Original Clinical Article

JOURNAL OF CHILDREN'S ORTHOPAEDICS

Journal of Children's Orthopaedics
2023, Vol. 17(6) 618–625

DOI: 10.1177/18632521231213150
journals.sagepub.com/home/cho

Lessons learned from "the great mimicker disease": A retrospective study of 18 patients with scurvy

Faisal Miraj[1], I Wayan Arya Mahendra Karda[1], Ali Abdullah[2], and Eugene Dionysios[1]

Abstract

Purpose: Scurvy is an uncommon medical condition that affects children and is caused by an inadequate intake of vitamin C. This study presents the characteristics of patients with scurvy to raise awareness of the diagnostic process in developing countries where laboratory testing for vitamin C levels is often not available.

Methods: A retrospective study was performed from period of 2018 to 2023. Data extraction includes patient age, sex, body mass index, constitutional symptoms, musculoskeletal, mucosal, cutaneous symptoms, other accompanying disorders, anemia, erythrocyte sedimentation rate, C-reactive protein, radiographic examination, vitamin C dose, and duration of treatment. Descriptive statistical analysis was performed in this study.

Results: Eighteen cases (17 males, 1 female) of scurvy were referred to our institution. Thirteen of 18 patients were misdiagnosed before referral. The median age at presentation was 4.5 (range, 2–11) years. The average body mass index was $13.93 \pm 0.63\,kg/m^2$. Half of patients had healthy weight. All patients presented with lower limb pain and 17 of 18 with refusal to walk. The median onset of diagnosis was 11 (range 4–48) weeks. White line of Frankel was described in all patients. Seven had anemia and 6 of 18 had increase in erythrocyte sedimentation rate and/or C-reactive protein levels. Only one patient had ascorbic acid levels evaluation before treatment since it was not readily available in our country. Treatment length varied from 2 weeks to 6 months.

Conclusion: The diagnosis of scurvy is frequently delayed due to its extreme rarity in modern society and its ability to mimic numerous other conditions. In children presenting with limb pain and/or reluctance to walk and pathognomonic radiological findings, physicians must prioritize scurvy as a differential diagnosis. In scurvy, vitamin C supplementation is curative.

Keywords: Scurvy, clinical, radiological findings, laboratory findings, misdiagnosis, vitamin C treatment

What is known

- Scurvy is a rare condition in pediatric patients, resulting from vitamin C deficiency.
- Musculoskeletal symptoms are prominent in pediatric scurvy and occur in up to 80% of patients.

What is new

- Constitutional symptoms including malaise (89%) and irritability (72%) were presented.
- The most common musculoskeletal manifestations were lower limb pain (100%) and refusal to bear weight or walk (94%).
- The diagnosis of scurvy is made by clinical and radiographic findings and may be supported by additional findings such as reduced levels of vitamin C in the serum, but not always available.

[1]Department of Orthopaedic and Traumatology, Fatmawati Central General Hospital, Faculty of Medicine, Universitas Indonesia, Jakarta, Indonesia
[2]Division of Orthopaedic and Traumatology, Department of Surgery, Persahabatan General Hospital, Jakarta, Indonesia

Corresponding Author:
Faisal Miraj, Department of Orthopaedic and Traumatology, Fatmawati Central General Hospital, Faculty of Medicine, Universitas Indonesia, RS. Fatmawati Raya Street Number 4, Jakarta 12430, Indonesia.
Email: icalortho@gmail.com

Introduction

Scurvy is an uncommon medical condition that affects children and is caused by an inadequate intake of vitamin C. The prevalence of scurvy has decreased significantly over the past decade. This decline is attributable to advances in our knowledge of the disease's underlying pathophysiology and treatment methods enhancements.[1] Nonetheless, the disease persists even in industrialized nations.[2] Compared to specific adult populations, such as elderly individuals living alone without adequate care, individuals with alcohol dependence, and individuals with psychiatric disorders, the occurrence of scurvy in children is rare. Risk factors include infants who receive evaporated or simmering milk as their primary source of nutrition, those who are fed only meat, and those with dietary restrictions due to other conditions.[3,4]

Vitamin C is known as L-ascorbic acid or ascorbate. It is a crucial vitamin that is soluble in water and necessary for human health. It cannot be generated by the human body due to the lack of a specific enzyme responsible for converting glucose to ascorbic acid via gluconolactone oxidase.[3,5,6] This vitamin serves multiple crucial functions in numerous metabolic reactions.[7] Vitamin C is efficiently absorbed through the gastrointestinal system and exhibits extensive tissue distribution. The process of urinary excretion eliminates the rest. The suggested daily vitamin C intake ranges from 15 to 45 mg for individuals aged 1–13 years and from 65 to 75 mg for those aged 14–18 years.[8]

The spectrum of this disease is relatively wide, consisting of dental, dermatological, musculoskeletal, and even systemic, thus contributing to many misdiagnosis cases.[9] Musculoskeletal symptoms are prevalent in children with scurvy (80%).[10] The rare case and variable symptoms of the clinical signs make scurvy often left out from differential diagnosis. In this study, we presented variable clinical manifestations, radiological features, and the management of scurvy to spread awareness of the disease, which is still being reported from our developing country.

