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Buletin Sains Kesihatan
Bulletin of Health Sciences

Nutrition and Lifestyle Intervention in a Patient with Polycystic Ovary Syndrome, Obesity, and Dyslipidaemia: A Case Report

Intervensi Nutrisi dan Gaya Hidup bagi Pesakit Menghidap Sindrom Ovari Polikistik, Obesiti, dan Dislipidemia : Sebuah Laporan Kes

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ABSTRACT

This case report presents a 30-year-old Malay woman with Polycystic Ovary Syndrome (PCOS) and obesity (BMI 33.5 kg/m²), referred for dietary management after inconsistent weight outcomes. The patient reported a sedentary lifestyle, emotional distress following her father's passing, and poor dietary habits, including intake of high saturated fats and refined sugars. Biochemical test findings revealed elevated triglycerides, LDL, and total cholesterol levels. A targeted intervention focusing on a calorie-restricted diet (1200–1500 kcal/day), reduction of fat and sugar intake, and increased fibre was implemented alongside gradual physical activity. Follow-up indicated initial improvements, including healthier food choices and moderate physical activity, though adherence challenges persisted. This case highlights the critical role of a multidisciplinary approach in addressing PCOS-related metabolic risks through lifestyle changes, patient-centred support, and regular follow-ups to ensure sustainable health improvements and prevent complications like type 2 diabetes and cardiovascular disease.

Keywords: diet, lifestyle, obesity, PCOS

ABSTRAK

Laporan kes ini membentangkan seorang wanita Melayu berusia 30 tahun dengan Sindrom Ovari Polikistik (PCOS) dan obesiti (BMI 33.5 kg/m²) yang dirujuk untuk pengurusan diet selepas keputusan penurunan berat badan yang tidak konsisten. Pesakit mempunyai gaya hidup sedentari, tekanan emosi selepas kehilangan bapa serta tabiat pemakanan tidak seimbang termasuk pengambilan tinggi lemak tepu dan gula ringkas. Ujian biokimia menunjukkan trigliserida, LDL dan kolesterol total melebihi paras normal. Intervensi pemakanan yang dilaksanakan melibatkan diet terhad kalori (1200–1500 kcal/hari), pengurangan lemak dan gula serta peningkatan pengambilan serat, disertai penambahan aktiviti fizikal secara beransur-ansur. Pemantauan susulan menunjukkan penambahbaikan awal dari segi pilihan makanan lebih sihat dan aktiviti fizikal sederhana, walaupun cabaran terhadap pematuhan diet masih wujud. Kes ini menekankan kepentingan pendekatan multidisiplin dalam menangani risiko metabolik berkaitan PCOS, termasuk penglibatan intervensi pemakanan, aktiviti fizikal, sokongan psikososial dan pemantauan berkala untuk memastikan hasil kesihatan berterusan. Strategi ini juga berpotensi mencegah komplikasi jangka panjang seperti diabetes jenis 2 dan penyakit kardiovaskular.

Kata Kunci: diet, gaya hidup, obesiti, PCOS

INTRODUCTION

Polycystic ovary syndrome (PCOS) is a multifactorial and polygenic endocrine disorder, affecting approximately 15% to 18% of women of reproductive age globally (Fauser et al. 2012). This complex condition is closely associated with hormonal imbalances, insulin resistance, and chronic low-grade inflammation, all of which contribute to a range of metabolic complications. Obesity, particularly visceral adiposity, can worsen

the clinical manifestations of PCOS by worsening insulin sensitivity and amplifying the risk of dyslipidaemia, type 2 diabetes, and cardiovascular diseases. The interplay of these conditions represents a significant public health challenge due to their high prevalence and intricate management requirements.

Insulin resistance plays a central role in the metabolic dysfunctions associated with PCOS, including hypertension, dysglycemia, and dyslipidaemia (Di Meo et al. 2017). Insulin resistance refers to the reduced biological response of target tissues to insulin stimulation. While any tissue with insulin receptors can develop insulin resistance, the liver, skeletal muscle, and adipose tissue are the primary contributors. This condition hampers glucose disposal, leading to a compensatory increase in insulin production by beta cells and resulting in hyperinsulinemia (Nolan et al. 2019). Excess body fat, particularly in the abdominal region, significantly influences the progression of PCOS by worsening insulin resistance.

Although insulin resistance is a common feature in women with PCOS regardless of body weight, obesity amplifies its adverse effects (Tosi et al. 2017). The increase in fat mass, particularly visceral fat, intensifies insulin resistance as adipose tissue is not merely an energy storage site but an active endocrine organ, producing peptide hormones like resistin and leptin, as well as inflammatory cytokines such as interleukin-1 beta (IL-1β) and tumour necrosis factor-alpha (TNF-α) (Makki et al. 2013). Dysfunctional adipocytes in visceral fat further contribute to inflammation and metabolic dysregulation, creating a vicious cycle that worsens the clinical presentation of PCOS. This mechanism not only heightens the risk of type 2 diabetes but also increases the likelihood of pancreatic β-cell dysfunction (Moran et al. 2010). Consequently, women with both PCOS and obesity face a heightened risk of developing metabolic syndrome, characterized by dyslipidaemia, hypertension, and impaired glucose tolerance. The management of PCOS and its associated risks requires a multifaceted approach targeting weight reduction, improvement in insulin sensitivity, and hormonal balance. Lifestyle interventions, including a calorie-controlled diet, regular physical activity, and behavioural modifications, are the key to achieving these goals. Addressing excess adiposity through sustained lifestyle changes can significantly improve insulin sensitivity and alleviate metabolic complications. Early and comprehensive management is crucial for preventing the progression of associated conditions such as type 2 diabetes and cardiovascular disease, thereby improving the long-term health outcomes of individuals with PCOS.

CASE PRESENTATION

CLIENT HISTORY

Patient is a 30 years old, Malay lady, referred to dietitian for obesity management with underlying polycystic ovary syndrome (PCOS). This is her 4th visit to the outpatient clinic with no changes in her dietary and health status. Patient is single and currently living with her mother. She works in an office from 8 am to 5 pm. She is not involved in any other activities outside of work, admitted to practicing a sedentary lifestyle and mostly spends her time at home. The patient's participation in health-promoting activities diminished, which is indicative of adjustment difficulties following bereavement.

ANTHROPOMETRY DATA

The patient's anthropometric measurements were obtained using OMRON HBF-375 body composition monitor and stadiometer. Patient's height was 1.55 meters, and her weight was 85.4 kg. Since her last visit four months ago, she has gained 3.2 kg. Her BMI is 33.5 kg/m², classified as Obese Class 2 based on the Malaysia Management of Obesity Clinical Practice Guidelines (2023). The trends in her weight, body fat percentage, and visceral fat levels during her visits are detailed in Table 1.

The patient initially demonstrated improvements during her second visit but later experienced weight gain and an increase in body fat and visceral fat levels, surpassing her initial recorded data. The body fat percentages exceeded the targeted body fat percentage of 20%-30% in women (Abernathy et al. 1996) and while visceral fat too exceeded the targeted rate of below 10 based on the reference range provided by Omron Healthcare. Upon assessment, the patient reported that her weight loss in May 2024 might be due to a prolonged fever and the subsequent weight gain might be related to stress after her father's passing 4 months ago.

BIOCHEMICAL DATA

Biochemical data was recorded on 17/12/2024 where the patient was tested on fasting serum lipid and HbA1c. The results are as in Table 2. The results indicate dyslipidaemia, with elevated triglycerides, LDL, and total cholesterol levels while the HbA1c level is still in the normal range.

TABLE 1: Anthropometry measurements of the patient

Variable	23/2/2024	10/5/2024	16/8/2024	27/12/2024
Weight (kg)	84.0	79.8 (- 4.2)	82.2 (+ 2.4)	85.4 (+ 3.2)
Body Fat (%)	40.5	39.3 (- 1.2)	39.8 (+ 0.5)	40.9 (+1.1)
Visceral Fat (rate)	17	14.5 (- 2.5)	16 (+ 1.5)	17.5 (+ 1.5)

TABLE 2: Biochemical data of the patient

Test	Baseline	Target	Deviation (%)
Triglyceride (mmol/l)	1.86 (+)	<1.7	+9.1
LDL (mmol/l)	5.84 (+)	<3.80	+53.7
NHDL (mmol/l)	6.69	-	-
HDL (mmol/l)	1.32	>1	-
Total Cholesterol (mmol/l)	8.01 (+)	<5.2	+54.0
HbA1c (%)	5.5	<6.5	-

The results were compared to the reference range set by the hospital. These abnormalities suggest poor dietary management, possibly exacerbated by physiological factors associated with PCOS. As this was her first blood test, no comparisons were made with previous biochemical data. She is not prescribed with any medication for cholesterol management.

NUTRITION-FOCUSED PHYSICAL FINDINGS

The patient reported experiencing intermenstrual bleeding, a symptom she has observed intermittently since 2019. However, she noted that her menstrual cycles have been regular over the past year, which may indicate stabilization of hormonal fluctuations. Despite this, her sedentary lifestyle remains a significant concern, as she spends most of her time at home outside of working hours. Recently, she has also begun experiencing back pain, which started approximately one week ago and may further impede her physical activity levels.

DIET HISTORY

The patient's dietary intake reveals a pattern of high-calorie meals with limited nutritional diversity and frequent consumption of processed or high-fat foods. Nutritional assessment was conducted using Nutritionist Pro™ software to evaluate the patient's dietary patterns and intake composition. Diet history is taken using diet recall method by interviewing the patient. The analysis revealed a mean daily energy intake of 1,978 kcal, with macronutrient distribution comprising 91 g protein (18% of total energy), 180 g carbohydrates (36% of total energy), and 90 g fat (41% of total energy). The proportion of calories derived from fat substantially exceeded current dietary guidelines, which recommend 20-35% of total energy from fat sources.

Micronutrient and fibre analysis demonstrated significant deficiencies. Daily fiber intake ranged between 4-5 g, representing a marked deficit compared to recommended intake levels of 20-30 g/day. Added sugar consumption exhibited temporal variation, averaging 30 g/day on weekdays compared to 2-3 g/day on weekends. Sodium intake consistently exceeded 1,900 mg/day, contributing to the patient's overall cardiovascular risk profile.

Morning meal composition typically included two slices of bread with jam and butter, accompanied by a chocolate-flavored beverage mix, providing approximately 516 kcal while contributing 30 g of added sugars with negligible protein or fibre content. The midday meal, consisting of rice served with fried chicken and coconut-based curry preparations, represented the primary source of sodium intake (>350 mg per serving) while maintaining high energy density. Mid-afternoon snacking patterns included cream biscuits contributing approximately 133 kcal and 22 g of refined carbohydrates, further elevating simple sugar consumption. Evening meals, typically comprising fried rice noodles with half a portion of *nasi ambang* (a traditional mixed rice dish consisting of rice, fried fish, noodles, coconut-based condiments, and salted fish), added approximately 540 kcal with 23 g fat content and minimal fibre contribution.

Weekend dietary patterns demonstrated similar compositional characteristics, with breakfast alternatives such as pancakes and sambal anchovies maintaining elevated fat content (15 g) and moderate

sugar levels (2-3 g) while providing minimal fiber (<3 g per serving). Additional food choices including processed chicken nuggets, instant noodle, and coffee beverages containing sweetened condensed milk further increased saturated fat and added sugar intake.

The comprehensive dietary analysis indicates a pattern characterized by excessive energy density, elevated fat content (particularly saturated fats), predominance of refined carbohydrates, excessive sodium and added sugar consumption, with concurrent severe deficiency in dietary fibre, fresh fruit, and vegetable intake. This nutritional profile demonstrates significant alignment with the patient's clinical presentation of dyslipidemia and polycystic ovary syndrome-associated metabolic dysfunction, suggesting dietary modification as a critical therapeutic intervention target.

The patient's overall dietary habits are characterized by a reliance on energy-dense and highly processed foods, with limited consumption of whole foods, particularly vegetables and fruits. Protein sources are primarily from fried or processed options, and her meals are low in fibre and high in added sugars and fats. She rarely consumes dairy or fortified alternatives, as indicated by her intake of chocolate milk only twice a month. This dietary pattern, combined with a lack of regular physical activity (step count <5000 steps per day), contributes to her current weight status and metabolic imbalances, which include dyslipidaemia and PCOS-associated challenges.

NUTRITION DIAGNOSIS

Excessive energy intake related to limited adjustment to lifestyle changes as evidenced by current dietary intake of 1800-2000 kcal/day exceeding the requirement of 1200-1500 kcal/day.

NUTRITION INTERVENTION

The primary focus of this nutrition intervention was to create a sustainable dietary plan that supports healthy weight loss while addressing the patient's dyslipidaemia and underlying PCOS. The goals for this dietary intervention were to promote a healthy weight loss of 2-4kg in a month (Malaysia Management of Obesity Clinical Practice Guidelines, 2023) and to improve triglyceride, LDL and total cholesterol levels. Based on the same guideline, a diet consists of 1200-1500 kcal/day and 30% of fat allowance daily was prescribed to the patient. This allows up to 800 kcal calorie deficit daily to aid weight loss.

One key aspect of this intervention was reducing sugar intake, which can be essential for both weight management and improving her blood lipid profile. The patient was advised to discontinue the consumption of 3-in-1 drinks, because of their high added sugars content and unnecessary calories. A healthier alternative was prescribed such as low-fat chocolate milk, which provides protein and essential nutrients with low added sugars. Similarly, her afternoon snack of cream biscuits was replaced with plain crackers that were lower in fat and sugar.

Another major dietary adjustment involved increasing her fibre intake, which will not only support satiety and weight loss but also help regulate blood sugar levels and improve lipid metabolism. The patient was recommended to include at least one cup of non-starchy vegetables during lunch and dinner. Vegetables such as spinach, broccoli, tomatoes, and cucumbers can be incorporated into meals as salads, stir-fries, or lightly steamed sides, offering a low-calorie, nutrient-dense addition to the diet. In line with the goal of following a low-fat diet, the type of fat consumed was emphasized. The patient was encouraged to reduce intake of saturated and trans fats commonly found in fried foods, creamy gravies, and processed snacks. Instead, she was recommended healthier fats from sources such as fish, nuts, seeds, and small amounts of olive or canola oil. The patient was recommended to alternate cooking methods such as grilling, steaming, baking, or air-frying instead of deep-frying most of her meals to consume lower fats.

Physical activity is another vital component of this intervention. The patient was advised to gradually increase her physical activity levels to meet the recommended 150 minutes of moderate-intensity exercise per week. Activities such as brisk walking, cycling, or simple home exercises can be incorporated into her routine to promote weight loss, improve cardiovascular health, and enhance overall well-being. By addressing these dietary and lifestyle factors comprehensively, the patient can achieve gradual weight loss, improve her lipid profile, and better manage the symptoms associated with PCOS. Compliance with the intervention plan, combined with regular follow-ups and support can help in achieving our goals.

