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Implementation of an anaemia walk-in clinic: Feasibility and preliminary data from the Orthopedic University Hospital

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Abstract

Background: Approximately one in three patients suffers from preoperative anaemia. Even though haemoglobin is measured before surgery, anaemia management is not implemented in every hospital.

Objective: Here, we demonstrate the implementation of an anaemia walk-in clinic at an Orthopedic University Hospital. To improve the diagnosis of iron deficiency (ID), we examined whether reticulocyte haemoglobin (Ret-He) could be a useful additional parameter.

Material and Methods: In August 2019, an anaemia walk-in clinic was established. Between September and December 2019, major orthopaedic surgical patients were screened for preoperative anaemia. The primary endpoint was the incidence of preoperative anaemia. Secondary endpoints included Ret-He level, red blood cell (RBC) transfusion rate, in-hospital length of stay and anaemia at hospital discharge.

Results: A total of 104 patients were screened for anaemia. Preoperative anaemia rate was 20.6%. Intravenous iron was supplemented in 23 patients. Transfusion of RBC units per patient (1.7 ± 1.2 vs. 0.2 ± 0.9; $p = 0.004$) and hospital length of stay (13.1 ± 4.8 days vs. 10.6 ± 5.1 days; $p = 0.068$) was increased in anaemic patients compared to non-anaemic patients. Ret-He values were significantly lower in patients with ID anaemia (33.3 pg [28.6–40.2 pg]) compared to patients with ID (35.3 pg [28.9–38.6 pg]; $p = 0.015$) or patients without anaemia (35.4 pg [30.2–39.4 pg]; $p = 0.001$).

Conclusion: Preoperative anaemia is common in orthopaedic patients. Our results proved the feasibility of an anaemia walk-in clinic to manage preoperative anaemia. Furthermore, our analysis supports the use of Ret-He as an additional parameter for the diagnosis of ID in surgical patients.

KEYWORDS

anaemia walk-in clinic, blood transfusion, iron deficiency, orthopaedic patients, patient blood management, reticulocyte haemoglobin

Patrick Meybohm and Andrea Meurer contributed equally to this study.

1 | INTRODUCTION

Preoperative anaemia is common in surgical patients scheduled for major surgery.[1] Within orthopaedic surgery, preoperative anaemia prevalence ranges from 14% for hip or knee endoprosthesis to 45% for duoprosthesis implantation.[2,3] Anaemia is associated with increased morbidity and mortality, prolonged hospital length of stay (LOS), intensive care admissions and red blood cell (RBC) transfusions.[1,4-7] Anaemia-related postoperative complications are associated with increased medical costs, thus putting enormous pressure on health-care facilities.[8] Iron deficiency (ID) accounts for ~60% of all anaemia cases.[9] The effectiveness of iron supplementation in iron-deficient patients has been demonstrated in many studies.[10] For example, supplementation of intravenous (IV) iron in orthopaedic patients 1–3 days before surgery was associated with a reduction of RBC transfusion rate from 37% to 24% and LOS from 11.7 to 10.7 days.[11] In order to minimise risks associated with anaemia in surgical patients, a patient blood management (PBM) programme has evolved within the last decade.[12] PBM is an evidence-based, patient-centred, multidisciplinary approach to reduce anaemia (pillar 1), minimise iatrogenic blood loss (pillar 2) and optimise patient-specific tolerance of anaemia (pillar 3) in order to maintain the patient's own blood volume.[13] So far, more than 100 individual PBM measures have been defined based on the broad interdisciplinary fields and temporal application.[14] In this context, an anaemia walk-in clinic was established in 2014 at the University Hospital in Frankfurt.[15,16] Overall, IV iron supplementation in iron-deficient anaemia (IDA) patients undergoing major non-orthopaedic surgery was associated with a decreased transfusion rate and LOS.[16] Even though the effectiveness of an anaemia walk-in clinics has been demonstrated,[10,15-18] anaemia walk-in clinics have only been implemented in a few hospitals so far. Reasons might be the lack of knowledge and/or resources. In addition, there is only limited information available for assistance in implementation of an anaemia walk-in clinic. For the detection of ID, most hospitals measure ferritin or transferrin saturation (TSAT).[19] It is worth noting that ferritin is an acute-phase protein, and therefore, false-positive increased serum ferritin levels may be observed in patients with increased inflammation values.[20] Recently, a reticulocyte haemoglobin equivalent (Ret-He) has been proposed as an additional marker to detect ID.[21] Reticulocytes are immature RBCs and exist for up to 2 days in the peripheral blood. Thus, Ret-He provides information of shortly produced RBCs.[22] In addition, Ret-He is not affected by inflammation compared to ferritin.[20] At the Orthopedic University Hospital Friedrichsheim (OUF), about 4000 patients undergo orthopaedic surgeries each year. Here, an anaemia walk-in clinic was established within 4 weeks in August 2019. Now, we discuss the implementation and associated barriers. To improve detection of ID, we examined whether Ret-He could be a useful additional parameter.