Materials and methods

Our institutional review board approved this investigation. A retrospective chart and radiographic evaluation were conducted on patients who visited our pediatric orthopedic clinics between 2018 and 2023. We examined the medical record for each patient and extracted the following data: patient age, sex, body mass index (BMI), constitutional symptoms, musculoskeletal, mucosal, and cutaneous symptoms, and other comorbidities. We also evaluated the laboratory examination of all patients, including the presence of anemia, increased erythrocyte sedimentation rate (ESR) and/or C-reactive protein (CRP). Males at our institution have a normal hemoglobin range of 10.7–14.7 g/dL, a normal ESR range of 0–10 mm, and a normal CRP range of 0.5 mg/dL.

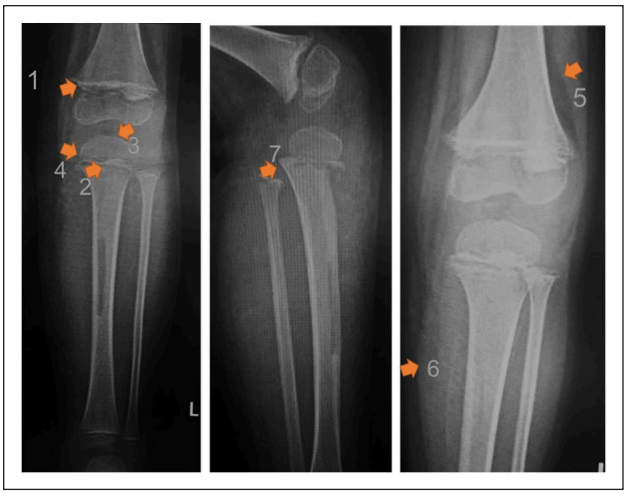

Figure 1. Radiographic findings of scurvy in anteroposterior and lateral radiograph view: 1: Frankel line; 2: Trummerfeld zone (Scorbutic zone); 3: ring epiphysis (Wimberger); 4: Pelkan spur; 5 and 6: periosteal elevation (subperiosteal hemorrhage) with new bone formation; 7: epiphyseal slides.

The evaluations of radiographs and magnetic resonance imaging (MRI) were documented. Wimberger ring, Frankel sign, and the Corner sign (Pelkan's spur) are radiographic findings that indicate scurvy. The Wimberger ring is a white calcification line encircling the epiphyseal centers, giving the shaft a "ground-glass" appearance. At the extremities of the metaphysis, a white line represents the Frankel sign. Scurvy lines or scorbutic zone means transverse bands of decreased density adjacent to the Frankel sign and Corner sign (Pelkan's spur), a lateral metaphyseal spur resulting from infarctions.[11]

Only during the recovery phase of scurvy can paraepiphyseal subperiosteal hemorrhages be detected.[3] A lack of collagen can lead to physiolysis and epiphyseal separations in bones that are structurally fragile and have a diminished capacity to withstand load-bearing stresses or intense muscular tension.[12] Figure 1 provides a comprehensive illustration of radiographic findings. The dosage and duration of vitamin C administration until symptom resolution were then documented and evaluated. In this investigation, descriptive statistical analysis was conducted.

Results

We identified 18 cases of scurvy between 2018 and 2023 referred to our institution. Before being referred to an orthopedic surgeon for evaluation of the findings on musculoskeletal and radiographs, all patients were evaluated by their primary care physicians. This study included 17 males and 1 female, with a median age of 4.5 (2–11) years at presentation. The average BMI was 13.93 ± 0.62 kg/m^2. Nine out of 18 patients (50%) had a low nutritional status.

Patients with a BMI below the fifth percentile for their age, gender, and height were considered underweight. Others (50%) were classified as being of a healthful weight (BMI between the 5th and 85th percentiles). All patients consumed well-prepared food in limited or nonexistent quantities of vegetables and fruits. In addition, UHT (ultra-high temperature) milk supplementation was observed in these patients.