OUTCOME AND FOLLOW-UP

A follow-up evaluation was conducted one-month post-intervention via digital communication. The patient reported implementing dietary and lifestyle modifications with varying degrees of adherence. She began meal preparation, bringing home-prepared meals to work 2-3 times weekly, including grilled chicken sandwiches and fried rice with chicken breast and vegetables prepared with controlled oil amounts. On days without meal preparation, she continued consuming energy-dense workplace food options due to limited healthier alternatives.

FIGURE 1: Summary of Visit and Follow-up Activity

Current Visit

- Assess weight, diet history, lipid profile and PCOS symptoms.

- Set goals on healthy weight loss (2-4 kg/month) and improvement in lipid profile results.

Follow-up via messaging app

Progress noted:

- - Started meal prepping 2-3 times/week

- - Reduced 3-in-1 drink intake (occasional only)

- - Began 30 minutes home exercise 2x/week

Next Follow-up

- Scheduled for weight measurement and fasting lipid profile test in 3 months.

- Assess adherence and reinforce lifestyle modification upon assessment.

Consumption of 3-in-1 beverage mixes was reduced to occasional intake, primarily on days when breakfast was skipped, representing progress in sugar reduction. The patient also initiated home-based exercise, performing 30-minute sessions twice weekly (total: 60 minutes/week). While this falls below the recommended 150 minutes of moderate-intensity weekly activity, it represents initial progress toward increased physical activity. Weight measurement was not obtained due to lack of home weighing equipment. A comprehensive three-month follow-up appointment was scheduled to assess weight changes and repeat fasting lipid profile evaluation. The patient demonstrated partial adherence to lifestyle interventions with gradual dietary improvements and initiation of regular exercise, indicating that continued monitoring and support are warranted to optimize therapeutic outcomes.

DISCUSSION

The patient's current eating patterns, featuring a high intake of saturated fats and refined sugars combined with inadequate fibre consumption, are contributing to the aggravation of her metabolic issues. These dietary patterns are strongly associated with adverse health outcomes in women with PCOS. A 2017 study analysing the diets of 54 women with PCOS demonstrated that poor dietary habits contribute to metabolic disorders, potentially impairing ovarian function (Szczuko et al. 2017). This is evident in this case, as the patient's fasting serum lipid profile reveals significant abnormalities, including elevated triglycerides, LDL cholesterol, and total cholesterol, indicative of dyslipidaemia. To address these concerns, the patient was prescribed a dietary plan consisting of 1200-1500 kcal per day with 30% of daily caloric intake derived from fat. This prescription aligns with the PCOS management guidelines, which emphasize the importance of promoting healthy lifestyle behaviours in all women with PCOS to achieve or maintain a healthy weight and improve overall health outcomes (Teede et al. 2023). For individuals with excess weight, the guidelines recommend a weight loss target of 5-10%, achieved through an energy deficit of 500-750 kcal per day, which corresponds to the prescribed caloric range.

Findings from multiple studies highlight the significant role of dietary interventions, particularly low-calorie diets, in managing PCOS. Diets such as the Mediterranean and DASH diets, rich in fibre and essential nutrients, further contribute to metabolic and hormonal balance. Research consistently demonstrates that caloric restriction improves insulin sensitivity, reduces hyperandrogenism, and aids in weight loss, all of which are crucial for alleviating PCOS symptoms (Xenou et al. 2021). A study in 2020 by Kazemi et al. found that Mediterranean and DASH diets, rich in fibre, antioxidants, and healthy fats results in improved ovarian morphology, reduced insulin resistance, and regulated follicular development (Kazemi et al. 2020). Furthermore, another case-control study in Italy found that women with PCOS who adhered to a Mediterranean diet exhibited improved insulin resistance and reduced inflammation (Barrea et al. 2019). Similarly, a study in 2015 by Phy et al. reported that a low-starch, dairy-restricted diet led to weight loss, improved insulin sensitivity, and reduced androgen levels, while Shishehgar et al. (2019) showed that hypocaloric diets enhanced menstrual regularity and lowered hyperandrogenaemia (Phy et al. 2015; Shishehgar et al. 2019). These findings highlight the importance of personalized nutritional strategies as a fundamental component of PCOS management.

Physical activity is another crucial component of the management strategy. The guidelines suggest a minimum of 150 minutes per week of moderate-intensity exercise or 75 minutes per week of vigorous-intensity exercise to prevent weight gain. For effective weight loss and prevention of weight regain, this recommendation increases to 250 minutes per week of moderate-intensity exercise or 150 minutes per week of vigorous-intensity exercise (Teede et al. 2023). Incorporating these exercise recommendations, along with dietary and behavioural modifications, forms the cornerstone of lifestyle intervention in PCOS management. The effectiveness of such interventions was supported by evidence from a Cochrane review of 15 randomized controlled trials (RCTs) involving 498 participants. This review found that lifestyle interventions, compared to minimal intervention or usual care, led to significant reductions in weight and body mass index (BMI) (Lim et al. 2019). Furthermore, these interventions also improved metabolic parameters, including reductions in total cholesterol, low-density lipoprotein cholesterol (LDL-C), and fasting insulin. Such metabolic improvements are particularly important for this patient, given her dyslipidaemia and elevated visceral fat levels.

In addition to weight and metabolic benefits, dietary modifications targeting macronutrient quality and balance can also play a role in alleviating PCOS symptoms. For instance, increasing dietary fibre intake and reducing refined sugar consumption may improve insulin sensitivity, regulate blood glucose levels, and support lipid metabolism. Based on a study, the impact of soluble dietary fibre on short-chain fatty acids can be seen where fermentable fibre provides significant metabolic benefits by positively influencing the gut microbiome, leading to the production and release of short-chain fatty acids (Barber et al. 2020). Likewise, shifting fat intake from saturated and trans fats to unsaturated fats, sourced from fish, nuts, seeds, and plant oils, can positively influence cardiovascular risk factors. Behavioural strategies, such as goal setting, self-monitoring, and regular follow-ups, are integral to ensuring adherence to dietary and physical activity recommendations.

A key limitation of this case report is the absence of standardized psychosocial assessment tools during the patient's visits. Although the patient reported emotional distress following bereavement, instruments such as the PHQ-9 for depression or quality of life questionnaires were not administered at the time of assessment. As a result, the psychological impact on dietary adherence and motivation could not be objectively quantified. Future cases would benefit from incorporating validated mental health screening tools alongside dietary and lifestyle evaluations to provide a more comprehensive understanding of patient progress and barriers to adherence. The interplay between dietary changes, physical activity, and behavioural interventions not only addresses the immediate weight and metabolic concerns but also reduces the risk of associated conditions such as type 2 diabetes and cardiovascular disease. For this patient, a comprehensive approach that includes regular monitoring, personalized support, and gradual progression toward these lifestyle targets is essential for sustainable improvement in her health outcomes.

CONCLUSION

In summary, obesity intensifies the metabolic and hormonal disturbances associated with Polycystic Ovary Syndrome (PCOS), through its impact on insulin resistance and the development of comorbidities such as dyslipidaemia, type 2 diabetes, and cardiovascular disease. Effective management therefore requires a comprehensive, multifaceted approach that prioritizes weight reduction and improvements in insulin sensitivity. Sustainable lifestyle interventions, including a calorie-controlled, nutrient-dense diet coupled with regular physical activity, remain the foundation of PCOS care. Evidence indicates that even a modest 5–10% reduction in body weight can yield substantial benefits in insulin sensitivity, lipid regulation, and hormonal balance, thereby reducing long-term metabolic risks. Addressing dietary quality by limiting saturated fats, refined sugars, and processed foods, while promoting fibre-rich foods,

lean proteins, and healthy fats, is central to improving metabolic outcomes. Ultimately, early diagnosis combined with continuous, patient-centred management can help prevent disease progression, enhance metabolic health, and improve the overall quality of life for women living with PCOS.

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Exclusive Enteral Nutrition And The Crohn's Disease Exclusion Diet In The Nutritional Management Of Crohn's Disease

Pemakanan Enteral Eksklusif dan Diet Pengecualian Penyakit Crohn dalam Pengurusan Pemakanan Penyakit Crohn

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ABSTRACT

Crohn's disease is a chronic inflammatory condition affecting the gastrointestinal tract, often leading to serious complications that impact quality of life. Nutritional therapy is increasingly recognized as an important component of management due to its role in inducing remission, improving nutritional status, and supporting growth. This case study aims to describe the nutritional management of a 17-year-old boy with refractory Crohn's disease, growth failure, and iron deficiency anemia. On admission, he presented with significant undernutrition, including a body mass index below the 3rd percentile and 18% weight loss within eight months. Nutritional intervention involved transitioning from a standard to a semi-elemental enteral formula to enhance gastrointestinal tolerance and optimize energy and protein intake. Exclusive enteral nutrition was subsequently initiated as a primary therapeutic strategy, before progressing to a structured exclusion diet tailored to minimize symptom triggers and support long-term disease control. Ongoing monitoring, individualized dietary education, and close follow-up led to notable improvements in weight status, symptom control, and overall nutritional adequacy. This case highlights the effectiveness of structured dietary strategies in the comprehensive management of Crohn's disease, particularly in pediatric patients with growth and nutritional challenges.

Keywords: Crohn's disease, nutritional therapy, enteral nutrition, exclusion diet, pediatric nutrition management.

ABSTRAK

Penyakit Crohn merupakan keadaan keradangan kronik yang menjejaskan saluran gastrousus, dan sering membawa kepada komplikasi serius yang menimpactkan kualiti hidup. Terapi pemakanan semakin diiktiraf sebagai komponen penting dalam pengurusan kerana peranannya dalam menggalakkan pengampunan penyakit, memperbaiki status pemakanan, serta menyokong pertumbuhan. Kajian kes ini bertujuan untuk menerangkan pengurusan pemakanan bagi seorang remaja lelaki berusia 17 tahun dengan penyakit Crohn refraktori, kegagalan tumbesaran, dan anemia kekurangan zat besi. Semasa kemasukan ke hospital, beliau menunjukkan tanda-tanda kekurangan zat pemakanan yang ketara, termasuk indeks jisim badan di bawah persentil ke-3 dan penurunan berat badan sebanyak 18% dalam tempoh lapan bulan. Intervensi pemakanan melibatkan peralihan daripada formula enteral standard kepada formula semi-elemen bagi meningkatkan toleransi gastrousus serta mengoptimumkan pengambilan tenaga dan protein. Pemakanan enteral eksklusif kemudiannya dimulakan sebagai strategi terapeutik utama, sebelum beralih kepada diet pengecualian berstruktur yang disesuaikan untuk meminimumkan pencetus simptom serta menyokong kawalan penyakit jangka panjang. Pemantauan berterusan, pendidikan diet secara individu, dan susulan rapi telah membawa kepada peningkatan ketara dalam status berat badan, kawalan simptom, serta kecukupan pemakanan secara keseluruhan. Kajian kes ini menekankan keberkesanan strategi diet berstruktur

dalam pengurusan menyeluruh penyakit Crohn, khususnya dalam kalangan pesakit pediatrik dengan cabaran tumbesaran dan pemakanan.

INTRODUCTION

Crohn's disease is a long-term inflammatory disorder that primarily affects the gastrointestinal tract, causing lesions that can occur anywhere from the mouth to the anus and potentially leading to complications outside the digestive system. Its prevalence is steadily increasing in both adults and children, and individuals with the condition often present with a variety of symptoms, including persistent diarrhea, abdominal pain, rectal bleeding, fever, unintended weight loss, and chronic fatigue (Veauthier & Hornecker 2018), which collectively impact their overall quality of life. Treatment often involves medication to reduce inflammation and manage symptoms, as well as dietary changes and, in some cases, surgery for severe cases. A dietary approach is crucial to help manage symptoms and improve overall nutritional status. Interest in nutritional therapy for various diseases, including Crohn's disease, has grown, as dietary patterns are linked to the risk of developing the condition and can be modified to influence its progression, with preclinical evidence highlighting how dietary factors affect inflammation, intestinal barrier function, and the gut microbiome (Verburgt et al. 2021).

However, evidence on the practical application of different nutritional strategies in pediatric Crohn's disease, particularly in cases complicated by growth failure and refractory symptoms, remains limited. Reporting individual cases can therefore provide valuable clinical insight into how stepwise dietary interventions may be implemented in real-world settings, as well as their impact on disease outcomes and nutritional recovery. This case study will explore Mr. T, a 17-year-old Malay boy's clinical history, nutritional challenges, and the interventions that aimed to improve his nutritional status and overall well-being, emphasizing the impact of these measures in managing the disease and promoting recovery.

CASE REPORT

Written informed consent was obtained from the patient and legal guardian for the publication of this case report.

PATIENT'S HISTORY

Mr. T, a 17-year-old Malay boy, was admitted to Kuala Lumpur Women and Children Hospital for an Esophagogastroduodenoscopy (OGDS) and colonoscopy on 17/10/2024. He is a Form 5 student in the art stream but has not attended school for two months and is now attending the hospital school. A foster child raised by his maternal aunt since birth, Mr. T's biological mother, aged 35, has two children and no known medical issues. His foster mother, a 51-year-old housewife, has four children, while his 55-year-old foster father, a former lorry driver, has not worked for 10 years due to a pelvic fracture. The family's income comes from two elder sisters and social welfare.

Mr. T has refractory Crohn's disease, diagnosed in December 2018, complicated by a postoperative anastomotic leak, faltering growth, Southeast Asian ovalocytosis with iron deficiency anemia, morphine allergy causing rashes and chest pain, vitamin D insufficiency, and poor medication compliance. From the time of diagnosis, he showed progressive nutritional decline with recurrent weight loss and suboptimal height gain compared to age-appropriate growth expectations. Despite multiple nutritional interventions, including periods of enteral nutrition support and dietary counseling, his weight-for-age and BMI remained below the 3rd percentile, while his linear growth faltered, placing his height-for-age below the 10th percentile. Between 2018 and 2024, he experienced several relapses associated with reduced oral intake, micronutrient deficiencies, and poor adherence to prescribed nutritional regimens, which cumulatively worsened his growth trajectory. His treatment included Ferrous Fumarate 200 mg for iron deficiency, Ascorbic Acid 100 mg for vitamin C, Folic Acid 5 mg, and Thiamine 60 mg. Omeprazole 40 mg injection was used for peptic ulcers and reflux, and Prednisolone 5 mg was given to manage inflammation.