2 | METHODS

This observational study is part of a multicentre observational epidemiological trial focusing on the implementation of PBM in surgical patients (Trial Registration: ClinicalTrials.gov, NCT02147795). The study protocol was approved by the ethics committee of the University Hospital Frankfurt (Ref. 318/17), and the requirement for written informed consent by patients was waived. The anaemia walk-in clinic was recently implemented at the University Hospital Frankfurt[15,16] in accordance with the PBM bundles published by Meybohm et al.[14] Here, we report the implementation of an anaemia walk-in clinic at another hospital, the OUF.

2.1 | Overall requirements for anaemia management in an anaemia walk-in clinic

Our anaemia walk-in clinic was individualised according to local conditions, infrastructure, staff and economic resources. At the OUF, an anaemia coordinator was in charge of the hospital's anaemia management. The anaemia coordinator played a central role in communication and multidisciplinary organisation. The cooperation of further key stakeholders, like hospital administration, chief medical staff, nursing staff, anaesthesiologists and surgeons, was established. Support by the hospital pharmacy department (to facilitate access to IV iron formulas), financial department (to manage costs associated with anaemia management), information technology (IT) department and central clinical laboratory was required. To ensure awareness of the importance of anaemia management, medical education to health-care personnel was provided in order to extend or refresh knowledge on different forms of anaemia, anaemia management, blood transfusion and alternatives (Table 1).

TABLE 1 Overall requirements for anaemia management in an anaemia walk-in clinic

Step 1: Structural requirements, Involvement of key stakeholders [role]	OUF
Anaemia walk-in clinic coordinator [Communication, management]	✓
Hospital administrators, chief medical staff, nursing staff [Support]	✓
Anaesthesiologist [Perioperative anaemia management, interdisciplinary work]	✓
Surgeons [Support of preoperative anaemia management, interdisciplinary work]	✓
Central clinical laboratory [Perform laboratory test]	✓
Finance department [Cost management]	✓
Pharmacy department [Purchase of drugs]	✓
Information technology department [Display clinical data]	✓
[a]Local SOP/protocol for preoperative anaemia management	✓
[a]Medical education and training for medical staff	✓
[a]Different medical specialties for extended anaemia management (gastroenterology, nephrology, cardiology, haematology, internal medicine)	✓

Note: "✓" denotes implemented.
Abbreviations: OUF, Orthopedic University Hospital Frankfurt; SOP, standard operating procedure.
[a]Optional, not mandatory.