One patient (6%) had an additional congenital cardiac disease disorder, one patient (6%) had a neurogenic bladder, and two patients (11%) had speech and developmental delays. The detailed patient information is presented in Table 1 below.

All patients presented with lower extremity pain (100%), with bilateral involvement predominant (72%). All of the discomfort in the lower limbs was localized around the knee. The agony was constant and unrelated to daily activities. Seventeen patients (94%) refused to walk or sustain weight. Eleven patients (61%) exhibited limb enlargement. One patient (6%) walked with a limp and three (17%) were reticent to move their lower extremities, simulating paralysis. Two patients (11%) had back pain and one (6%) had upper limb discomfort. Seven patients (39%) had a trauma or fall history. Four of these patients (22%) pursued alternative treatment before consulting a physician, a common practice in our country contributing to diagnostic delays. Our study's median onset of diagnosis was 11 (range 4–48) weeks.

Six patients (33%) were diagnosed with mucosal abnormalities, including gum hemorrhage, and five (28%) were diagnosed with gum hypertrophy—6% of patients presented with petechiae or ecchymosis. Six patients (33%) exhibited perifollicular hemorrhage, while five (28%) exhibited corkscrew hairs. Our patients showed constitutional symptoms, including malaise (89%) and irritability (72%). Four patients (24%) exhibited chronic symptoms of appetite loss.

On all patients, radiographs of symptomatic areas were taken. There was subperiosteal hemorrhage in 16 patients (89%). The classic radiographic manifestations of the white line of Frankel were described for all patients (100%). A scorbutic zone was discovered in 17 patients (94%). Wimberger's ring and Pelkan's spur appeared in 13 patients (72%). Four patients (22%) exhibiting both the eponymous symptoms and epiphyseal separation were diagnosed with epiphyseal separation. Before beginning treatment, two patients underwent MRI examinations of the extremity on two separate occasions. Two patients

Table 1. Characteristics of the patients.

Characteristics	Number and percentage of cases (n = 18)	
Age	Median 4.5 (range, 2–11) years	
Sex	Male 17 (94%) female 1 (6%)	
BMI	Mean $13.93 \pm 0.63\,kg/m^2$	
Constitutional symptoms	Poor nutritional status 9 (50%)	Malaise 16 (89%)
	Irritability 13 (72%)	Loss of appetite 4 (24%)
Musculoskeletal symptoms	Lower limb pain 18 (100%), bilateral 13 (72%), and unilateral 5 (28%)	Refusal to walk 17 (94%)
	Swelling 11 (61%)	History of fall 7 (39%)
	History of alternative medicine 4 (22%)	Upper limb pain 1 (6%)
	Back pain 2 (11%)	Paralysis 3 (17%)
		Limping 1 (6%)
Mucosal	Gum hypertrophy 5 (28%)	Gum bleeding 6 (33%)
Cutaneous symptoms	Petechiae/ ecchymosis 1 (6%)	Perifollicular hemorrhage 6 (33%)
	Corkscrew hair 5 (28%)	
Other disorders	Speech and developmental delay 2 (11%)	Congenital heart disease 1 (6%)
	Neurogenic bladder 1 (6%)	
Anemia	Yes 7 (39%)	
Increased ESR and/or CRP	Yes 6 (33%)	
Radiographic findings	Subperiosteal hemorrhage 16 (89%)	Scorbutic zone 17 (94%)
	White line of Frankel 18 (100%)	Wimberger's ring 13 (72%)
	Pelkan's spur 13 (72%)	Epiphyseal slide 4 (22%)
Previous diagnosis	Salter–Harris fracture 3 (17%)	Polyarthritis 1 (6%)
	Juvenile rheumatoid arthritis 1 (6%)	Chronic osteomyelitis 1 (6%)
	Transverse myelitis 2 (11%)	Paralysis/paraplegia 2 (11%)
	Pseudotumor 1 (6%)	Tuberculosis infection 2 (11%)
	Unknown diagnosis 5 (28%)	
Onset of diagnosis until treatment	Median 11 (range 4–48) weeks	
Other invasive procedure	MRI of the extremity 2 (11%), open/closed biopsy 2 (11%)	MRI of the spine 2 (11%)
Duration until resolution	Median 4 (range of 2–16) weeks	

BMI: body mass index; ESR: erythrocyte sedimentation rate; CRP: C-reactive protein; MRI: magnetic resonance imaging.

who were suspected of having transverse myelitis underwent a normal MRI of the spine.