ANTHROPOMETRY

During the initial assessment conducted on 15/10/2024, the recorded weight was 31 kg and his best weight was recorded in February which was 38kg. Mr. T's height was measured at 158 cm that resulted in a Body Mass Index (BMI) of 12.4 kg/m2. By referring to the CDC Growth Charts, Mr. T's weight, height, and BMI are all below the 3rd percentile for his age and gender, indicating significant undernutrition (Figure 1). The ideal body weight (IBW) for his height is 53 kg, at the 50th percentile, these findings underscore the urgent need for targeted nutritional interventions to support Mr. T 's growth and overall nutritional status.
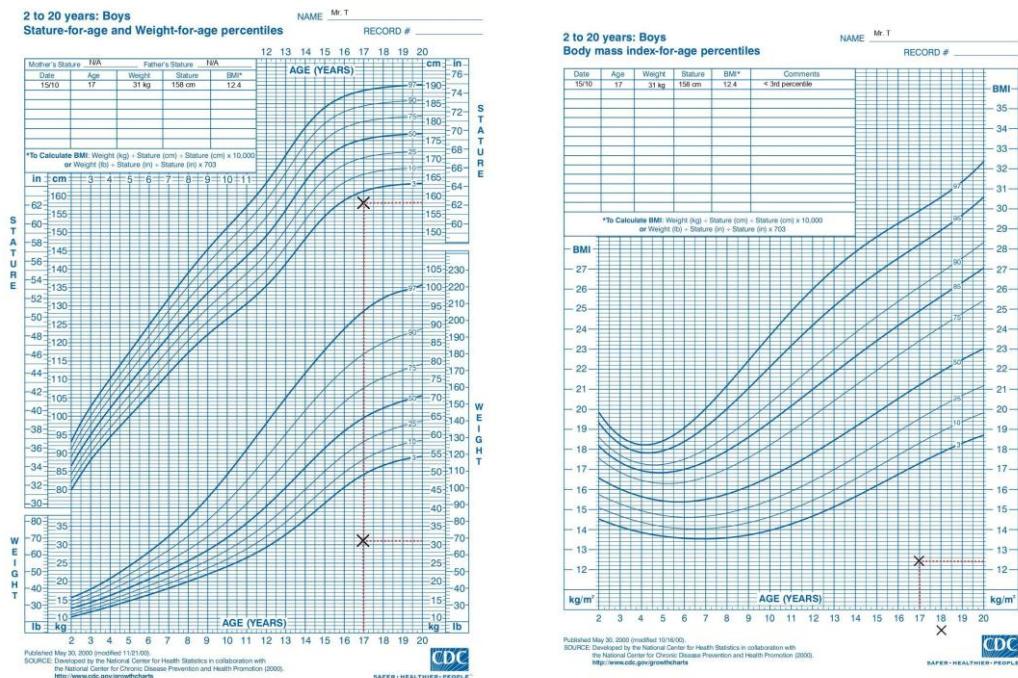
FIGURE 1 The Patient's Growth According to CDC Growth Chart

BIOCHEMICAL DATA

The latest laboratory results obtained on 15th October 2025 revealed several abnormalities relevant to Mr. T's nutritional and clinical status. He presented with hyponatremia (sodium 132 mmol/L), which may indicate fluid imbalance, and hyperkalemia (potassium 5.2 mmol/L), potentially related to dehydration, impaired renal excretion, or medication effects. His creatinine was notably low (31 µmol/L), reflecting reduced muscle mass likely due to chronic illness and undernutrition. Hemoglobin was decreased (11.4 g/dL), consistent with iron deficiency anemia, while serum albumin was also reduced (30 g/L), suggesting protein malnutrition and ongoing inflammation. Importantly, his C-reactive protein was markedly elevated (65.3 mg/L), confirming active inflammatory disease activity. These findings collectively demonstrate the nutritional challenges and active disease burden faced by the patient.

CLINICAL

Mr. T's vital signs were within normal limits, with a temperature of 36.5°C, blood pressure of 107/69 mmHg, and a heart rate of 124 bpm. Mr. T was able to ambulate independently and reported having bowel movements twice a day, with normal stool consistency.

DIETARY ASSESSMENT

Mr. T was on a normal oral diet in addition to nasogastric tube (NGT) feeding. He reported experiencing stomach aches for the past two months, which led to a reduced dietary intake. His estimated energy intake was approximately 1341 kcal/day with suboptimal oral intake. A summary of Mr. T's dietary intake is outlined below:

- Breakfast: 1 small bowl of cereal + 1 packet of full cream milk
- Lunch: Usually skipped due to poor appetite, occasionally only 1 glass of cocoa drink or plain water
- Dinner: 1 slice of bread or 2 tablespoons of rice + Oral Nutrition Support (via NGT): Standard formula, given 4 times per day

Previously, Mr. T was receiving oral nutrition support via NGT feeding at home. He had previously tolerated semi- elemental formula but was switched back to standard formula due to stock issues. During admission, he was able to take only small amounts of porridge orally while mainly relying on oral nutrition support.

At the last intervention, he was prescribed a new feeding regime (every 3 hours, 6 times/day). However, he only managed to trial the regime once after being kept NBM for OGDS. He reported stomach discomfort and loose stool (Bristol type 6), leading to a change back to his previous feeding regime.

TABLE 1 Laboratory Results of Mr. T

Test	Result	Normal Value	Indication
Electrolytes			
Sodium (mmol/L)	132 ↓	138-145	Low sodium could indicate dilutional hyponatremia due to fluid imbalance.
Potassium (mmol/L)	5.2 ↑	3.4-4.7	High potassium may suggest impaired renal excretion, dehydration or potentially influenced by medications.
Chloride (mmol/L)	101	98-107	Normal
Renal Function			
Urea (mmol/L)	3.0	2.60-7.50	Normal
Creatinine (umol/L)	31 ↓	55.0-96.0	Low creatinine may indicate reduced muscle mass which can be seen in patients with chronic disease or malnutrition.
Full Blood Count (FBC)			
Haemoglobin (g/dL)	11.4 ↓	13.5-18.0	Low hemoglobin suggests anemia, which is consistent with iron deficiency anemia.
Inflammatory Marker			
C- Reactive Protein (mg/L)	65.3 ↑	0.0-5.0	Elevated CRP indicates inflammation or infection, potentially related to the patient's chronic inflammatory condition (refractory Crohn's disease).
Protein Status			
Albumin (g/L)	30 ↓	35.0-50.0	Low albumin levels may reflect protein malnutrition, poor nutritional status, or chronic inflammatory conditions, common in patients with Crohn's disease.

NUTRITION DIAGNOSIS

[Resolved] Inadequate enteral nutrition infusion related to feeding optimization in progress as evidenced by current feeding regime only meets 68% of energy requirement.

[Active] Unintended weight loss related to reduced food intake due to stomach ache as evidenced by weight dropped by 7kg in 8 months time (18% of weight loss).

NUTRITION INTERVENTION

The goal of the intervention was to improve Mr. T's nutritional intake by ensuring adequate calorie and protein intake. Mr. T's energy requirement was estimated at 2480 kcal per day, based on 80 kcal per kilogram of body weight, while his protein requirement was 77.5g per day, calculated at 2.5g per kilogram of body weight, as referenced from Dorothy E.M. Francis, Diet for Sick Children

(1987). The intervention involved switching Mr. T's nutrition from a standard formula to a semi-elemental product with 6 scoops mixed with 250 ml of water every 3 hours, 6 times per day, as he reported only being able to tolerate 250 ml per feeding. A semi-elemental formula is easier to digest and absorb, helping reduce gastrointestinal discomfort and ensuring adequate calorie and protein intake. It is especially suitable for patients with compromised digestion, such as those with conditions like Crohn's disease. This regimen provided an estimated 1692 kcal per day (meets 68% of estimated energy requirement) and 75.6 g of protein per day (meets 98% of estimated protein requirement). His feeding tolerance and weight progression would be closely monitored during the next follow-up.

A total of 10 dietetic follow-up sessions from 16th of October to 18th of November have been conducted for Mr. T to closely monitor his progress, assess his nutritional intake, and make necessary adjustments to his dietary plan to support his recovery and overall health. To summarize the follow-up sessions, Mr. T was initially on clear fluid on the first follow-up as for the preparation for an OGDS. On the next follow-up, he started with the planned feeding regime which was a semi elemental formula but reported experiencing stomach discomfort and loose stools (Type 6) , so it was switched to standard formula, which was better tolerated. The doctor then planned to begin exclusive enteral feeding (EEN) and the plan included gradually increasing the dilution, beginning with 7 scoops and gradually increasing to 8 and then 9 scoops every 4 hours with the same volume of water, 250 ml/ feeding. The final regime provided a total of 2360 kcal/ day (meets 94% of estimated energy requirement) and 94.5 g protein/ day (achieves 100% of estimated protein requirement). After he showed improvement with normal stools and no stomach pain, he remained on EEN and the next step was to start the Crohn's Disease Exclusion Diet (CDED), with Mr. T and his mother were educated about it and were given handouts. The CDED diet was ordered for Mr. T in the hospital, noting that only olive oil can be used in cooking and no flour is allowed in the diet. The detailed menu of CDED diet in the hospital was summarized as below:
● Breakfast: Chicken porridge + 1 piece of potato
● Lunch: Rice + Chicken soup + 1 piece of potato + Vegetables (Carrot/ Spinach/ Cucumber/ Tomato) + 1 whole apple
● Dinner: Rice + 2 whole egg (Fried/ full boiled) + Vegetables (Carrot/ Spinach/ Cucumber/ Tomato) + 2 pieces of banana

Mr. T continued with ONS, 9 scoops of standard formula + 250ml of water, three times a day to provide 1180 kcal/ day (48% of estimated energy requirement) and 47.3 g protein/ day (61% of estimated protein requirement). In CDED phase 1, oral nutrition support needs to provide 50% of energy requirement and will then be reduced in phase 2 and phase 3. Initially, Mr. T struggled to finish his meals, but he was encouraged to complete them and as he adapted, he was able to eat well, and the plan was maintained. Education on using Modulife, a comprehensive patient platform that simplifies following the CDED by providing 24/7 expert support and user-friendly tools that offers exclusive features such as tracking tools, tailored recipes and meal plans, unlimited messaging with experts, and on-demand educational resources to enhance patient guidance and support was also provided to Mr. T and his caregiver.

The plan continued during follow-up visits, focusing on supporting adherence to the CDED diet and ONS with some recommendations given to increase his acceptance towards ONS such as trying with other flavours (matcha/ coffee/ wheat/ almond). During the last follow-ups, Mr. T demonstrated full adherence to the CDED diet, and his understanding of the diet, along with that of his caregiver, was confirmed. In summary, the treatment plan shifted to exclusive enteral feeding (EEN) starting with a low dilution and gradually increasing to higher amounts to ensure adequate calorie and protein intake. This step-up approach allowed Mr. T to adjust and reach nutritional goals.

Once he stabilized, he transitioned to the CDED diet, initially struggling to complete meals. However, with encouragement and dietary adjustments, he showed improvement in his intake and overall adherence.

OUTCOME

The outcome for the anthropometry part showed positive signs where Mr. T's weight improved progressively from 31.9 kg at the initial review to 35.3 kg at the last follow-up, reflecting a total weight gain of 3.4 kg in about one month. This weight improvement aligns with the implementation of nutritional interventions, including the introduction of exclusive enteral nutrition (EEN) and gradual incorporation of the Crohn's Disease Exclusion Diet (CDED), which ensured adequate calorie and protein intake. These strategies likely contributed to better nutritional status and weight restoration. Thus, the previous nutrition diagnosis, unintended weight loss was resolved.

On the other hand, the patient's biochemical results after follow-up on 15/10 and 28/10 showed notable improvements. For electrolytes, sodium increased from 132 mmol/L to 140 mmol/L, moving into the normal range (138–145 mmol/L), indicating improvement. Potassium decreased from 5.2 mmol/L (above normal) to 4.3 mmol/L, which is

within the normal range (3.4–4.7 mmol/L), also reflecting improvement. Chloride remained stable and within the normal range, measured at 101 mmol/L and 103 mmol/L (normal: 98–107 mmol/L). Regarding renal function, urea levels increased slightly from 3.0 mmol/L to 4.8 mmol/L, remaining within the normal range (2.6–7.5 mmol/L). Creatinine remained consistently low at 31 µmol/L, below the normal range (55–96 µmol/L). Low creatinine may indicate reduced muscle mass, which can be associated with chronic disease or malnutrition. Moreover, for the full blood count (FBC), hemoglobin showed a slight increase from 11.4 g/dL to 11.6 g/dL, though still below the normal range (13.5–18.0 g/dL). This suggests persistent anemia, likely related to iron deficiency, despite some improvement. The inflammatory marker, C-reactive protein (CRP), demonstrated a significant decrease from 65.3 mg/L to 5.6 mg/L. Although still

slightly elevated compared to the normal reference (0–5 mg/L), this result indicates substantial improvement in inflammation, likely related to the patient's refractory Crohn's disease. Last but not least, the albumin improved from 30 g/L to 33 g/L, but remained below the normal range (35–50 g/L). Persistently low albumin may reflect protein malnutrition, poor nutritional status, or ongoing inflammation, which is commonly seen in patients with Crohn's disease.

Figure 2.0 shows a line graph illustrating the patient's biochemical progression from 15th October to 28th October 2025. In addition, overall, from the first follow-up to the latest summary of clinical data, Mr. T's clinical status showed improvements in vital signs, with temperature remaining stable, blood pressure within a consistent range of 92/54 to 118/72 mmHg, and heart rate
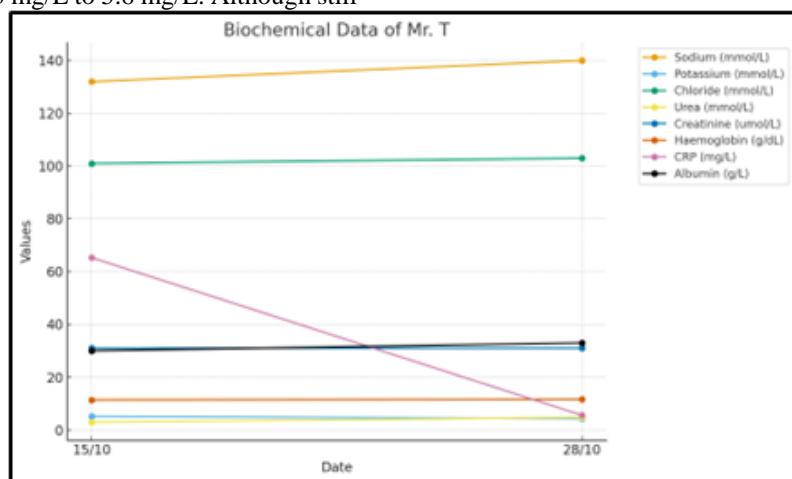

FIGURE 2 Line Graph of The Patient's Biochemical Progression
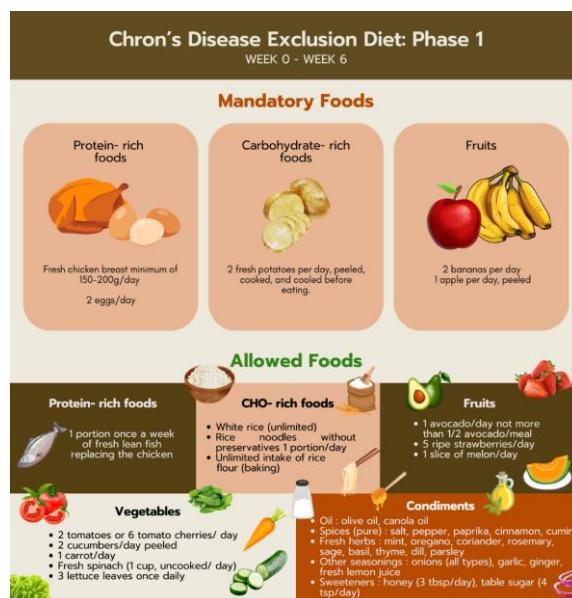
FIGURE 3 Mandatory and Allowed Foods in CDED: Phase

FIGURE 4 Disallowed Foods in CDED: Phase 1

stabilizing between 88–119 bpm. Bowel output also improved from 1-2 times daily with Bristol type 6 to normal stool, type 4, indicating better gastrointestinal function.