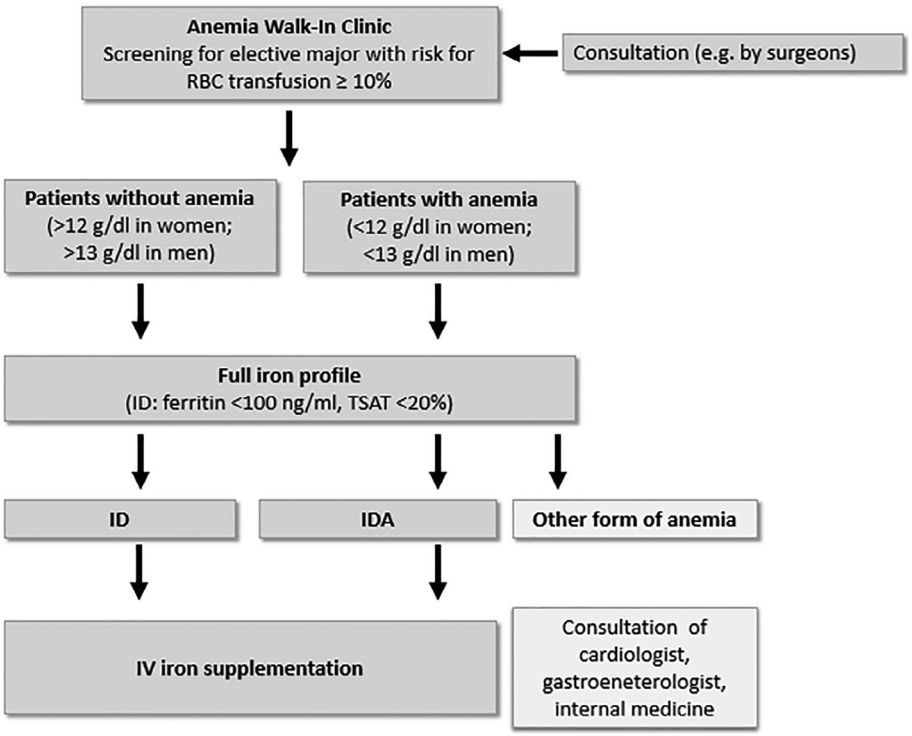

FIGURE 1 Diagnostic algorithm of the anaemia walk-in clinic. ID, iron deficiency; IDA, iron deficiency anaemia; IV, intravenous; RBC, red blood cell; TSAT, transferrin saturation

2.2 | Everyday clinical requirements of an anaemia walk-in clinic

To identify potential eligible patients, surgical timetables and schedules of the pre-hospital admission unit of patients undergoing major elective orthopaedic surgery were screened. Lists of major surgeries for the assessment of preoperative anaemia management were available to the staff at any time. Blood samples were drawn either at the pre-hospital admission unit or by the staff on the ward from non-mobile patients. As demonstrated in Figure 1, a defined pathway, including screening process, diagnostic algorithm and treatment protocol, was used to ensure consistency and sustainability. IV iron supplementation was administrated until the day of surgery or, in case of organisational issues, after surgery under constant monitoring of vital signs (non-invasive blood pressure [NIBP], heart rate [HR], oxygen saturation). Anaemia management of one patient (blood sampling, consultation, screening of medical records, IV iron supplementation, monitoring of vital signs) took up to 30–60 min. Any diagnosis and treatment were documented in the clinical documentation system (Table 2).

2.3 | Patients and procedures

From September to December 2019, patients (age ≥ 18 years) scheduled for major elective orthopaedic surgery with ≥10% probability for RBC transfusion were screened for preoperative anaemia: endoprosthetic surgery at shoulder and hip; prosthesis change after hip, shoulder and total knee arthroplasty; acetabular cup and hip replacement; triple osteotomy; periprosthetic fracture; spinal fusion (bi-segmental and multi-segmental); scoliosis correction; vertebral body replacement; and great bone tumour surgery. Elective knee joint arthroplasty was excluded from preoperative anaemia management because a tourniquet was used during surgery, and therefore, the probability for blood loss and RBC transfusion was low. All patients received standard perioperative care. RBC transfusion was carried out in accordance with the German transfusion guidelines. Briefly, RBC transfusion is recommended in asymptomatic patients with haemoglobin (Hb) levels <6 g/dl, in patients with cardiovascular risk factors with Hb levels between 6 and 8 g/dl or in patients with clinical symptoms of anaemic hypoxia.[23]

2.4 | Blood samples

Laboratory parameters included serum ferritin, transferrin, TSAT, Ret-He and soluble transferrin receptor (sTfR), haematological values (Hb, mean corpuscular Hb (MCH), mean corpuscular volume (MCV)), liver profile (gamma-glutamyl-transferase [GGT], aspartate aminotransferase [AST], alanine aminotransferase [ALT], lactate-dehydrogenase [LDH], bilirubin and alkaline phosphatase), inflammation markers (C-reactive protein [CRP] and leukocytes) and kidney disease markers (creatinine, urea). Blood samples were processed within 2 h, allowing the diagnosis and potential treatment of ID and IDA the same day.