Seven (39%) of our patients had anemia, while six (33%) had elevated ESR and/or CRP levels. Since it was not readily available in our country, only one of our patients had their ascorbic acid levels evaluated prior to beginning treatment. The parents were able to ship the plasma serum abroad and the result came as low value of < 0.1 (reference: 0.4–2.0 mg/dL). After treatment with vitamin C, one patient's serum was analyzed (normal results: 1.1).

In our study, scurvy resembled numerous other conditions. Before referral to our institution, 28% of cases had an unknown diagnosis. Salter–Harris fracture was suspected in three (17%) patients. Infection with tuberculosis (11%), paralysis/paraplegia (11%), transverse myelitis (11%), polyarthritis (6%), adolescent rheumatoid arthritis (6%), chronic osteomyelitis (6%), and pseudotumor (6%). Intriguingly, eight patients were incorrectly diagnosed by other orthopedic surgeons for various reasons before consulting with our institution.

Two patients (11%) had undergone an invasive diagnostic procedure, such as an open or closed biopsy. One of the biopsies revealed a fibro-osseous tumor that had migrated to the medulla and periosteum. A patient suspected of having tuberculosis infection was administered anti-tuberculosis medication for 7 months before scurvy was diagnosed. Two weeks of intravenous antibiotics were given to a patient with suspected chronic osteomyelitis, but no improvement was observed.

All patients were given 100 to 250 mg/day of vitamin C in two doses over the course of 2 weeks, and continued with 50 to 100 mg a day until resolution of the disease (1–3 months). After that, a daily maintenance dose of 30 mg was administered. The duration of treatment ranged from 2 weeks to 6 months, or until complete recovery of clinical symptoms and signs. In our study, the median duration until resolution was 4 weeks (range: 2–16) weeks. After 1 to 3 months of treatment, a second radiograph was taken in series. It demonstrated significant recovery at the location where the previous pathological process had manifested. Figures 2 and 3 illustrate examples of scurvy cases at our institution.

Figure 2 depicted our initial encounter with a 3-year-old boy (BMI = 14.0 kg/m^2 or underweight) who presented with pain, refusal to walk, edema, and corkscrew hairs within the last 3 months. Before referral, it was suspected that he had chronic osteomyelitis, and he had already received 2 weeks of intravenous (IV) antibiotics. His hemoglobin level was 9.2 g/dL, but his ESR and/or CRP levels were normal. His imaging modalities revealed classic symptoms of scurvy, but the MRI suggested osteomyelitis. This patient underwent surgical debridement with intra-operative findings of subperiosteal and intramedullary hematoma, bone formation, and the absence of exudate. After a second review of his clinical and radiographic findings, scurvy was suspected and he was treated with vitamin C. His condition improved within 2 weeks and was completely resolved within 6 weeks.

Figure 3 presents an additional case study example from our investigation. A 4-year-old boy with a BMI of 13.6 kg/m^2 or underweight presented with pain, edema, reluctance to walk, and a 6-month history of trauma. Before referral, he was suspected of having a soft tissue tumor with a differential diagnosis of pseudotumor. There were no laboratory abnormalities detected. On T2-weighted images outside of the tibial shaft (periosteal), the MRI revealed a strong signal intensity. The results of his core needle biopsy were inconclusive. Eventually, scurvy was suspected, and vitamin C treatment was initiated. In a 1-year follow-up, no complaints were found despite a 2-month resolution period.

Discussion

Due to the inability of the human body to synthesize vitamin C, adequate dietary intake is required.[13] During the weaning era, vitamin C-rich fruits and vegetables are typically included in the daily diet. Citrus fruits and vegetables are the greatest sources of vitamin C. Nevertheless, many of these foods can lose their vitamin C content due to cooking, storage, and oxidization.[14] Consideration should be given to vitamin C deficiency in patients with abnormal dietary intake and low nutritional status. In our study, 9 out of 18 (50%) patients had inadequate nutritional status. Indonesia, the fourth most populous country in the globe, continues to struggle with malnutrition. About 17.7% of its more than 88.4 million pediatric population was deemed to be malnourished.[15] Half of our patients were of normal weight. Recent studies have also documented the occurrence of scurvy in healthy "picky eaters" who choose to consume primarily carbohydrates and no vegetables or fruits.[9]

The majority of our patients were male (94%) and their median age at presentation was 4.5 (2–11) years. According to this study, the median age at onset is 42 months, and males are disproportionately affected (74%).[9] Only four (22%) of our patients had additional comorbidities associated with a higher risk of vitamin C deficiency. In previous investigations, 76% of patients with neurological and hematological disorders were found to have scurvy.[9]