DISCUSSION

The use of exclusive enteral nutrition (EEN) as an effective treatment for Crohn's disease (CD) has been well-documented over the past 20 years, involving a nutritionally complete liquid diet replacing solid and other fluids (except water) and serving as the primary induction therapy for remission in newly diagnosed children and adolescents with CD in New Zealand and other countries, typically administered for 8 weeks with gradual volume increase over the first 3 to 4 days based on tolerance and side effects, followed by a slow reintroduction of foods after the treatment period (Adamji & Day 2019). Multiple studies have demonstrated that exclusive enteral nutrition (EEN) is both effective and safe for inducing remission in children with luminal Crohn's disease, leading to its widespread use as the primary treatment after diagnosis. This is also evident in Mr. T's previous treatment when the doctor recommended starting exclusive enteral nutrition (EEN) as part of his management plan, and we can see that Mr. T was able to achieve his nutritional requirements with the planned regime of oral nutritional supplements (ONS).

The European Society for Parenteral and Enteral Nutrition (ESPEN) guidelines suggest that another dietary management, which is the Crohn's Disease Exclusion Diet (CDED) can be considered a potential alternative to EEN for both pediatric and adult patients. The CDED is a three-phase dietary

plan starting with a highly restrictive Phase 1 (weeks 0–6) that eliminates potential triggers while emphasizing high-quality proteins and microbiome-supporting ingredients, followed by a more flexible Phase 2 (weeks 6–12) where restricted foods are gradually reintroduced, and concluding with Phase 3 from week 13 onward for at least nine months, transitioning to a personalized and sustainable dietary approach to enhance long-term adherence (Sigall Boneh et al. 2024). Each phase of the CDED diet includes specific mandatory foods to support gut health and nutritional needs. According to ModuLife, in Phase 1, high-quality protein sources like chicken, eggs, along with carbohydrates- rich food such as potatoes and rice with fruits such as bananas and apples, are essential. This structured approach is why we can see that in Mr. T's planned menu, there is a careful selection of these mandatory foods to support his condition and overall well-being. The figures below show phase one of the CDED diet, which Mr. T was following upon review.

Phase 2 introduces additional options for each food group including fish, oat, whole wheat bread, chickpeas and a wider range of fruits and vegetables. Phase 3, maintenance phase, emphasizes a balanced diet with a mix of these foods tailored to the patient's tolerance and nutritional needs. There is no food that is mandatory in the third phase, but foods that have the potential to cause harm should be controlled or avoided. The dietitian plays an important role in the Crohn's Disease Exclusion Diet (CDED) by designing personalized meal plans, educating patients on food triggers, and monitoring nutritional intake to help manage symptoms and improve overall health. Previous studies have demonstrated that the CDED can induce remission and reduce

objective inflammation markers in pediatric patients (Fliss-Isakov et al. 2023).

CONCLUSION

In conclusion, the use of exclusive enteral nutrition (EEN) and the Crohn's Disease Exclusion Diet (CDED) have shown significant improvements in Mr. T's overall nutritional status. These dietary approaches, combined with careful monitoring and adherence to nutritional guidelines, were key in improving his health and quality of life, aligning with current best practices for managing pediatric Crohn's disease. Key points of learning from this case include the essential role dietitians play in creating, implementing, and adjusting effective dietary plans tailored to individual needs, the importance of patient education and ongoing support in maintaining adherence, and the benefits of a clear, structured approach when managing complex conditions like Crohn's disease. This case study also emphasizes that when nutritional strategies are thoughtfully planned and consistently followed, significant improvements in health, symptoms, and overall well-being can be achieved, showcasing the potential for positive outcomes through targeted, evidence-based dietary interventions.

ACKNOWLEDGEMENTS

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Contrast-Limited Adaptive Histogram Equalisation (CLAHE) as Post Processing Method for Hip Joint Phantom Imaging

Penyamaan Histogram Adaptif Terhad Kontras (CLAHE) sebagai Kaedah Pascapemprosesan untuk Pengimejan Fantom Sendi Pinggul

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ABSTRACT

This work aims to quantitatively analyse diagnostic images and improve the quality via post-processing technique. Metal hip joint phantom images were utilised, with ImageJ as a tool for post-processing and a tool in analysing medical images. Contrast Limited Adaptive Histogram Equalisation (CLAHE) method was performed on metal hip phantom images. Contrast noise ratio (CNR) were calculated for images after CLAHE methods were performed. Data was statistically analysed using SPSS Statistics 20. For all the images, there were negative correlation between noise and kVp adjustment while positive correlation was observed on CNR when mAs was adjusted. The CLAHE method showed an improvement in contrast, though it was not statistically significant (mean CNR difference = 0.011). This suggests potential for enhancing diagnostic image quality using post-processing methods.

Keywords: metal hip joint phantom, image quality, CLAHE, post-processing

ABSTRAK

Kajian ini bertujuan untuk menganalisis imej diagnostik secara kuantitatif dan meningkatkan kualitinya melalui teknik pascapemprosesan. Imej fantom sendi pinggul berlogam telah digunakan, dengan perisian ImageJ sebagai alat pascapemprosesan serta analisis imej perubatan. Kaedah Penyamaan Histogram Adaptif Terhad Kontras (CLAHE) telah diaplikasikan pada imej fantom sendi pinggul berlogam. Nisbah hingar kontras (CNR) dikira bagi imej selepas kaedah CLAHE dilaksanakan. Data dianalisis secara statistik menggunakan SPSS Statistics 20. Bagi semua imej, terdapat korelasi negatif antara hingar dan pelarasan kVp, manakala korelasi positif diperhatikan pada CNR apabila mAs dilaraskan. Kaedah CLAHE menunjukkan peningkatan dalam kontras, namun perbezaannya tidak signifikan secara statistik (perbezaan min CNR = 0.011). Dapatan ini mencadangkan potensi penggunaan kaedah pascapemprosesan dalam meningkatkan kualiti imej diagnostik.

Kata Kunci: fantom sendi pinggul berlogam, kualiti imej, CLAHE, pascapemprosesan

INTRODUCTION

In diagnosing abnormalities or diseases in patients, medical imaging techniques such as general X-rays, computed tomography (CT), magnetic resonance imaging (MRI), positron emission tomography (PET), and ultrasound (US) are commonly employed (Abhisheka et al. 2024). The interpretation and analysis of these images play a crucial role in ensuring accurate diagnosis and effective treatment. Medical image processing is often utilised to enhance the clarity and interpretability of medical images, which may involve improving visualisation through image enhancement, (Rifai et al. 2024) or extracting

relevant information, either manually or through automated techniques. Contrast-limited adaptive histogram equalisation (CLAHE) can be applied to medical images to enhance contrast, addressing common issues such as noise and intensity inhomogeneity (Mahmoudi et al. 2022). By enhancing visualisation and extracting critical diagnostic information, post-processing plays a vital role in ensuring precise and reliable medical assessments.

Medical image analysis can be categorised into quantitative and qualitative approaches. Quantitative analysis involves objective measurements and calculations, such as assessing contrast, noise levels, contrast-to-noise ratio (CNR), and signal-to-noise ratio (SNR), (Hokamura et al. 2024) along with various other metrics related to pixel intensity and image quality. These numerical evaluations help in standardising image assessment, ensuring consistency, and facilitating comparisons across different imaging modalities. On the other hand, qualitative analysis relies on subjective interpretation by radiologists or medical professionals to assess image clarity (Li et al. 2024), anatomical structures, and pathological findings. When image quality is suboptimal, various image enhancement techniques, such as noise reduction, contrast adjustment, and edge enhancement, can be applied to improve the diagnostic value. These enhancements help in better visualisation of critical structures, allowing for more accurate detection and characterisation of abnormalities, ultimately supporting more effective diagnosis and treatment planning.

Post-processing in diagnostic imaging refers to the enhancement and analysis of medical images after acquisition to improve their interpretability and diagnostic accuracy. This process involves various techniques such as contrast adjustment, noise reduction, edge enhancement, and reconstruction algorithms (Hussain et al. 2024) to optimise image quality. Advanced methods, including 3D reconstruction, further aid in detecting abnormalities and improving clinical decision-making. Post-processing is particularly essential in modalities like CT, MRI, and PET, where raw images may require refinement to highlight specific anatomical structures or pathological findings. In this study, CLAHE is applied to analyse hip phantom images using ImageJ version 1.51j8. The effectiveness of contrast enhancement is then evaluated on the processed images following the application of CLAHE.

MATERIALS AND METHODS

In this study, all metal hip phantom images were converted to 8-bit format. A total of nine images were acquired using different kVp and mAs settings. The metal hip joint phantom was constructed using white cement to simulate human bone, stainless steel to represent the metal implant, and Perspex along with water, as their densities closely match human tissues. The images were captured at 40, 70, and 100 kVp, which are commonly used parameters for metal hip joint imaging. The selection of materials was based on their density, with white cement having a density of 2.33 g/cm³, closely resembling human bone. Perspex, with a density of 1.19 g/cm³, closely matches soft tissue density as referenced in ICRU-44. Water, with a density of 1.0 g/cm³, was used as a tissue-equivalent material. Table 1 lists the different acquisition parameters and images of hip joint phantom.

ImageJ version 1.51j8 was used for image post-processing. The region of interest (ROI) was selected to determine pixel intensity. The mean and standard deviation calculated from each ROI were recorded. The histogram and pixel data of the entire image were obtained using ImageJ. Pixel data for specific areas of interest were also measured with the software. All these measurements were conducted by the same operator to ensure consistency. ImageJ plugins were utilised for image enhancement, specifically contrast-limited adaptive histogram equalization (CLAHE). Figure 1 illustrates the example of histogram in ImageJ.

RESULTS AND DISCUSSION
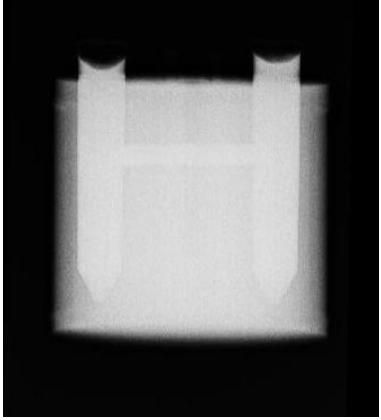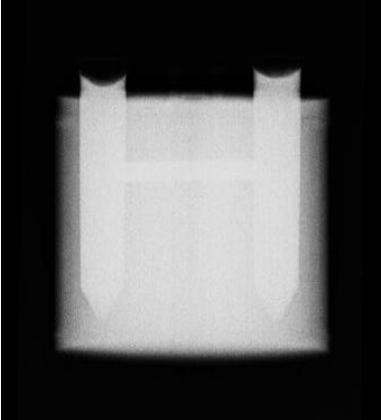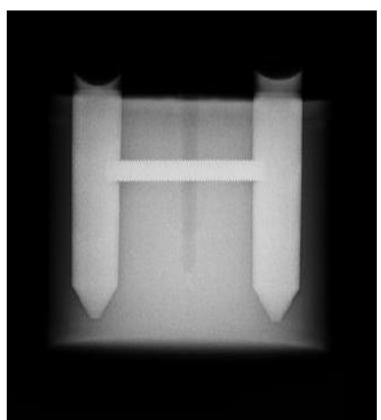
The acquisition parameters utilised for metal hip joint phantom were 40, 70, and 100 kVp, along with 10, 50, and 80 mAs. The image quality parameters analysed in this study included noise and contrast-to-noise ratio (CNR). Table 2 presents the noise and CNR values for the original hip phantom images. Figure 2 depicts the relationship between noise and kVp at a constant mAs, while Figure 3 illustrates the variation of CNR with mAs at a constant kVp for the hip phantom images.

The results indicate that at a constant kVp, an increase in mAs led to a corresponding increase in CNR. A positive correlation was observed, as determined through Pearson correlation analysis using SPSS, as illustrated in Figure 4. This finding aligns with previous research, which similarly reported that higher technical factor settings contribute to an increase in CNR values in medical images (Pauwels et al. 2014). CLAHE was employed as a post-processing technique to enhance contrast in hip phantom images. This study evaluated image quality by calculating contrast and CNR. Figure 5 presents the raw hip phantom images alongside those processed with CLAHE. Table 3 summarises the contrast values prior to enhancement, while Table 4 provides the contrast values after applying CLAHE. A paired sample t-test was conducted to compare the mean contrast values before and after applying CLAHE. The analysis revealed a mean difference of 0.011.

While the tabulated data indicated an increase in contrast, the results from the paired sample t-test using SPSS showed that this increase was not statistically significant, likely due to the limited sample size. Nevertheless, CLAHE proved to be an acceptable method for enhancing the bone-metal contrast, as qualitative assessment demonstrated noticeable improvement in image contrast, despite the lack of statistical significance. Previous study reported that CLAHE-enhanced images exhibit finer details, making them more suitable for diagnostic purposes (Mansour & Gaheen 2024)..

TABLE 1 List of different acquisition parameters and images of hip joint phantom.

No.	Images	kVp	mAs
1		40	10
2		40	50
3		40	80
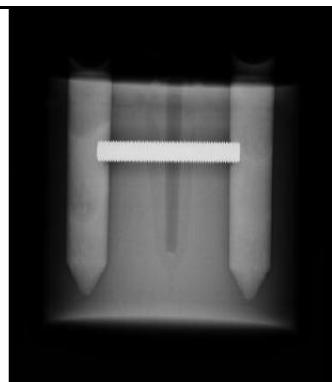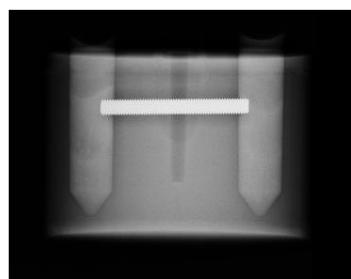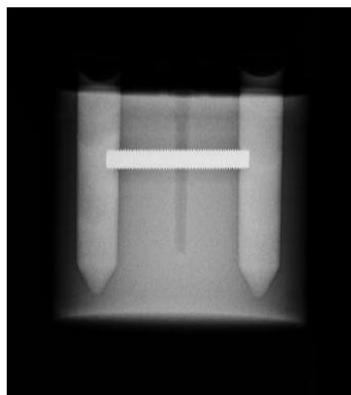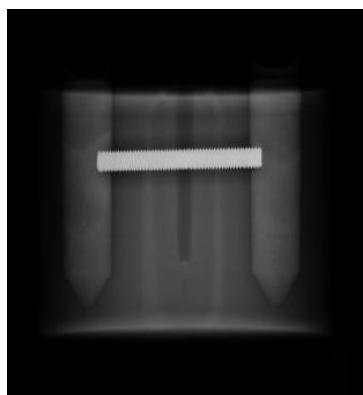
4		70	10
5		70	50
6		70	80
7		100	10
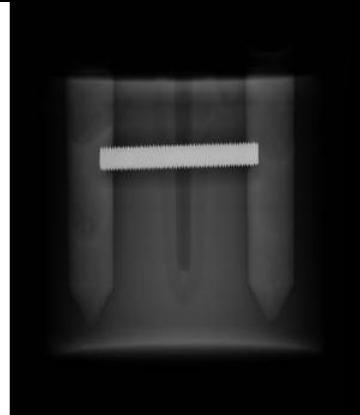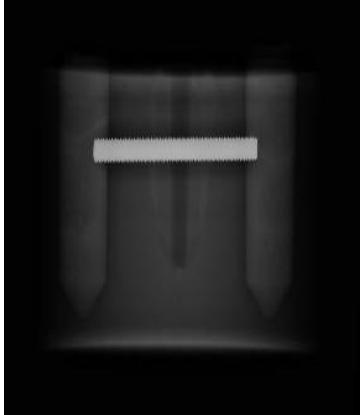
8		100	50
9		100	80

TABLE 2 Noise and CNR for the original hip phantom images.

