapy was effective in replenishing iron stores and improving iron metabolism in CKD patients (Table 3).

The increase in ferritin is similar to the results of Cesarano *et. al*., who found that during the trial, regulated transferrin saturation (>20%) increased from 11.8% to 50.0% while ferritin response rates stayed constant.[12] On the other hand, the study conducted by Hamza Nawaz, *et. al* ., demonstrated a noteworthy rise in serum iron levels in Group I after intravenous therapy, with levels rising from 84.41±5.56 mcg/dL to 143.40±6.01 mcg/dL.[13]

17. Iron-Related Parameters Mean and Percentage Change

Ferritin levels rose by an average of 219.7 ng/mL (41.4% increase), while TIBC showed a slight decrease of 4.4 μg/dL (-1.9%) post-therapy (Table 4).

18. Correlation Between Iron Markers

A strong correlation was observed between post-therapy ferritin and TIBC (0.99), with hemoglobin improvement most strongly linked to ferritin (0.86) (Figure 6).

18.1. BMI of patient

The average BMI decreased from 22.8 pre-intervention to 21.2 post-intervention, indicating a slight reduction in body mass, possibly due to hemodialysis-related factors (Table 5).

19. Cost-Effectiveness Analysis

The cost-effectiveness study revealed that each unit increase in hemoglobin levels cost Rs. 1,138.30, with a total intervention cost of Rs. 226,523, averaging Rs. 1,921.30 per patient (Table 6).

20. Clinical Observations

Clinical observations of adverse events showed that out of 93 cases, 74 patients experienced hypertension, 15 had hypotension, 3 had fever and chills, and 1 had hypothermia, with hypertension being the most common (Figure 7).

In a similar vein, Takahiro Kuragano, *et. al*., discovered that patients with hemoglobin levels less than 10 g/dL were more likely to begin iron therapy, including intravenous iron, with 37.1% of patients undergoing anemia treatment within a year. Kuragano's study's cumulative incidence of therapy initiation emphasizes how crucial prompt iron supplementation is in halting the progression of anemia in individuals with chronic kidney disease.[11]

21. Conclusion

The study demonstrates the significant impact of single-dose Intravenous Iron therapy on hemoglobin levels and related outcomes in hospitalized Chronic Kidney Disease (CKD) patients. The treatment resulted in substantial improvements in hemoglobin and Iron-related measures such as ferritin, and there was a positive association between post-therapy ferritin levels and hemoglobin improvement. Common comorbidities such as hypertension and diabetes were

prevalent, and anemia emerged as a strong predictor of poor outcomes. The findings underscore the importance of early iron medication in reducing anemia risks, with manageable reported adverse events, highlighting the therapy's efficacy and safety in CKD management. Furthermore, our cost-effectiveness analysis demonstrates that the intervention provided significant health benefits at a reasonable cost per patient.

22. Ethical Approval

SIMS & RC/EC -10 /RR-03/ 2024-25

23. Source of Funding

None.

24. Conflict of Interest

None.

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