2.5 | Classification of iron deficiency anaemia

According to the World Health Organization (WHO), anaemia is defined as a Hb concentration of <12 g/dl in women and <13 g/dl for

men. Iron deficiency was defined by laboratory results according to Munoz[24] and Anker et al.[25] Briefly, ID was defined as serum ferritin level < 100 ng/ml and TSAT <20%,[24] and in case of chronic kidney disease or heart failure, a serum ferritin level < 300 ng/ml was used.[25] In addition, full medical history of the patient was taken into account.

2.6 | Iron supplementation

Patients with ID or IDA received IV iron (ferric carboxymaltose [FCM] 50 mg/mL; Vifor, Saint Galene, Switzerland), administered at a dose of 500 mg in 100 ml of saline over 15 min (or 1000 mg in 250 ml of saline over 30 min depending on laboratory results). IV iron was administered by the anaemia manager. Contraindications were pregnancy, history of hypersensitivity reaction, acute infection under treatment with antibiotics (CRP > 5 mg/L), iron overload or recovery disorder (e.g., hemochromatosis). During IV iron administration, the patient's vital signs were monitored. A follow-up visit prior to surgery to check erythropoiesis response was not performed within the implementation process.

2.7 | Data collection

Data were extracted from the electronic hospital information system. Patient-specific observation periods ranged from pre-hospital admission to hospital discharge.

2.8 | Endpoints

The primary endpoint was the prevalence of preoperative anaemia in patients undergoing major orthopaedic surgery. Secondary endpoints were Ret-He level, RBC transfusion rate, LOS and prevalence of anaemia at hospital discharge.

2.9 | Statistical analysis

Descriptive statistical methods such as mean ± SD, median and interquartile range (IQR) (25%; 75%) were used to analyse the data. The Shapiro–Wilk test was used to assess the normality of continuous variables. Normally distributed data were compared with the Student's *t*-test. Non-normally distributed data were compared with the Mann–Whitney *U* test. Categorical variables were compared with the Chi Square test of Fisher's exact test. For group comparison of preoperative Ret-He level, the Kruskal–Wallis test was used. For this analysis, subgroups were formed regarding Hb level and iron status: *IDA subgroup* (anaemia and ID), *ID subgroup* (no anaemia but ID), *control subgroup* (no anaemia, no ID) and *subgroup of others* (anaemia due to any other reason, no ID). Statistical analysis and graphical illustration were performed using IBMSPSS Statistics (Version 26, IBM). A p value <0.05 was considered to be statistically significant.

3 | RESULTS

3.1 | Patient characteristics

Between September and December 2019, 104 patients were scheduled for major orthopaedic surgery and screened for the presence of preoperative anaemia and ID. In seven patients, surgery was postponed due to urgent further clarification of comorbidities (n = 4), infections (n = 2) or alcohol withdrawal therapy (n = 1). The remaining 97 patients were included in analysis (Figure S1). Overall, 20 of 97 (20.6%) patients were anaemic. No difference was found between age and gender in both groups. The prevalence of existing comorbidities differed significantly between the groups regarding respiratory (p = 0.008) and chronic renal disease (p = 0.017). No significant difference was found in type of surgery between the two groups (Table 3).

3.2 | Hb levels, RBC transfusions and LOS in the anaemia and non-anaemia groups

The preoperative Hb level of patients in the anaemia group was lower (11.6 [10.8–11.8] g/dl) compared to the non-anaemia group (13.3

TABLE 2 Everyday clinical requirements of an anaemia walk-in clinic

Step 2: Clinical requirements of an anaemia walk-in clinic [role]	OUF
Dedicated anaemia personnel [Screening of timetables, IV iron administration]	✓
Dedicated health-care personnel [Identification of patients, blood sampling]	✓
Identification of surgeries with ≥10% probability of RBC transfusion	✓
Physical space for consulting room [Anaemia walk-in clinic]	✓
Identification of anaemia	✓
[a]Early anaemia management (ideally up to 3 weeks prior to surgery)	Ø
Ultra-short anaemia management prior to surgery (until the day of surgery)	✓
Anaemia management after surgery	✓
Monitoring during IV iron administration [NIBP, HR, Oxygen Saturation]	✓
Mobile monitoring for IV iron administration on the ward [NIBP, HR, Oxygen Saturation]	✓
Clinical documentation System [Documentation of clinical results or procedures]	✓

Note: "✓" denotes implemented.
Abbreviations: HR, heart rate; IDA, iron-deficient anaemia; IV, intravenous; NIBP, non-invasive blood pressure; OUF, Orthopedic University Hospital Frankfurt; RBC, red blood cell.
[a]Optional, not mandatory.