No	kVp	mAs	Noise	Contrast to noise ratio
1	40	10	74.385	0.912
2	40	50	74.615	0.483
3	40	80	56.821	0.246
4	70	10	41.848	1.335
5	70	50	51.146	0.536
6	70	80	47.477	2.707
7	100	10	26.345	1.263
8	100	50	24.280	0.511
9	100	80	20.447	0.514
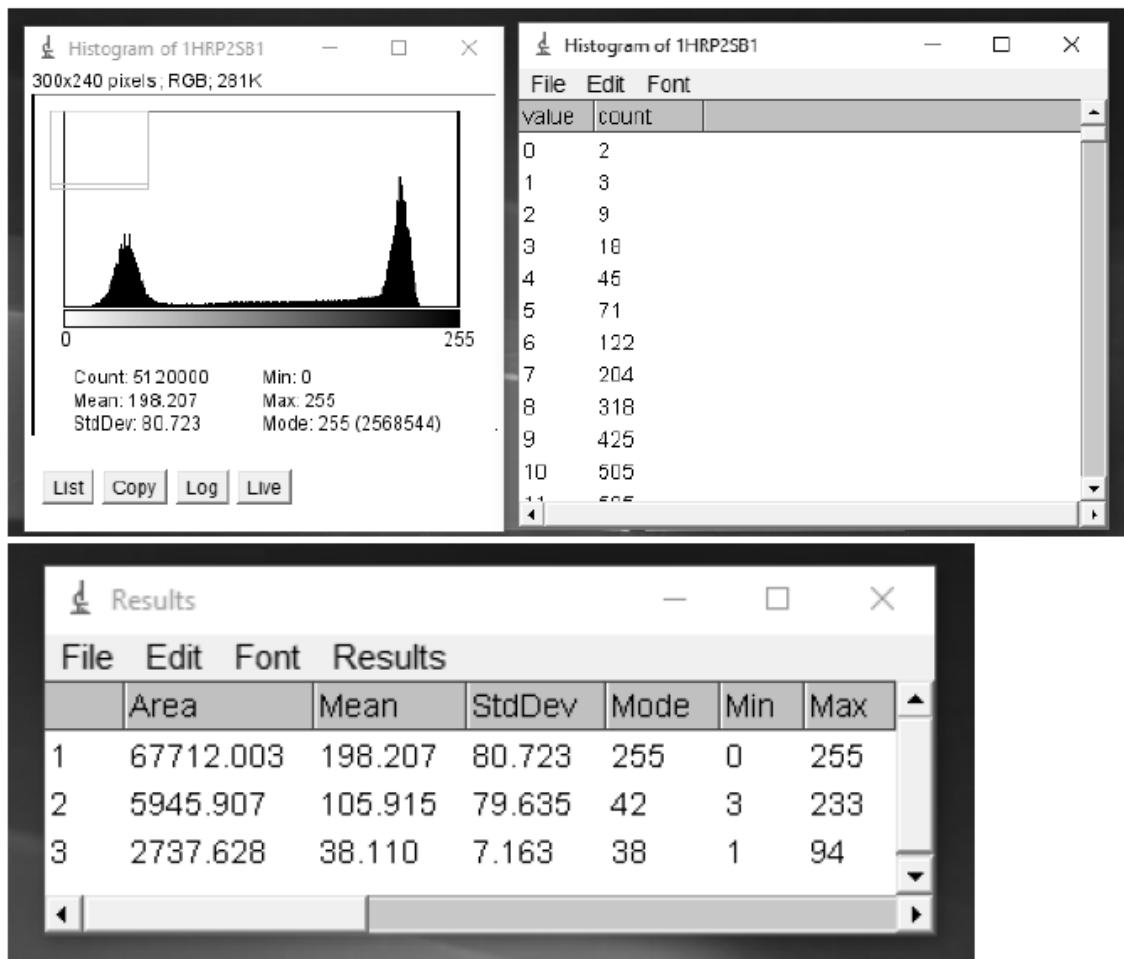
FIGURE 1 ImageJ Display of Pixel Intensity and Histogram.
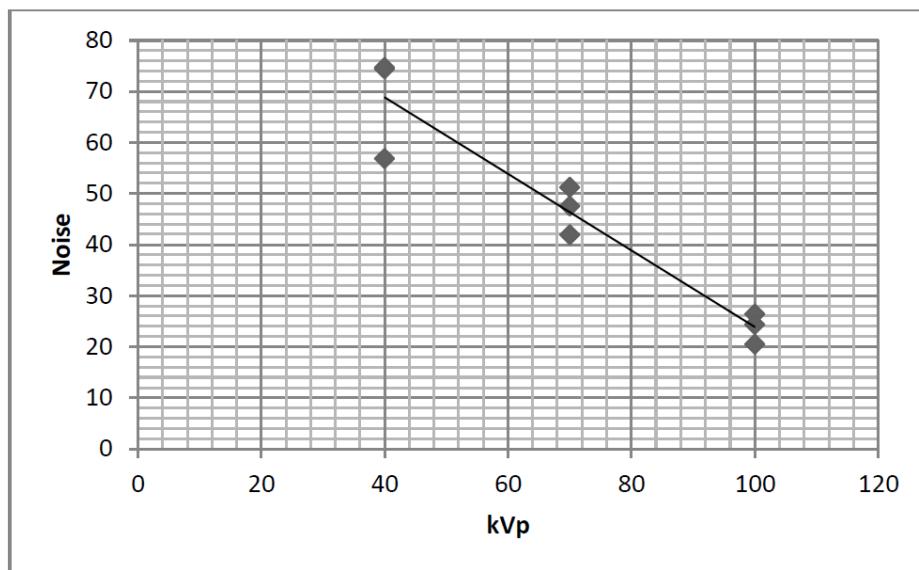
FIGURE 2 Noise versus kVp at constant mAs in original hip phantom images
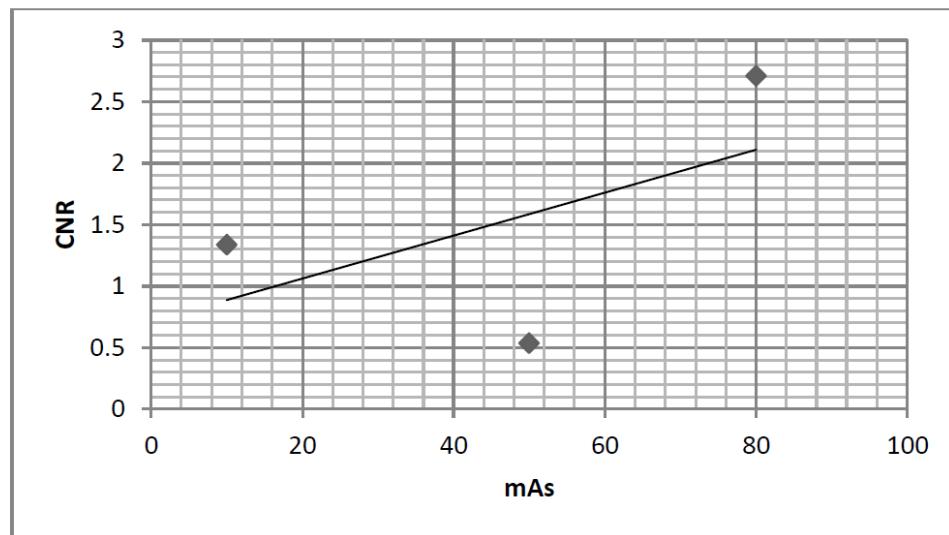
FIGURE 3 CNR versus mAs at constant kVp of original hip phantom images

		mAs	CNR
mAs	Pearson Correlation	1	.558
	Sig. (1-tailed)		.311
	N	3	3
CNR	Pearson Correlation	.558	1
	Sig. (1-tailed)	.311	
	N	3	3

FIGURE 4 Pearson correlation of image's CNR with mAs at constant kVp

A

B

C

D
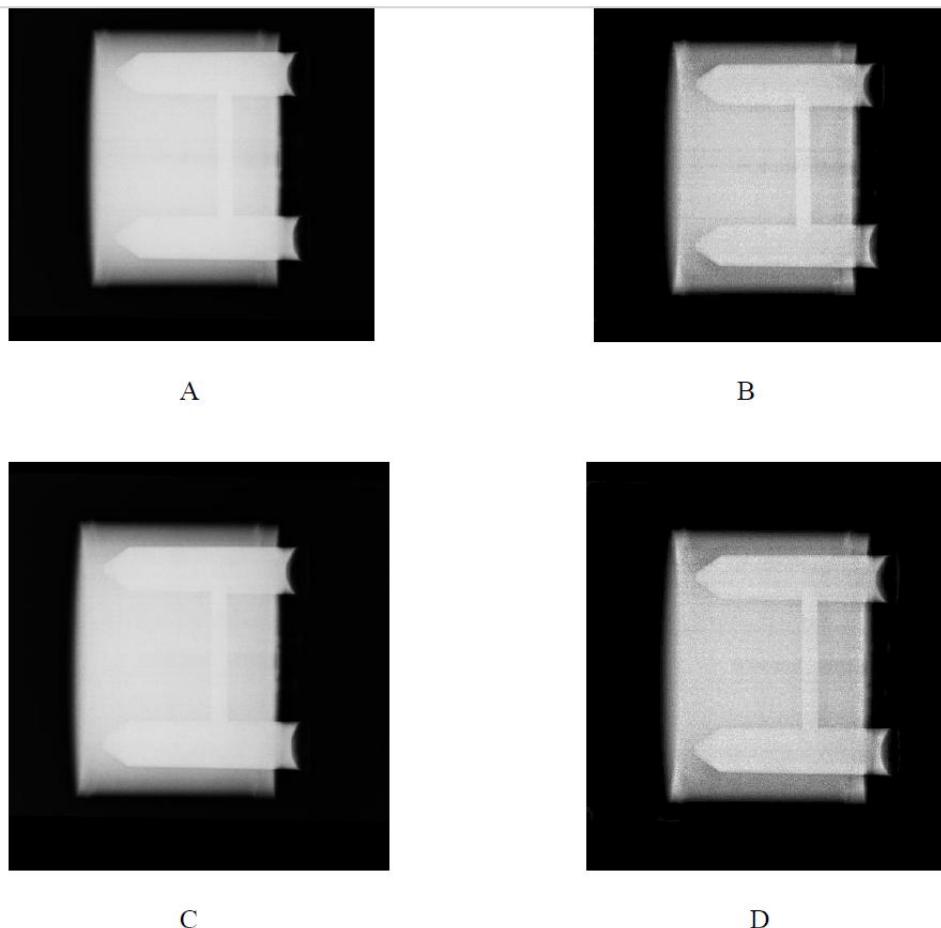
FIGURE 5 (A) The raw image of hip phantom (40kVp, 10mAs), (B) is the image after CLAHE, (C) is the raw image of hip phantom (40kVp, 50mAs), (D) is the image after CLAHE

TABLE 3 Contrast value before enhancement with CLAHE.

Image	Contrast (bone - steel)	ROI selection	Contrast (soft tissue - air)	ROI selection
A	0.006	Image 1 & 5	0.035	Image 3 & 7
C	0.012	Image 2 & 6	0.001	Image 4 & 8

TABLE 4 Contrast value after enhancement with CLAHE

Image	Contrast (bone - steel)	ROI selection	Contrast (soft tissue - air)	ROI selection
B	0.014	Image 1 & 5	0.006	Image 3 & 7
D	0.028	Image 2 & 6	0.049	Image 4 & 8

Previous research by (Acharya et al. 2018) demonstrated that CLAHE enhances images by processing small tiles (8 × 8 pixels) and utilising bilinear interpolation to blend neighbouring tiles, thereby eliminating boundaries, equalising intensity, and improving contrast. Similarly, other studies have also reported that CLAHE effectively enhances image contrast. Previous studies have demonstrated the effectiveness of CLAHE in assigning displayed intensity levels, particularly in chest CT scans (Mahmoudi et al. 2022). Various histogram techniques can be utilised to enhance radiograph contrast, helping to overcome challenges faced by physicians during image analysis. These techniques offer valuable tools for physicians and medical professionals across multiple specialties beyond radiology. Additionally, exploring alternative image enhancement algorithms and evaluating existing methods through current research on different types of medical images can further improve diagnostic accuracy.

CONCLUSION

In conclusion, the image quality of hip phantom images was enhanced in this study. For metal hip joint images, the mean difference before and after histogram equalisation was 0.011. This finding highlights the potential of post-processing techniques in improving the overall quality of diagnostic images, suggesting possible value in clinical applications for better visualisation of structures affected by metal implants without the need for additional radiation dose.

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Effects of Whole-Body Vibration Training as an Adjunct to Rehabilitation Exercise in Knee Osteoarthritis: A Protocol for Systematic Review and Meta-Analysis

Kesan Latihan Getaran Seluruh Badan sebagai Tambahan kepada Senaman Pemulihan dalam Osteoartritis Lutut: Protokol untuk Ulasan Sistematik dan Meta-Analisis

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ABSTRACT

Knee osteoarthritis (KOA) poses significant challenges, causing substantial impairment, disability, and healthcare costs. Whole-body vibration training (WBVT) is being explored as a potential treatment for KOA, but its efficacy remains uncertain due to inconsistent clinical evidence. This review aims to synthesize existing literature on the effects of WBVT as a supplementary intervention alongside conventional rehabilitation exercises in KOA management. The inclusion criteria encompass clinical trials investigating the combined effects of WBVT and rehabilitation exercises in KOA, published in either English or Chinese. Eligible trials will be identified through systematic searches across eight electronic databases, including PubMed, Web of Science, Embase, PEDro, SPORTDiscus, Scopus, ScienceDirect, and the China National Knowledge Infrastructure, from inception to May 2024. Data extraction will focus on WBVT parameters, rehabilitation exercises, and primary outcomes. Methodological quality will be assessed using the PEDro scale and Cochrane's risk of bias assessment. Meta-analysis utilizing RevManager software will synthesize continuous data on pain, physical function, and disability, presented via forest plots. This study seeks to comprehensively elucidate the synergistic effects of WBVT combined with rehabilitation exercises in KOA, a departure from previous reviews concentrating solely on WBVT effects. The findings aim to validate WBVT programs and assist healthcare practitioners in selecting optimal rehabilitation strategies for KOA management. Research outcomes will be disseminated in a peer-reviewed journal, with any methodological modifications explicitly addressed. This review will provide comprehensive evidence on the synergistic effects of WBVT combined with conventional rehabilitation exercises in KOA management. The findings are expected to support evidence-based integration of WBVT into clinical practice and guide healthcare practitioners in optimizing rehabilitation strategies.