Initial symptoms of scurvy include nonspecific symptoms such as irritability, appetite loss, and low-grade fever.[2] In our study, malaise (89%) and irritability (72%) were presented as constitutional symptoms. Four patients (22%) exhibited signs of appetite loss. Mucosal abnormalities may not be typical and may only be observed in patients with inadequate oral hygiene. Bleeding, which is a result of vessel wall fragility, manifested predominantly as petechiae over the extremities, bruises, and hematomas. Bleeding could also occur within the nerve sheaths, resulting in "painful scurvy paralysis."[2] Six patients (33%) were

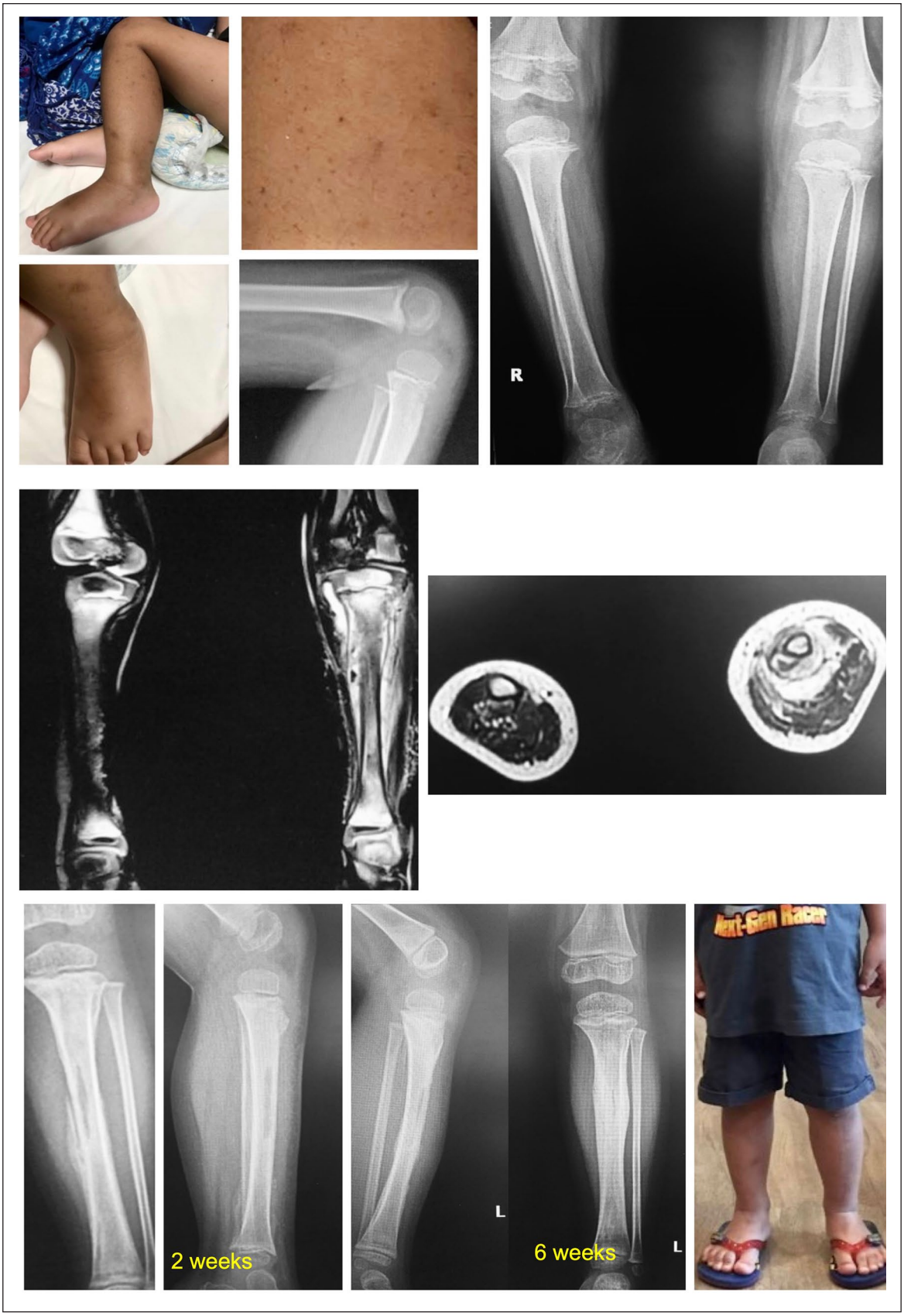

Figure 2. Case example-1.