TABLE 3 Demographic data, type of surgery, Hb level, RBC transfusion and LOS between the anaemia and non-anaemia groups

	Anaemia *n* = 20	Non-anaemia *n* = 77	*p* value
Gender (female) *n* (%)	15 (75.0)	53 (68.8)	=0.405
Age (years)[a]	72 (66–80)	67 (57.5–76)	=0.364
Underlying comorbidities *n* (%)			
Cardiovascular	15 (75)	42 (54.5)	=0.079
Endocrine disorders	10 (50.0)	25 (32.5)	=0.117
Respiratory	7 (35.0)	7 (9.1)	=0.008
Chronic renal disease	5 (25.0)	4 (5.2)	=0.017
Cerebrovascular	2 (10.0)	5 (6.5)	=0.444
Chronic liver disease	1 (5.0)	2 (2.3)	=0.504
Surgery performed *n* (%)			
Prosthesis change after hip-, shoulder-, knee joint arthroplasty	7 (35.0)	17 (22.1)	=0.182
Spinal fusion	5 (25.0)	17 (22.1)	=0.495
Surgical revision of spinal fusion	4 (20.0)	8 (10.4)	=0.211
Hip joint arthroplasty	3 (15.0)	30 (39.0)	=0.496
Shoulder joint arthroplasty	1 (5.0)	3 (3.9)	=0.609
Bone tumour surgery	0 (0.0)	2 (2.6)	=0.628
Preoperative Hb level (g/dl)[a]	11.6 (10.9–11.8)	13.3 (12.6–14.0)	<0.001
Hb level at discharge (g/dl)[a]	9.0 (8.2–9.7)	9.9 (8.7–11.3)	<0.001
RBC units per patient[b]	1.7 (± 2.1)	0.2 (± 0.9)	=0.004
LOS (days)[b]	13.1 (± 4.8)	10.6 (± 5.1)	=0.068

Abbreviations: Hb, haemoglobin; LOS, length of hospital stay; RBC, red blood cell.
[a]Results are expressed as median (IQR).
[b]Results are expressed as mean (±SD).

[12.6–14.0] g/dl) ($p < 0.001$). Anaemic patients received significantly more RBC units (1.7 [±2.1] units per patient) compared to patients without anaemia (0.2 [±0.9] units per patient; $p = 0.004$). LOS was higher in anaemic patients (13.1 [±4.8] days) compared to non-anaemic patients (10.7 [±5.1] days; $p = 0.068$). At the time of hospital discharge, Hb values were significantly lower in patients with preoperative anaemia (9.0 [8.2–9.7] g/dl) compared to patients without preoperative anaemia (9.9 [8.7–11.3]; $p < 0.001$). All patients survived until hospital discharge (Table 3).

3.3 | Comparison of RBC indices and iron parameters between the anaemia and non-anaemia groups

We compared RBC indices between the anaemia and non-anaemia groups and found no difference in MCV, MCH, ferritin and TSAT values. Significant differences were found in serum iron (74.0 [62.3–97.0] mcg/dl) versus 91.0 (71.0–110.0) mcg/dl; $p = 0.042$), sTfR (3.3 (2.2–4.4) mg/L versus 2.6 (2.1–3.2 mg/L; $p = 0.030$) and mean corpuscular haemoglobin concentration (MCHC) (32.7 (31.9–33.2) g/dl versus 33.6 (32.8-34.3) g/dl; $p = 0.003$). Ret-He was significantly lower in the anaemia group compared to the non-anaemia group (33.7 (32.0–35.2) pg versus 35.2 (32.4–36.3) pg; $p = 0.014$) (Table 4).