Keywords: Exercise, Knee osteoarthritis, Meta-analysis, Rehabilitation, Systematic review, Whole-body vibration training

ABSTRAK

Osteoartritis lutut (KOA) menimbulkan cabaran besar kerana menyebabkan kerosakan fungsi, kecacatan, serta peningkatan kos penjagaan kesihatan. Latihan getaran seluruh badan (WBVT) sedang diterokai sebagai satu kaedah rawatan berpotensi untuk KOA, namun keberkesanannya masih tidak jelas berikutan bukti klinikal yang tidak konsisten. Ulasan ini bertujuan untuk mensintesis literatur sedia ada mengenai kesan WBVT sebagai intervensi tambahan bersama senaman pemulihan konvensional dalam pengurusan KOA. Kriteria inklusi merangkumi ujian klinikal yang menilai kesan gabungan WBVT dan senaman pemulihan dalam KOA, diterbitkan

dalam bahasa Inggeris atau Cina. Artikel yang sesuai akan dikenal pasti melalui carian sistematik dalam lapan pangkalan data elektronik iaitu PubMed, Web of Science, Embase, PEDro, SPORTDiscus, Scopus, ScienceDirect, dan China National Knowledge Infrastructure, dari awal penerbitan sehingga Mei 2024. Pengekstrakan data akan menumpukan pada parameter WBVT, senaman pemulihan, serta hasil utama. Kualiti metodologi akan dinilai menggunakan skala PEDro dan penilaian risiko bias Cochrane. Meta-analisis menggunakan perisian RevManager akan mensintesis data berterusan mengenai kesakitan, fungsi fizikal, dan kecacatan yang dipersembahkan melalui plot hutan. Kajian ini bertujuan untuk menjelaskan secara menyeluruh kesan sinergistik WBVT yang digabungkan dengan senaman pemulihan dalam pengurusan KOA, berbeza daripada ulasan terdahulu yang hanya menumpukan kepada kesan WBVT semata-mata. Penemuan ini dijangka dapat menyokong pengesahan program WBVT serta membantu pengamal kesihatan memilih strategi pemulihan yang optimum untuk pengurusan KOA. Hasil penyelidikan akan disebarkan dalam jurnal berwasit, dengan sebarang pengubahsuaian metodologi akan dilaporkan dengan jelas.

Kata kunci: Senaman, Osteoartritis lutut, Meta-analisis, Pemulihan, Ulasan sistematik, Latihan getaran seluruh badan

INTRODUCTION

Knee osteoarthritis (KOA) poses a significant health challenge (Peat & Thomas 2021), characterized by the progressive degeneration of knee joints, primarily due to wear and tear leading to the gradual loss of articular cartilage (Du et al. 2023). The primary symptoms of KOA include knee pain, swelling, limited mobility, stiffness, and functional impairment (Ahmad et al. 2018), all of which significantly impact daily activities and diminish the overall quality of life (Du et al. 2023). Globally, KOA has a reported prevalence of 16.0% and an incidence rate of 203 per 10,000 person-years, indicating a concerning trend (Cui et al. 2020). With the increasing prevalence of KOA worldwide, it imposes a substantial burden on individuals, healthcare systems, and society as a whole (Ackerman et al. 2019), emphasizing the urgent need for effective management strategies (Peat & Thomas 2021). Despite employing various modalities such as medication, physical therapy, and exercise in KOA management, achieving optimal outcomes remains challenging (Ahmad et al. 2022; Peat & Thomas 2021). Among the emerging therapies, whole-body vibration training (WBVT) has garnered attention due to its potential to enhance muscle function, aid in rehabilitation, and reduce the risk of sports-related injuries (Qiu et al. 2022; Wang et al. 2022).

Theoretically, WBVT entails utilizing motor-driven vibrating platforms, which transmit energy through the body, inducing changes in the length of the muscle-tendon complex and eliciting reflexive muscle contractions (Aminian-Far et al. 2011; Park et al. 2015). The mechanism behind WBVT is intricate, encompassing several physiological responses, including but not limited to: (i) induction of rapid muscle contractions through vibration stimuli, activating both voluntary and involuntary muscle fibers, thereby augmenting muscle activation compared to static exercise (Park et al. 2015); (ii) facilitation of motor unit recruitment and synchronization, fostering motor learning and neural adaptations, thus enhancing muscle performance (Aminian-Far et al. 2011; Park et al. 2015); (iii) elevation of growth hormone levels and reduction in cortisol levels (Park et al. 2015); and (iv) imposition of mechanical stress on bones, stimulating bone remodeling processes (Park et al. 2015). Its application in musculoskeletal disorders, including KOA, is increasingly explored (Wang et al. 2022). However, despite growing interest, the clinical efficacy of WBVT remains uncertain, with conflicting findings reported in recent randomized controlled trials. While some studies have demonstrated positive effects on pain (Wang et al. 2022), physical function, and disability (Zhang et al. 2021), others have shown no significant difference compared to conventional exercise interventions (Aggarwal et al. 2020; Bokaeian et al. 2016; Fernandes et al. 2020).

Existing systematic reviews have addressed the efficacy of WBVT in KOA (Li et al. 2015; Qiu et al. 2022; Wang et al. 2022); however, most have focused solely on its isolated effects without considering its integration with conventional rehabilitation exercises, which are the cornerstone of conservative KOA treatment. Moreover, methodological limitations and heterogeneity in WBVT protocols across studies have raised questions about the reliability and generalizability of findings (Imrey 2020). For instance, this study acknowledges a systematic review and meta-analysis conducted by Qiu et al. (2022), which encompassed five databases and analyzed 14 trials (Qiu et al. 2022). Their findings indicated that WBVT had additional positive effects on pain, knee extensor muscle strength, and physical function in KOA (Qiu et al. 2022). However, it's important to recognize that the control groups across the individual trials exhibited variations, and the review did not specifically address the impact of rehabilitation exercise, which is considered the primary recommended conservative treatment (Bannuru et al. 2019; Collins et al. 2019; Peat & Thomas 2021). Consequently, the differences in control groups may influence the outcomes,
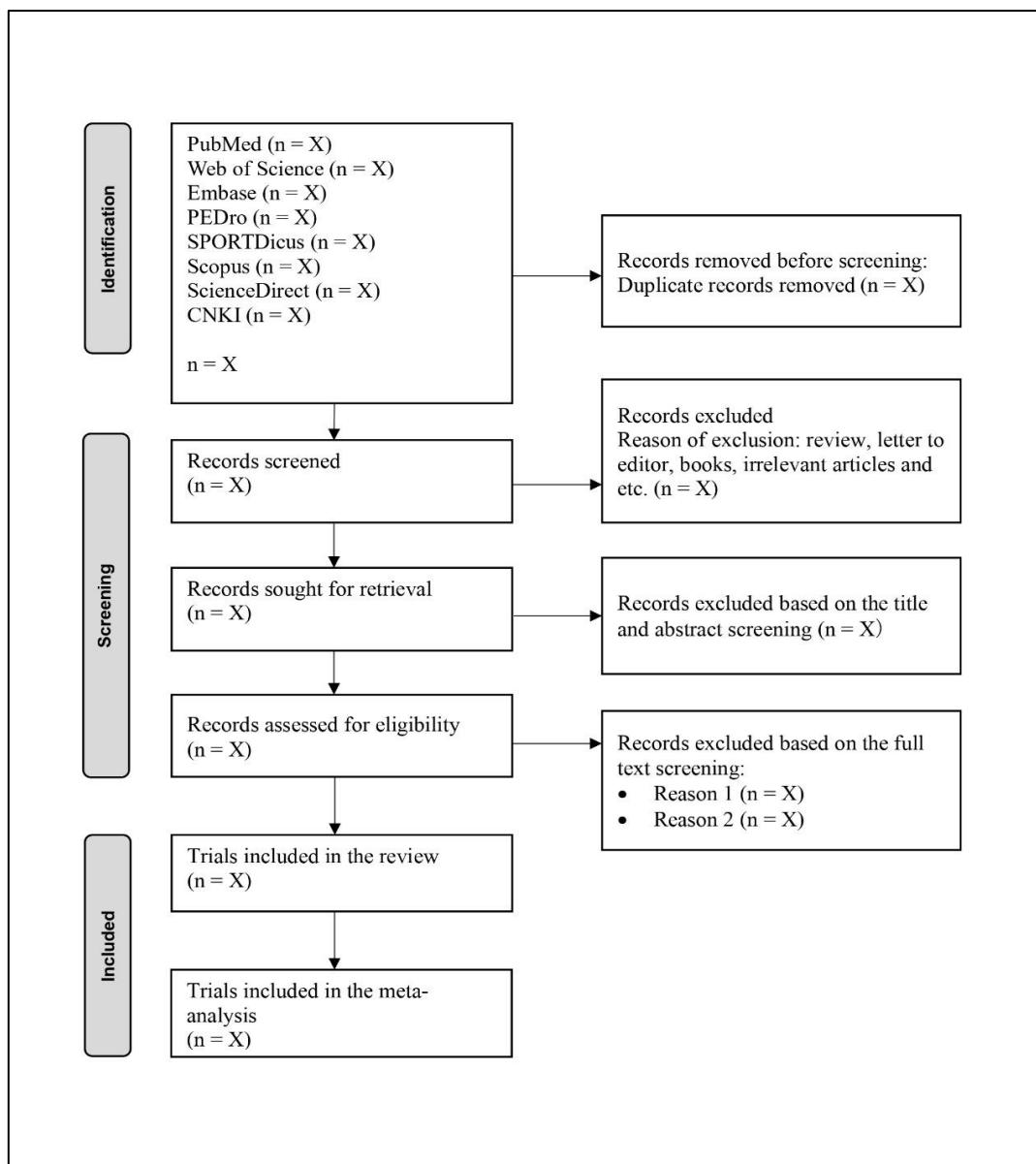
FIGURE 1 The PRISMA flow diagram.

particularly in the meta-analysis (Imrey 2020; Tawfik et al. 2019). To date, no systematic review has focused specifically on the synergistic effects of WBVT combined with conventional rehabilitation exercises for KOA, despite this combination reflecting real-world clinical practice. Therefore, this systematic review and meta-analysis aim to address these gaps by synthesizing existing literature on the combined effects of WBVT and conventional rehabilitation exercises in KOA management. This study represents an improvement in methodology, particularly in its specified context regarding WBVT as an adjunct to rehabilitation exercises, and in its comprehensive search across wide-ranging databases encompassing both English and Chinese language publications. By specifically focusing on this integrated approach, we aim to provide comprehensive insights into the synergistic effects of WBVT and rehabilitation exercises, which may offer valuable guidance for healthcare practitioners in optimizing KOA rehabilitation strategies.

MATERIALS AND METHODS

REVIEW PROTOCOL

This study was designed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al. 2015), and the protocol has been registered with PROSPERO (CRD42024508386). The primary review question guiding this study is: "What are the effects of whole-body vibration training as a supplementary intervention alongside conventional rehabilitation exercises on pain, physical function, and disability in individuals with knee osteoarthritis?"

SEARCH STRATEGY AND DATA SOURCES

To construct the search strategy, Medical Subject Headings (MeSH) terms and relevant keywords pertaining to KOA and WBVT were integrated, ensuring inclusivity of variations for each term. The selected keywords include 'knee osteoarthritis', 'gonarthrosis', 'arthr*', 'whole-body vibration', 'vibration', and 'WBV*'. Through the application of Boolean Operators 'AND' and 'OR', these keywords were combined to broaden the systematic search. Following preliminary investigations, the preferred search approach emerged as "(vibration OR whole-body vibration OR WBV) AND (knee osteoarthritis OR gonarthrosis OR arthr*)", which generated the highest relevance and quantity of hits.

The study will systematically search eight electronic databases: PubMed, Web of Science (WOS), Embase, PEDro, SPORTDiscus, Scopus, ScienceDirect, and the China National Knowledge Infrastructure (CNKI). The search strategy will be tailored to fit the syntax and functionalities of each database. Two authors will independently conduct the database searches using a standardized approach (Tawfik et al. 2019). The search will encompass the inception of databases to May 2024. Additionally, retrieved articles will be cross-referenced (Horsley et al. 2011). However, this study will not attempt to contact authors for additional information.

ELIGIBILITY CRITERIA

The following criteria will be applied for inclusion in this study, established based on the Population, Intervention, Comparison, and Outcome (PICO) framework (Tawfik et al. 2019): (1) randomized controlled trials; (2) the studied population comprises adults diagnosed with KOA according to the American College of Rheumatology criteria; (3) participants in the experimental group received WBVT and conventional rehabilitation exercises; (4) the control groups received conventional rehabilitation exercises; (5) studies with reported clinical outcomes including pain intensity, physical function, and disability scores; (6) regardless of the year of publication; and (7) published in English or Chinese language. Meanwhile, the exclusion criteria were clinical trials focusing solely on WBVT without a comparison group receiving conventional rehabilitation exercises, review articles, letters to the editor, articles published only as abstracts, and animal trials.

DATA SCREENING, SELECTION, AND EXTRACTION PROCESS

Two independent reviewers will conduct the initial screening of titles and abstracts based on the eligibility criteria outlined above (Tawfik et al. 2019). Full-text articles of potentially relevant studies will be retrieved and assessed for eligibility based on the inclusion and exclusion criteria. Any discrepancies will be resolved through discussion or consultation with a third reviewer. Data extraction will be performed using a standardized data extraction form, including the following details: study publication details (author, year), trial design (blinding, allocation concealment, and randomization), participants' characteristics (sample size, demographics, baseline characteristics), grouping and intervention details (WBVT parameters, rehabilitation exercise protocols) and main findings related to pain, physical function, and disability outcomes. A visual representation of the screening and selection process is provided in Figure 1.