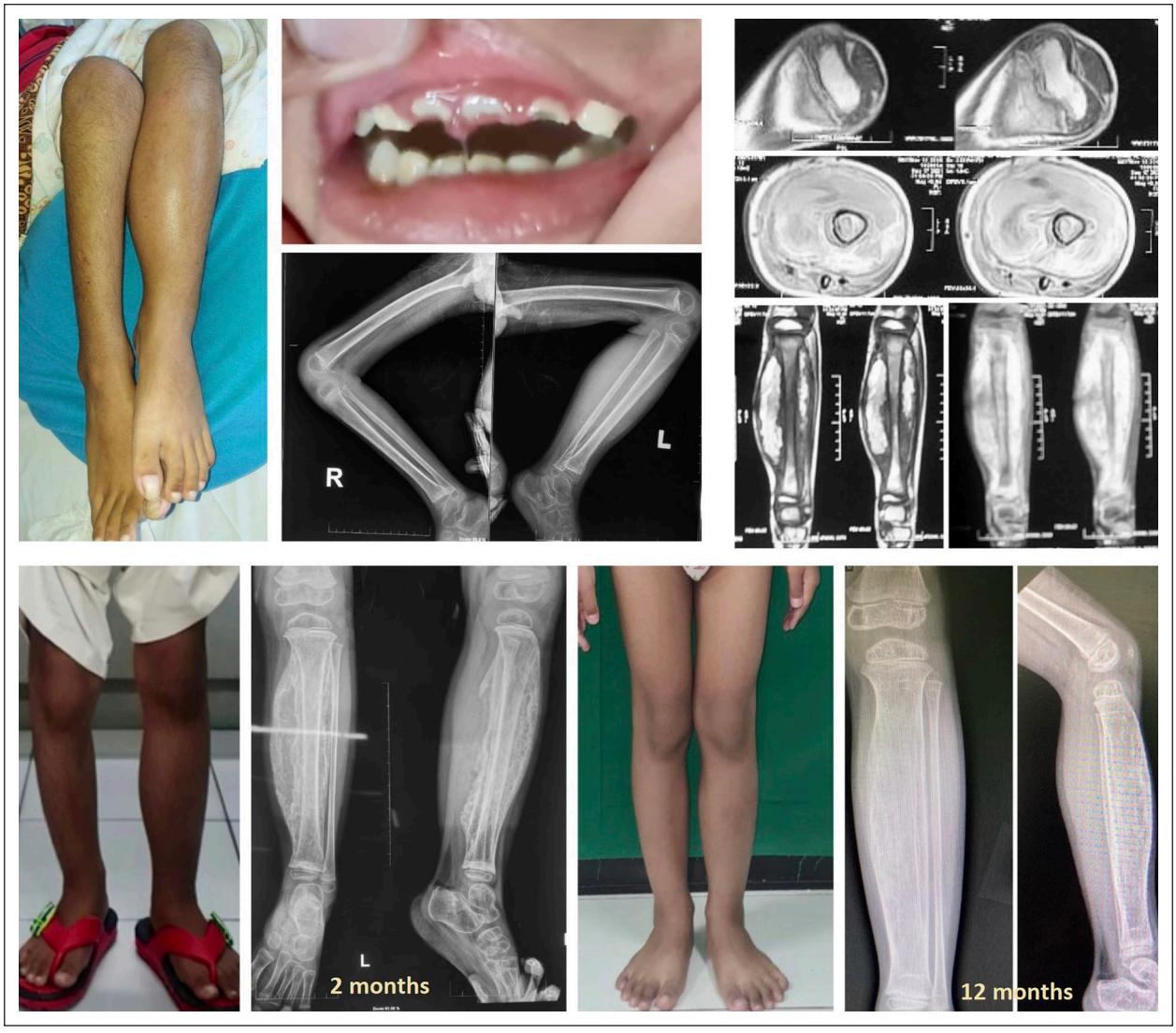

Figure 3. Case example-2.

diagnosed with mucosal abnormalities, including gum hemorrhage, and five patients (28%) were diagnosed with gum hypertrophy. Six percent of patients presented with petechiae or ecchymosis. Six patients (33%) exhibited perifollicular hemorrhage, while five patients (28%) exhibited corkscrew hairs.