3.4 | Ret-He in diagnosis of preoperative iron deficiency

In the anaemia group ($n = 20$), IDA was diagnosed in 12 of 20 patients (60.0%); 8 of 20 patients (40.0%) presented with any other form of anaemia. In the non-anaemia group ($n = 77$), ID was present in 37 of 77 patients (48.1%); 40 of 77 patients (51.9%) did not have any form of anaemia or ID. Ret-He levels before surgery were 33.3 pg (28.6–40.2 pg) in the IDA subgroup and 35.3 pg (28.9–38.6 pg) in the ID subgroup. For the control subgroup, median Ret-He was 35.4 pg (30.2–39.4 pg) and 34.4 pg (32.7–35.8 pg) in the subgroup of others. Ret-He values were significantly lower in the IDA subgroup compared to the control ($p = 0.001$) and ID subgroup ($p = 0.015$) (Figure 2).

3.5 | Treatment of iron deficiency

Overall, IV iron was supplemented in 23 patients. There were no contraindications in patients assessed for IV iron supplementation. In patients with IDA, 12 of 12 patients (100.0%) received IV iron. In addition, 11 of 37 non-anaemic ID patients (29.7%) received IV iron. Of all supplemented patients, 13 patients (56.5%) received IV iron between 7 and 1 days prior to surgery at pre-hospital admission appointment, 7 (30.4%) patients between 1 and 2 days after surgery

TABLE 4 RBC indices, iron status parameters and CRP for the anaemia and non-anaemia groups and for all patients before surgery

	Anaemia *n* = 20	Non-anaemia *n* = 77	*p* value	All *n* = 97
Hb (g/dl)	11.6 (10.9–11.8)	13.3 (12.6–14.0)	<0.001	13.3 (12.5–14.0)
MCV (fl)	89.2 (85.2–93.5)	89.4 (84.1–91.6)	=0.382	89.4 (84.5–92.1)
MCH (pg)	29.7 (28.4–30.5)	30.2 (28.7–31.2)	=0.305	29.9 (28.5–30.8)
MCHC (g/dl)	32.7 (31.9–33.2)	33.6 (32.8–34.3)	=0.003	33.2 (32.6–34.2)
Ferritin (ng/ml)	76.5 (38.8–177.5)	104.0 (61.0–191.0)	=0.243	96.0 (57.5–187.5)
TSAT (%)	19.9 (16.0–30.0)	23.2 (17.8–30.4)	=0.443	22.5 (16.9–30.0)
sTfR (mg/L)	3.3 (2.2–4.4)	2.6 (2.1–3.2)	=0.030	2.7 (2.1–3.3)
Iron (mcg/dl)	74.0 (62.3–97.0)	91.0 (71.0–110.0)	=0.042	84.0 (69.0–108.5)
Ret-He (pg)	33.7 (32.0–35.2)	35.2 (32.4–36.3)	=0.014	35.1 (33.0–36.3)
CRP (mg/dl)	0.2 (0.1–0.6)	0.3 (0.1–0.5)	=0.989	0.3 (0.1–0.5)

Note: Results are expressed as median (IQR). Mann–Whitney *U* test was performed to compare parameters between the group of patients with any form of anaemia (anaemia group) and patients without anaemia (non-anaemia group).
Abbreviations: CRP, C-reactive protein; Hb, haemoglobin; MCH, mean corpuscular haemoglobin; MCHC, mean corpuscular haemoglobin concentration; MCV, mean corpuscular volume; Ret-He, reticulocyte haemoglobin equivalent; sTfR, soluble transferrin receptor; TSAT, transferrin saturation.