RISK OF BIAS AND METHODOLOGICAL QUALITY ASSESSMENT

The methodological quality of the selected studies will undergo rigorous evaluation by two independent authors utilizing both the PEDro scale (de Morton 2009) and the Cochrane risk-of-bias assessment (Sterne et al. 2019). Any disparities in scoring will be resolved through thorough discussion until a consensus is reached between the reviewers. According to the PEDro scale, studies scoring six or higher will be classified as high quality, indicating a low risk of bias, while those scoring three or lower are deemed to be of low quality, suggesting a high risk of bias (de Morton 2009). Moreover, the Cochrane risk-of-bias assessment tool will be employed to assess bias across multiple domains, encompassing selection bias, performance bias, detection bias, attrition bias, reporting bias, and other potential biases (Sterne et al. 2019). Each domain will be scrutinized for its risk level: low, high, or unclear (Sterne et al. 2019). This comprehensive evaluation enables researchers to discern the reliability of study findings, facilitating informed interpretations within the framework of the systematic review. An example of the Cochrane risk of bias is illustrated in Figure 2.

META-ANALYSIS PROCEDURE

The meta-analysis will focus on key outcomes, primarily knee pain intensity, physical function, or disability level scores, utilizing post-intervention data (immediately upon intervention completion) where available. Continuous data will be meticulously handled, where means and standard deviations will serve as the primary metrics for calculating a standard mean difference (SMD)
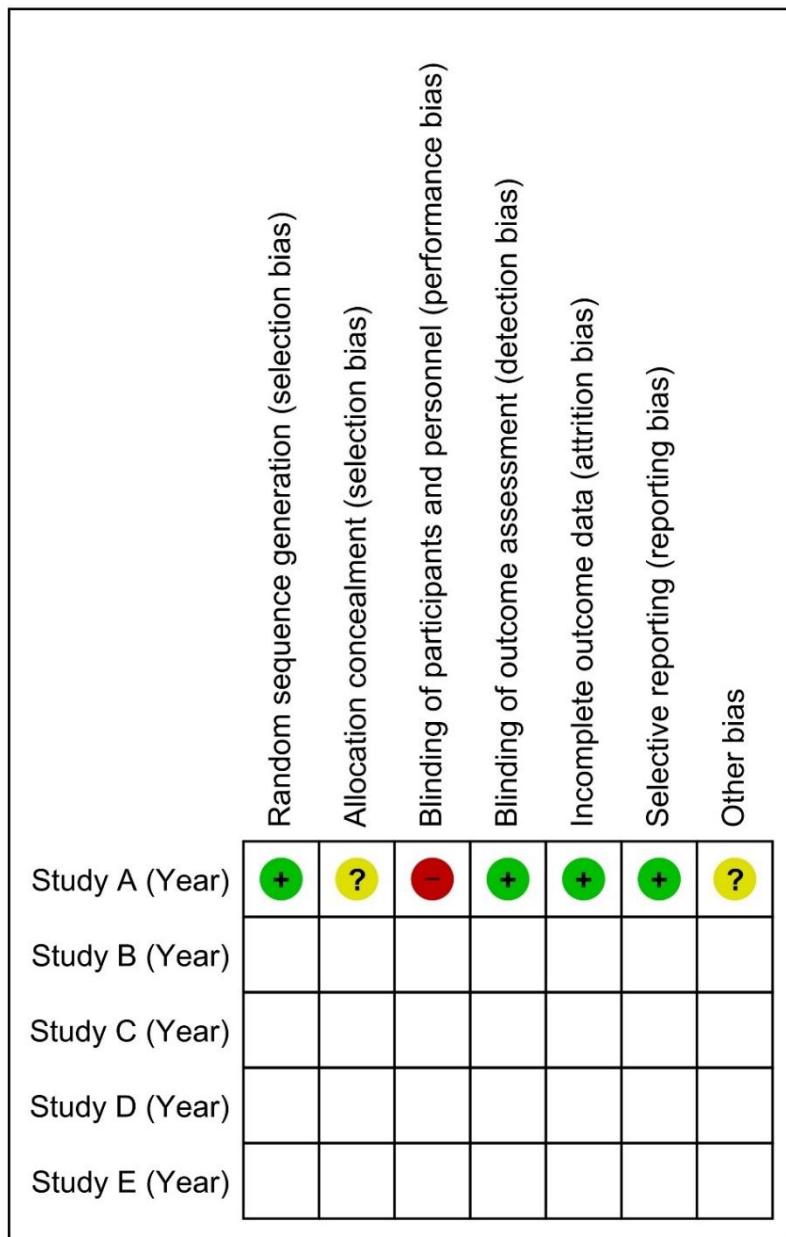
FIGURE 2 An example of summary of risk-of-bias analysis where '+' denotes low risk of bias; '?', unclear risk of bias; and '-', high risk of bias.
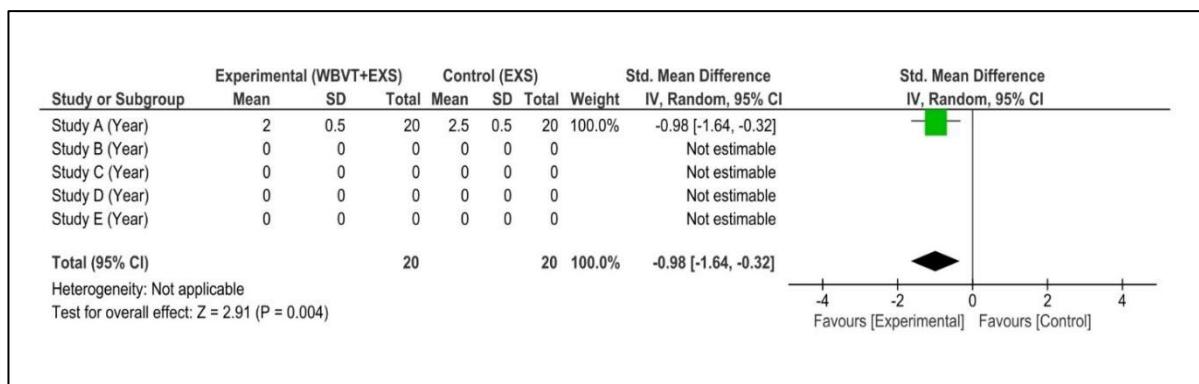

FIGURE 3 An example of a forest plot representing a meta-analysis.

alongside a 95% confidence interval (CI) (Tawfik et al. 2019). It's imperative to note that if studies report data differently, we will implement robust techniques to estimate mean (SD) values for uniformity across the analysis. This meta-analysis will be conducted independently by two reviewers to ensure reliability and consistency (Tawfik et al. 2019). Any discrepancies will be resolved through discussion and consensus to maintain methodological rigor.

Participant characteristics will undergo descriptive analysis at the group level using IBM SPSS Statistics software. The primary meta-analysis will be conducted utilizing Review Manager software (The Nordic Cochrane Centre), employing random-effects models to accommodate anticipated heterogeneity among included studies, particularly when significant heterogeneity ($I2 \geq 50\%$) exists (Tawfik et al. 2019). Sensitivity analyses will assess result robustness by excluding studies with a high risk of bias or small sample sizes (Tawfik et al. 2019). Additionally, subgroup analyses may be undertaken to explore potential sources of heterogeneity (Tawfik et al. 2019), such as variations in WBVT parameters or participant characteristics. A significance level of $P < 0.05$ will be set, with forest plots generated to visually represent meta-analysis results. Refer to Figure 3 for an example illustration of a forest plot in a meta-analysis context.

RESULTS AND DISCUSSION

The investigation of WBVT as a complementary intervention in KOA management presents a complex landscape, characterized by diverse study methodologies and conflicting findings (Aggarwal et al. 2020; Bokaeian et al. 2016; Park et al. 2013; Zhang et al. 2021). This systematic review and meta-analysis sought to elucidate the synergistic effects of WBVT when combined with conventional rehabilitation exercises, addressing a notable gap in the literature. By focusing on this aspect, the review aims to offer evidence-based recommendations to healthcare practitioners for optimizing rehabilitation strategies for KOA patients.

The synthesis of existing evidence in this review underscores the importance of considering WBVT within the context of broader rehabilitation strategies for KOA. Among the notable strengths of this study: (i) while previous reviews have predominantly examined WBVT in isolation (Li et al. 2015; Qiu et al. 2022; Wang et al. 2022), our analysis will specifically focus on its combined effects with rehabilitation exercises, (ii) comprehensive search strategy, which encompassed eight databases (significantly more than previous studies, typically covering four to six databases), and (iii) inclusion of both English and Chinese language publications (a departure from previous

reviews that focused solely on English literature). By adopting such an inclusive approach, we aimed to minimize the risk of publication bias and ensure a more representative sample of the available literature. However, despite these efforts, several limitations warrant consideration. The anticipated inherent heterogeneity among the included studies, including variations in WBVT protocols, patient demographics, and outcome measures, poses a challenge to data synthesis and interpretation (Imrey 2020). While sensitivity and subgroup analyses will be conducted to explore potential sources of heterogeneity, residual confounding factors may still influence the observed outcomes.

Furthermore, despite our proposed rigorous search strategy and protocol, it is possible that relevant studies may have been overlooked, particularly those published in non-peer-reviewed sources. Despite these limitations, the findings of this review offer valuable insights for clinical practice and research. Additionally, the identification of methodological gaps and areas for further investigation underscores the need for ongoing research to refine and optimize rehabilitation protocols in this population. The findings of this systematic review and meta-analysis will be disseminated through publication in a peer-reviewed journal and presentation at relevant conferences or scientific meetings. Additionally, findings will be shared with healthcare practitioners and policymakers to inform clinical practice and policy decisions related to KOA management.

CONCLUSION

This systematic review and meta-analysis will synthesize available evidence on the integration of WBVT with conventional rehabilitation exercises in KOA management. By elucidating the synergistic effects of WBVT, healthcare practitioners can tailor interventions to individual patients, potentially enhancing treatment efficacy, patient engagement, and adherence while optimizing healthcare delivery. Moreover, through dissemination in peer-reviewed journals and scientific conferences, we aim to foster knowledge translation and promote evidence-based practice, ultimately improving outcomes for individuals with KOA.

ETHICAL CONSIDERATIONS

Since this study involves the analysis of existing data from published studies, ethical approval is not required. However, ethical principles will be adhered to throughout the conduct of this systematic review and meta-analysis. Any amendments to this protocol will be documented and reported in the final manuscript, along with justifications for the changes.

DECLARATIONS

DATA AVAILABILITY

COMPETING INTERESTS

FUNDING

AUTHORS' CONTRIBUTIONS

Yan Peng and Mohd Azzuan Ahmad conceived the study, drafted the protocol. Chai Siaw Chui provided comments and revisions. All authors approved the final manuscript.

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Artikel Asli /*Original Article*

Bisfenol F Merubah Struktur Glomerulus Ginjal Tikus Sprague Dawley Jantan Melalui Mekanisme Tekanan Oksidatif

Bisphenol F Alter The Glomerulus Structure of Kidney in Male Sprague Dawley Rats via Oxidative Stress Mechanism

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ABSTRAK

Kesan ketoksikan Bisfenol A (BPA) telah membawa kepada pengenalan Bisfenol F (BPF) sebagai pengganti BPA. Penggunaan BPF secara berleluasa ini menyebabkan BPF telah dikesan dalam urin manusia. Namun, sehingga kini tiada kajian melaporkan tentang kesan BPF terhadap ginjal. Oleh itu, kajian ini dilakukan untuk mengkaji kesan BPF terhadap ginjal tikus jantan Sprague Dawley dengan menilai status tekanan oksidatif, sodium-potasium ATPase (Na+/K+), dan pemerhatian histologi. Sebanyak 28 ekor tikus jantan Sprague Dawley dibahagikan kepada empat kumpulan (7 ekor setiap kumpulan) iaitu kumpulan kawalan yang diberikan 1 mg/kg minyak jagung, kumpulan BPF1, BPF5 dan BPF10 masing-masing diberikan BPF pada dos 1, 5 dan 10 mg/kg selama 60 hari. Di akhir kajian, tikus dikorbankan dan ginjal tikus diambil untuk analisa tekanan oksidatif, penentuan ATPase natrium kalium (Na+/K+) dan pemerhatian histologi. Hasil kajian menunjukkan BPF menyebabkan aras glutation (GSH) kumpulan BPF5 dan BPF10 lebih tinggi secara signifikan berbanding kumpulan kawalan (p<0.05). Kumpulan BPF10 menunjukkan aktiviti superoksida dismutase (SOD) yang lebih tinggi secara signifikan berbanding kumpulan BPF1 (p<0.05). Tiada perbezaan yang signifikan antara kumpulan kajian bagi aktiviti Na+/K+ ATPase. Pemerhatian histologi menunjukkan struktur glomerulus yang lebih kecil pada kumpulan BPF10 berbanding kumpulan kawalan. Tiada perbezaan yang signifikan diperhatikan pada struktur tubul distal dan proksimal. Kesimpulannya, pendedahan BPF pada dos 10 mg/kg secara berterusan telah menyebabkan perubahan pada struktur glomerulus melalui mekanisme tekanan oksidatif.

Kata Kunci: Bisfenol, glomerulus, sodium-potasium ATPase, tubul proksimal, tubul distal.

ABSTRACT

The toxicity effects of Bisphenol A (BPA) have led to the introduction of Bisphenol F (BPF) as a substitute for BPA. The widespread replacement has resulted in the detection of BPF in human urine. However, to date, there have been no studies reporting on the effects of BPF on the kidneys. Therefore, this study was conducted to investigate the effects of BPF on the kidneys of male Sprague Dawley rats by evaluating the oxidative stress status, sodium-potassium ATPase (Na+/K+), and histological observations. A total of28 male Sprague Dawley rats were divided into four groups (sevenrats per group): a control group given 1 mg/kg corn oil, and three groups (BPF1, BPF5, and BPF10) given BPF at doses of 1, 5, and 10 mg/kg for 60 days. At the end of the study, the rats were sacrificed, and their kidneys were collected for analyses of oxidative stress, determination of sodium-potassium ATPase (Na+/K+), and histological observations. The results showed that BPF caused significantly higher levels of glutathione (GSH) in the BPF5 and BPF10 groups compared to the control group (p<0.05). BPF10 caused significantly higher in superoxide dismutase (SOD) activity compared to BPF1 (p<0.05). No significant differences were observed between the study groups for Na+/K+ ATPase activity. Histological observations

indicated shrinkage of glomerular structures in the BPF10 group compared to the control group. No significant differences were noted in the structure of distal and proximal tubules. In conclusion, repeated exposure to BPF at a dose of 10 mg/kg has caused changes in glomerular structure through oxidative stress mechanisms.

Keywords: Bisphenol, glomerulus, sodium-potasium ATPase, proximal tubule, distal tubule.

PENGENALAN

Bisfenol A (BPA) merupakan bahan kimia perindustrian yang digunakan dalam pengeluaran plastik polikarbonat dan resin epoksi khususnya dalam pembuatan bekas minuman dan makanan, lapisan dalaman tin logam serta alat permainan kanak-kanak (Bousoumah et al. 2021). Penggunaannya yang meluas telah menyebabkan BPA dikesan di persekitaran dan turut dikesan dalam sampel biologi manusia (Liu et al. 2021). BPA telah dikategorikan sebagai bahan kimia pengganggu endokrin (EDC), iaitu bahan yang menyebabkan gangguan pada sistem endokrin manusia. BPA berupaya mengganggu dan menghalang ikatan antara hormon dengan reseptornya, bertindak secara mimik kepada hormon endokrin serta mengakibatkan hormon androgen yang berlebihan dalam badan manusia (Hafezi & Abdel-Rahman 2019). Oleh itu, BPA telah menyebabkan kesan ketoksikan pada manusia seperti yang dilaporkan dalam kajian terdahulu.