Eighty percent of scorbutic cases develop musculoskeletal manifestations as the disease progresses, such as arthralgia, myalgia, limping, inability to bear weight, edema, and muscular hematomas.[16] The most prevalent musculoskeletal manifestations in this investigation were lower limb pain (100%) and refusal to bear weight or walk (94%). Young children are most severely affected by scurvy because their bones are still maturing and the periosteum is not as securely bound to the surface of the cortex as it is in adults.[17,18] A deficiency in vitamin C disrupts the formation of endochondral bone by causing deficient osteoid formation. Mineralization is generally unaffected, resulting in excessive calcification of the provisional zone of calcified cartilage. As a result of osteoid deficiency, however, the bones become frail and easily fractured.[12]

Seven of our patients (39%) had an injury or fall history. Four of these patients (22%), specifically massage therapy, pursued alternative treatment prior to medical consultation. Frequently, scurvy is misdiagnosed because both the patient and the physician are unfamiliar with the disease entity. The median duration of musculoskeletal symptoms in our study was 11 (range 4–48) weeks before medical consultation. Many patients pursued alternative treatment before receiving a definitive diagnosis due to the nonspecific pain. In many Asian countries, massage therapy is renowned for treating a variety of health conditions.[19]

Most diagnostic of scurvy are radiological alterations in the long bones. The bones of a juvenile with scurvy are brittle and easily fractured, frequently accompanied by

robust callus formation.[20] In vitamin C deficiency, the cortical bone becomes thinner, sometimes also referred to as a "pencil-point" cortex. The metaphyseal bone has fewer trabeculae, which, in turn, leads to a decrease in radiopacity that resembles pulverized glass.[21] A white Frankel line is one of the most common radiographic manifestations of scurvy.[16] All patients (100%) exhibited these classic radiographic findings. Scorbutic zone (94%), subperiosteal hemorrhage (89%), Pelkan's spur (72%), and Wimberger's ring (72%) were also observed. Four patients (22%) exhibited epiphyseal separation.

Scurvy laboratory abnormalities are nonspecific. Anemia, which may be hypochromic, normocytic, or macrocytic, is a frequent observation. Although hemorrhage can contribute to anemia, iron and folic acid deficiencies are the primary cause. Folic acid occurs in the same substances as vitamin C and is necessary for iron absorption. Seven (39%) of our patients had anemia. Six patients (33%) had an increase in ESR and/or CRP levels that mimicked an infection-related inflammatory process. The final prognosis is determined by measuring the concentration of ascorbic acid in the serum. Diagnosis of scurvy can be made based on low plasma concentration of vitamin C (< 0.2 mg/dL). Therefore, the most important diagnostic sign is clinical improvement following vitamin C treatment, which occurs between 1 week and 3 months after treatment.[9]

The diagnosis of scurvy is primarily founded on clinical symptoms, radiographic signs on bones, and a history of inadequate consumption of vitamin C. In scurvy, advanced radiographic imaging is not required.[2] In the literature, the MRI findings of scurvy are inadequately described. A frequent finding was diffuse multifocal signal decrease on T1-weighted images and signal increase on T2-weighted images in bone marrow, periosteal, and adjacent soft tissues. However, these findings are frequently nonspecific and may be indicative of hematological malignancies, osteomyelitis, or metastatic disease.[22]

It is not unusual for substantial clinical signs of scurvy to occur in the absence of characteristic radiologic changes. Symptoms that appear to correspond with more common diseases encountered in developed countries continue to contribute to diagnostic confusion. In our study, misdiagnosis was reported frequently. Before being referred to our facility, 13 of our patients (72%) were presumptively diagnosed with a different condition.

The use of up to daily 200 mg of vitamin C orally promotes rapid healing. As healing progresses, vitamin C intake can be decreased to 50 mg daily until full resolution.[23] Our patient exhibited rapid improvement following vitamin C therapy and was able to walk and stand shortly after treatment initiation. The duration of treatment ranged from 2 weeks to 6 months, or until complete recovery of clinical symptoms and signs. Our study's median duration until resolution was 4 weeks (range: 2–16) weeks.

Our study was limited by a small sample size and the fact that ascorbic acid was not readily available in our country, so we were unable to evaluate ascorbic acid levels before treatment initiation. Only clinical and radiological examinations were utilized to identify cases of scurvy.

Conclusion

The diagnosis of scurvy is frequently delayed due to its extreme rarity in modern society and its ability to mimic numerous other conditions. In children presenting with limb pain and reluctance to walk and pathognomonic radiological findings, physicians must prioritize scurvy as a differential diagnosis. In scurvy, vitamin C supplementation is curative.

Author contributions

F.M., I.W.A.M.K, A.A., and E.D. were involved in the conceptualization, methodology, formal analysis and investigation, visualization, writing—original draft preparation, and writing—review and editing of the article; I.W.A.M.K. and E.D. were involved in the project administration; I.W.A.M.K. and A.A. contributed to the resources; and supervision was done by F.M.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Ethical statement

This study was approved by ethical board of Fatmawati General Hospital, Jakarta, Indonesia. All of our patients gave written informed consent before.