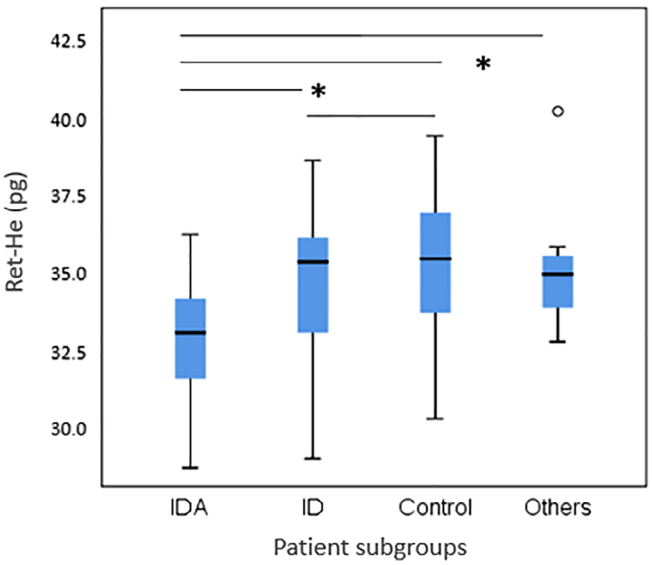

FIGURE 2 Reticulocyte haemoglobin equivalent (Ret-He) values in patient subgroups based on their iron status. Ret-He values among the different patient subgroups. Box-and-whisker plot represents Ret-He values in the four patient groups of this study. Comparison of values is carried out using the Kruskal–Wallis test. The horizontal lines represent mean values; $p = 0.015$ for comparing iron deficiency anaemia (IDA) versus iron deficiency (ID); $p = 0.001$ for IDA versus control; $p = 0.078$ for IDA versus others; $p = 0.292$ for ID versus control. $^{*}p < 0.05$ [Color figure can be viewed at wileyonlinelibrary.com]

and 3 (13.0%) patients on day 3 after surgery. Post-surgical application of IV iron was mainly because patients did not have time for IV iron infusion at the pre-hospital admission appointment (*n* = 5) or did not want to wait for laboratory results of iron profile (*n* = 5). No adverse events were observed in the context of IV iron administration. In the remaining 26 patients with ID, IV iron could not be administered due to organisational reasons (*n* = 4), missing laboratory results (*n* = 1), refusal of the patient (*n* = 2) and missing awareness of the staff about the anaemia walk-in clinic (*n* = 19).

4 | DISCUSSION

In many surgical patients, anaemia is present and associated with an impaired erythropoiesis due to ID.[26] Even though Hb values are measured before surgery, preoperative anaemia management is not performed in every hospital. In this study, we present the results of the implementation of an anaemia walk-in clinic at the OUF based on the example of the University Hospital in Frankfurt.[15,16] In addition, the usefulness of Ret-He in preoperative anaemia management was evaluated.

For implementation of the anaemia walk-in clinic, multidisciplinary consensus between hospital administration, leading professionals and medical staff at the OUF was established. Potential barriers such as lack of interest or underestimation of the impact of preoperative anaemia management were mostly eliminated by medical anaemia education in forms of written information material and lectures. Anaemia management was included in routing slips and electronic medical records, obvious to all health-care workers. For adherence and to ensure daily routine, a treatment algorithm for preoperative anaemia management was provided. Scheduling patients for anaemia management a few weeks prior to surgery was challenging. IV iron supplementation up to 21 days before surgery significantly increased Hb levels 4 weeks after surgery.[18] However, Spahn and colleagues revealed that ultra-short IV iron administration in combination with erythropoietin alpha, vitamin B12 and folic acid on the day before surgery can also be effective.[17] In our anaemia walk-in clinic, IV iron was administered until the day of surgery and up to 3 days after surgery.

In our analysis, anaemia was present in 20 of 97 (20.6%) patients; therefore, 12 of 20 anaemic patients (60.0%) presented with IDA. Iron

deficiency without anaemia was present in 37 of 77 cases (48.1%). Our results are in accordance with a study by Theusinger et al, where a preoperative anaemia rate of 20.0% was revealed in patients undergoing major orthopaedic surgery.[10] Besides ID being the most common form of preoperative anaemia, one-third of the patients suffer from anaemia of chronic inflammation, and another 30% suffer from anaemia of mixed cause or unexplained origin.[27] In the anaemia group, we observed a higher median age compared to the non-anaemia group. In addition, comorbidities, such as chronic kidney diseases, were significantly higher in the anaemia group. Reasons for anaemia in elderly orthopaedic patients may be caused by changes in stem cell physiology associated with inflammation, renal diseases or the use of multiple drugs.[27] Possible causes of ID in elderly patients may also include malnutrition, dysfunctional enteral iron absorption or chronic blood loss.[3] RBC consumption and LOS were increased in anaemic patients compared to non-anaemic patients. Reasons for prolonged hospital stay in the anaemia group may be associated with increased age and underlying comorbidities. The results of a higher use of RBC units in the anaemia group might be due to the more frequently performed surgeries of prosthesis change after arthroplasty, spinal fusion and surgical revision in these patients.