ORCID iD

Ali Abdullah https://orcid.org/0000-0003-2971-1060

Data availability

All the data are available and can be accessed via corresponding email after clearly stating the intention and permission to conduct research that requires our data. We used SPSS for Windows version 25 for data analysis.

References

1. Algahtani HA, Abdu AP, Khojah IM, et al. Inability to walk due to scurvy: a forgotten disease. *Ann Saudi Med* 2010; 30(4): 325–328.
2. Fain O. Musculoskeletal manifestations of scurvy. *Jt Bone Spine* 2005; 72(2): 124–128.
3. Weinstein M, Babyn P and Zlotkin S. An orange a day keeps the doctor away: scurvy in the year 2000. *Pediatrics* 2001; 108(3): E55.

4. Deicher R and Hörl WH. Vitamin C in chronic kidney disease and hemodialysis patients. *Kidney Blood Press Res* 2003; 26(2): 100–106.
5. Hornung TC and Biesalski HK. Glut-1 explains the evolutionary advantage of the loss of endogenous vitamin C-synthesis: the electron transfer hypothesis. *Evol Med Public Health* 2019; 2019(1): 221–231.
6. Pearson JF, Pullar JM, Wilson R, et al. Vitamin C status correlates with markers of metabolic and cognitive health in 50-year-olds: findings of the CHALICE cohort study. *Nutrients* 2017; 9(8): 831.
7. Camarena V and Wang G. The epigenetic role of vitamin C in health and disease. *Cell Mol Life Sci* 2016; 73(8): 1645–1658.
8. Kumar V, Choudhury P and Nelson. Nelson textbook of pediatrics: 2008. *Tropical Doctor* 2008; 39: 142.
9. Trapani S, Rubino C, Indolfi G, et al. A narrative review on pediatric scurvy: the last twenty years. *Nutrients* 2022; 14(3): 684.
10. Harknett KM, Hussain SK, Rogers MK, et al. Scurvy mimicking osteomyelitis: case report and review of the literature. *Clin Pediatr* 2014; 53(10): 995–999.
11. Miraj F and Abdullah A. Scurvy: forgotten diagnosis, but still exist. *Int J Surg Case Rep* 2020; 68: 263–266.
12. Nerubay J and Pilderwasser D. Spontaneous bilateral distal femoral physiolysis due to scurvy. *Acta Orthop Scand* 1984; 55(1): 18–20.
13. Aghajanian P, Hall S, Wongworawat MD, et al. The roles and mechanisms of actions of vitamin C in bone: new developments. *J Bone Miner Res* 2015; 30(11): 1945–1955.
14. Carr AC and Lykkesfeldt J. Vitamin C: from bench to bedside. *Nutrients* 2021; 13(4): 1102.
15. Kementerian Kesehatan Republik Indonesia. Basic health research [Riset kesehatan dasar] 2018. Jakarta, 2019, https://repository.badankebijakan.kemkes.go.id/id/eprint/3514/1/Laporan%20Riskesdas%202018%20Nasional.pdf
16. Pan T, Hennrikus EF and Hennrikus WL. Modern day scurvy in pediatric orthopaedics: a forgotten illness. *J Pediatr Orthop* 2021; 41(3): e279–84.
17. Choi SW, Park SW, Kwon YS, et al. MR imaging in a child with scurvy: a case report. *Korean J Radiol* 2007;8(5): 443–447.
18. Ratanachu-Ek S, Sukswai P, Jeerathanyasakun Y, et al. Scurvy in pediatric patients: a review of 28 cases. *J Med Assoc Thai* 2003; 86(Suppl. 3): S734–S740.
19. Seet V, Abdin E, Vaingankar JA, et al. The use of complementary and alternative medicine in a multi-ethnic Asian population: results from the 2016 Singapore mental health study. *BMC Complement Med Ther* 2020; 20(1): 52.
20. Oestreich AE. The acrophysis: a unifying concept for understanding enchondral bone growth and its disorders. *Skeletal Radiol* 2004; 33(3): 119–128.
21. Noordin S, Baloch N, Salat MS, et al. Skeletal manifestations of scurvy: a case report from Dubai. *Case Rep Orthop* 2012; 2012: 624628.
22. Gulko E, Collins LK, Murphy RC, et al. MRI findings in pediatric patients with scurvy. *Skeletal Radiol* 2015; 44(2): 291–297.
23. Levine M, Conry-Cantilena C, Wang Y, et al. Vitamin C pharmacokinetics in healthy volunteers: evidence for a recommended dietary allowance. *Proc Natl Acad Sci* 1996; 93(8): 3704–3709.