In our newly established anaemia walk-in clinic, 12 of 12 patients with IDA (100%) were supplemented with IV iron. Overall, 11 of 37 with ID (29.7%) received IV iron. Of the remaining 26 patients with ID, iron was not supplemented because of organisational reasons (n = 4), missing laboratory results (n = 1), patient's refusal (n = 2) and missing awareness of clinical staff (n = 19). We hypothesise that increasing awareness for anaemia management of the staff will enable assessment of a greater number of iron-deficient patients for IV iron supplementation.

Of all investigated parameters, iron parameters like ferritin and TSAT showed no significant differences between the anaemia and non-anaemia groups. Ret-He was significantly lower in the anaemia group compared to the non-anaemia group. An analysis of subgroups revealed that Ret-He was significantly lower in patients in the IDA subgroup compared to the ID subgroup and control subgroup. Ret-He is an early marker of iron-deficient erythropoiesis. Changes in MCV (21 days) and Hb value (60 days) occur when IDA has already taken place.[20] Furthermore, the effect of iron supplementation can be monitored closely with Ret-He as its effect can already be detected after 2 days, whereas ferritin levels increase only after 2 weeks.[20] In clinical practice, serum ferritin plays a major role in the diagnosis of IDA. However, ferritin as an acute-phase protein may increase false positively in the presence of inflammation, whereas Ret-He is not affected by inflammation.[28] Thus, with increased levels of Ret-He and ferritin in the presence of inflammation, IDA can be ruled out, and iron supplementation is not indicated. However, high levels of ferritin and a low Ret-He count indicate that ID and iron supplementation is recommended.[28] Therefore, we have included the Ret-He as a standard parameter to assess the presence of ID at the OUF and also at the University Hospital of Frankfurt and to enable effective preoperative anaemia management.

4.1 | Limitations

Our study has some limitations. First, we used an observational design; therefore, confounding factors cannot be excluded. One of the main limitations of this study is the low number of included patients. This limitation arises from the observational time of only 4 months. A longer time span would allow analysis of further endpoints, like the effect of IV iron supplementation on RBC transfusion rate. In addition, surgeries of prosthesis change, spinal fusion and surgical revision of spinal fusion were conducted more frequently in anaemic patients. This may suggest a higher rate of more complex cases in the anaemia group. In our anaemia walk-in clinic, elective knee joint arthroplasty was excluded from preoperative anaemia and ID management because surgery is performed with a tourniquet, and therefore, the risk of blood loss is minimised. However, these patients are likely to suffer from ID too. For the improvement of the anaemia walk-in clinic at the OUF, awareness of anaemia management of patients scheduled for major surgeries in clinical staff can still be improved. This may be achieved by further medical education and longer persistence of the anaemia walk-in clinic.

4.2 | Conclusion

In conclusion, our study provides detailed information for the implementation of an anaemia walk-in clinic. Preoperative anaemia is common in orthopaedic patients and was associated with a relevant increase in RBC concentrate consumption. In addition, our analysis supports the use of Ret-He as an additional parameter for diagnosis of ID and the decision for iron supplementation in orthopaedic patients. However, further studies are needed to investigate and validate its feasible utility and cost-saving effect in this clinical setting of preoperative anaemia management.

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CONFLICT OF INTEREST

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AUTHOR CONTRIBUTIONS

Vanessa Neef helped with substantial contributions to the conception and design of the work, data collection, analysis and interpretation of the data for the work and drafting the work and wrote the manuscript, and Suma Choorapoikayil helped with substantial contributions to the

conception and design of the work, interpretation of the data for the work, drafting the work and wrote the manuscript. David Meisenzahl, Paul Kessler, Florian J. Raimann, Florian Piekarski and Christoph Fleege helped with editing and revising the manuscript critically for important intellectual content. Kai D. Zacharowski and Andrea Meurer helped with implementing the study and editing and revising the manuscript critically for important intellectual content. Patrick Meybohm helped with substantial contributions to the acquisition, revising it critically for important intellectual content and final approval of the version to be published.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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