Disebabkan kesan ketoksikan BPA yang semakin membimbangkan, pihak industri pembuatan telah mengambil inisiatif untuk mencari pengganti BPA berdasarkan struktur induknya yang dikenali sebagai analog BPA. Analog BPA adalah bahan yang mempunyai persamaan struktur dan fungsi dengan BPA tetapi komposisi kimia yang berbeza (Trullemans et al. 2021). Analog BPA ini mempunyai ciri-ciri BPA yang diingini seperti rintangan haba dan daya tahan yang kuat. Bisfenol F (BPF) merupakan antara analog BPA yang paling banyak digunakan bagi menggantikan BPA, terutamanya dalam industri pembuatan makanan. BPF digunakan dengan meluas dalam pengeluaran plastik, resin, tin makanan, resit kertas terma, dan tin minuman ringan (Santonicola et al. 2021).

BPF telah ditemui dalam sampel persekitaran seperti tanah, sedimen, cecair kumbahan, serta dalam urin orang dewasa dan kanak-kanak pada kepekatan yang tinggi. Jumlah BPF dalam urin bertindak sebagai penanda biologi terhadap tahap pendedahan BPF. Selain daripada urin, BPF juga telah ditemui dalam serum manusia, plasenta dan darah tali pusat (Lehmler et al. 2018). Malahan, BPF turut dikesan dalam urin kanak-kanak berumur 6 tahun (Lee et al. 2022). BPF berkemungkinan mempunyai mekanisme ketoksikan yang sama seperti BPA. Walau bagaimanapun, kesan ketoksikan BPF tidak diketahui dengan sepenuhnya kerana bahan ini serta metabolitnya belum dikaji dengan terperinci. Memandangkan BPF dijumpai dalam urin manusia (Wang et al. 2019), metabolisme dan perkumuhan BPF adalah penting untuk dikaji.

Organ perkumuhan utama manusia iaitu ginjal merupakan organ yang berpotensi sebagai sasaran EDC seperti BPA. BPA mampu mengganggu fungsi ginjal dan mengakibatkan fibrosis ginjal dan kerosakan pada glomerulus dan tubul ginjal seterusnya menyebabkan tekanan oksidatif ginjal (Yoo et al. 2022). Hal ini boleh menyebabkan kerosakan ginjal akibat pendedahan secara berterusan kepada BPA (Kobroob et al. 2018). Ginjal adalah organ yang bertanggungjawab dalam metabolisme dan perkumuhan bahan buangan dan metabolit oleh unit berfungsinya iaitu nefron. Nefron terdiri daripada glomerulus dan tubul yang masing-masing bertanggungjawab dalam proses filtrasi dan serapan semula air dan bahan terlarut. Proses penyerapan semula air dan bahan terlarut memerlukan bantuan pam sodium-potassium ATPase (Na+/K+ ATPase) (Clemente-Suárez et al. 2023). Namun begitu, sehingga ke hari ini tiada kajian yang melaporkan tentang kesan BPF terhadap ginjal walaupun bahan ini telah dikesan dalam urin manusia. Oleh itu, kajian ini dijalankan untuk menilai kesan BPF terhadap ginjal selepas 60 hari pendedahan secara berterusan.

METODOLOGI KAJIAN

BAHAN KIMIA

Bisfenol F (SUP-51453-100 mg) dengan ketulenan 98% dan serbuk kolesterol telah dibeli daripada Sigma-Aldrich, Amerika Syarikat. Bahan kimia lain yang digunakan dalam kajian ini diperoleh daripada MERCK, Jerman, manakala lilin parafin diperoleh daripada Leica Biosystem Richmond, Inc., Jerman. Untuk pewarnaan Hematoksilin dan Eosin (H&E), serbuk Eosin Y dan Hematoksilin dibeli daripada Acros Organics™, Belgium. BPF seterusnya dilarutkan dalam minyak jagung untuk menghasilkan kepekatan 10 mg/kg, yang digunakan sebagai larutan stok. Larutan stok ini kemudian dicairkan untuk mendapatkan kepekatan 1 mg/kg dan 5 mg/kg. Pemilihan dos dalam kajian ini dipilih berdasarkan ½ dos lowest-observed-adverse-effect level (LOAEL) iaitu 10 mg/kg (Higashihara et al. 2007) dan ½ dos no-observed-adverse-effect level (NOAEL) iaitu 1 mg/kg (Lee et al. 2022). Pemilihan dos 5 mg/kg pula dipilih berdasarkan dos julat pertengahan bagi dos 10 mg/kg yang dianggarkan

memberi kesan yang lebih teruk berbanding dos 1 mg/kg.

REKA BENTUK KAJIAN

Tikus jantan Sprague Dawley (n=28) dengan berat antara 230-250 g telah digunakan dalam kajian ini dan dibeli daripada syarikat tempatan, A Sapphire Enterprise, Malaysia. Setiap ekor tikus diletakkan dalam sangkar plastik berlabel bebas BPA secara berasingan dengan kitaran cahaya 12 jam cerah/gelap pada suhu 28±2°C. Makanan dan minuman diberikan secara ad libitum sepanjang tempoh kajian. Tikus telah diambil seminggu lebih awal untuk tujuan aklimatisasi. Pengendalian tikus ini telah mendapat kebenaran dan kelulusan daripada Unit Etika Haiwan, Fakulti Perubatan, Universiti Kebangsaan Malaysia (FSK/2022/IZATUS-SHIMA/25-MAY/1250-MAY-2022-SEPT.-2023).

Tikus dibahagikan secara rawak kepada empat kumpulan kajian (n=7 bagi setiap kumpulan): kumpulan kawalan (minyak jagung 1 ml/kg berat badan), BPF1 (larutan BPF 1 mg/kg berat badan), BPF5 (larutan BPF 5 mg/kg berat badan), dan BPF10 (larutan BPF 10 mg/kg berat badan). Semua bahan diberikan secara oral secara paksa setiap hari selama 60 hari. Pada akhir kajian, tikus dikorbankan menggunakan kombinasi ketamin/xylazine/atropin pada dos 60/12/0.6 mg/kg melalui suntikan intraperitoneal (i.p.) (dos berlebihan). Seterusnya, ginjal diambil dan disimpan dalam peti sejuk beku bersuhu -80°C dan dalam formalin untuk analisis tekanan oksidatif, termasuk aras glutation (GSH), aktiviti superoksida dismutase (SOD), dan aras malondialdehid (MDA), serta untuk penentuan aktiviti ATPase natrium kalium (Na+/K+) dan pemerhatian histologi menggunakan pewarnaan Hematoksilin dan Eosin (H&E).

STATUS TEKANAN OKSIDATIF

Ginjal dinyahbeku pada suhu bilik dan ditimbang sebelum larutan salin normal ditambah dalam nisbah 1 : 9 (g tisu/ml salin normal). Ginjal dihomogenat dan diemparkan pada kelajuan 10,000 x g pada suhu 4°C selama 10 minit. Supernatan diasingkan untuk analisa GSH, SOD dan MDA masing-masing menggunakan kaedah oleh Ellman (1959), Beyer & Fridovich (1987) dan Stocks & Dormandy (1971). Kesemua hasil tindak balas diukur secara kolorimetrik menggunakan spektrofotometer.

PENENTUAN AKTIVITI NATRIUM KALIUM ATPase

Pengukuran aras Natrium Kalium ATPase dilakukan dengan menggunakan kit asai imunojerapan berpaut enzim komersil atau *enzyme-linked immunosorbent assay* (ELISA) yang diperolehi daripada syarikat Elabscience. Aktiviti natrium kalium ATPase diukur dengan menentukan aras fosforus, iaitu salah satu bahan yang terhasil akibat penguraian ATP semasa aktiviti natrium kalium ATPase. Hasil tindak balas diukur pada panjang gelombang 660 nm. Graf piawai nilai penyerapan melawan kepekatan piawai fosforus diplot untuk penentuan aktiviti natrium kalium ATPase.

PEMERHATIAN HISTOLOGI

Tisu ginjal yang telah difiksasi diambil dan diproses terlebih dahulu menggunakan mesin automasi pemprosesan tisu sebelum dibenamkan ke dalam blok parafin. Proses pemprosesan tisu melibatkan tiga peringkat yang dimulakan dengan dehidrasi menggunakan siri kepekatan alkohol (50%, 70%, 100%, 100%, 100%), pembersihan menggunakan campuran etanol dan xilena (1:1), serta xilena, dan impregnasi dengan lilin parafin. Selepas itu, sampel tisu dibenamkan ke dalam acuan pembenam dengan lilin parafin panas dan dibekukan untuk membentuk blok tisu. Blok tisu tersebut dipotong pada ketebalan 4 µm sebelum diwarnakan dengan pewarnaan H&E. Akhirnya, tisu histologi diperhatikan menggunakan mikroskop cahaya pada pembesaran 40X dengan skala 20 µm. Sebanyak 50 glomerulus, tubul proksimal dan tubul distal diukur diameter dan ketebalan epitelium untuk setiap kumpulan kajian. Setiap pengukuran diulang sebanyak tiga kali bagi mendapatkan nilai purata. Pemerhatian histologi ini telah disemak dan disahkan oleh pakar histopatologi.

ANALISIS STATISTIK

Semua ujian dilakukan secara duplikat, dan nilai purata dianalisis menggunakan ujian statistik melalui The Statistical Package for the Social Sciences (SPSS) versi 27. Normaliti data diuji menggunakan ujian Shapiro-Wilk, dan hasilnya menunjukkan bahawa data yang diperoleh adalah normal. Oleh itu, analisis dilakukan menggunakan ujian parametrik, iaitu analisis varian sehala (one-way ANOVA). Data yang menunjukkan nilai signifikan kemudiannya dianalisis menggunakan ujian post hoc Tukey. Kesemua data diekspresikan dalam bentuk purata ± SEM dan dianggap signifikan jika $p < 0.05$.

HASIL KAJIAN

STATUS TEKANAN OKSIDATIF

Rajah 1, 2 dan 3 masing-masing menunjukkan aras GSH, aktiviti SOD dan aras MDA ginjal tikus bagi semua kumpulan kajian. Hasil kajian menunjukkan aras GSH bagi kumpulan BPF5 (0.110 ± 0.0066) µmol/mg dan BPF10 (0.108 ± 0.0031) µmol/mg adalah lebih tinggi secara signifikan berbanding kumpulan kawalan (0.082 ± 0.0038) µmol/mg

(p<0.05). Tiada perbezaan yang signifikan diperhatikan bagi kumpulan BPF1 (0.094 ± 0.0063) µmol/mg dengan semua kumpulan kajian.

Malahan, aktviti SOD turut menunjukkan nilai yang lebih tinggi secara signifikan bagi kumpulan BPF10 (0.643 ± 0.0284) U/min/g berbanding kumpulan kawalan (0.454 ± 0.0264) U/min/g (p<0.05). Tiada perbezaan yang signifikan diperhatikan bagi kumpulan BPF1 (0.437 ± 0.0434) U/min/g dan BPF5 (0.513 ± 0.0377) U/min/g dengan semua kumpulan kajian.

Aras MDA bagi kumpulan kawalan ialah (1.768 ± 0.1608) µmol/g protein, kumpulan BPF1 ialah (1.767 ± 0.0924) µmol/g protein, kumpulan BPF5 ialah (1.611 ± 0.1994) µmol/g protein dan BPF10 ialah (2.147 ± 0.3269) µmol/g protein. Namun, tiada perbezaan yang signifikan diperhatikan pada aras MDA antara semua kumpulan kajian.

PENENTUAN AKTIVITI NATRIUM KALIUM ATPase

Rajah 4 menunjukkan aktiviti Na+/K+ ATPase ginjal tikus bagi semua kumpulan kajian. Hasil kajian menunjukkan tiada perbezaan yang signifikan bagi aktiviti Na+/K+ ATPase antara semua kumpulan kajian dengan purata nilai bagi setiap kumpulan adalah kawalan (4.39 ± 0.49) µmol Pi/mg/jam, kumpulan BPF1 (5.78 ± 0.92) µmol Pi/mg/jam, kumpulan BPF5 (6.32 ± 0.83) µmol Pi/mg/jam, dan kumpulan BPF10 (6.66 ± 0.89) µmol Pi/mg/jam
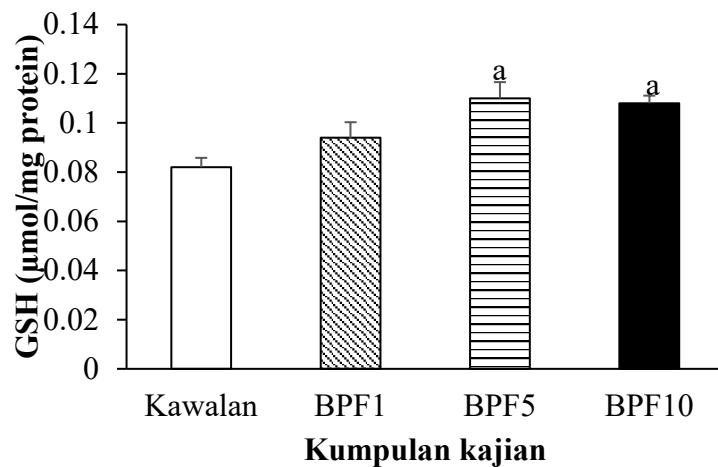
RAJAH 1 Perbandingan aras GSH ginjal tikus antara kumpulan kajian (n=7). Setiap data dinyatakan dalam purata ± SEM. a: Signifikan berbanding kumpulan kawalan (p<0.05)
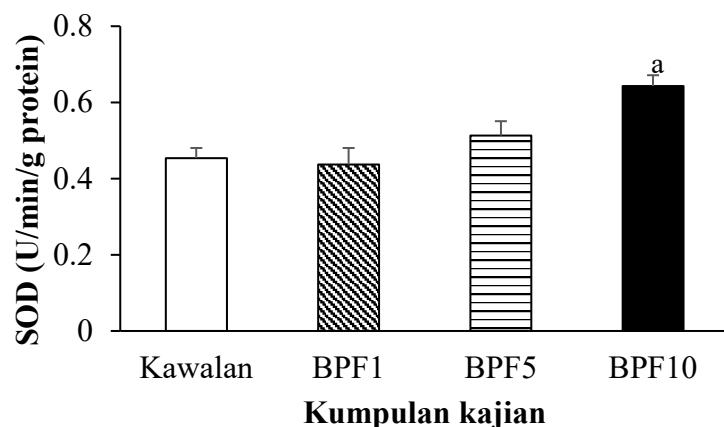
RAJAH 2 Perbandingan aktiviti SOD ginjal tikus antara kumpulan kajian (n=7). Setiap data dinyatakan dalam purata ± SEM. a: Signifikan berbanding kumpulan kawalan (p<0.05)
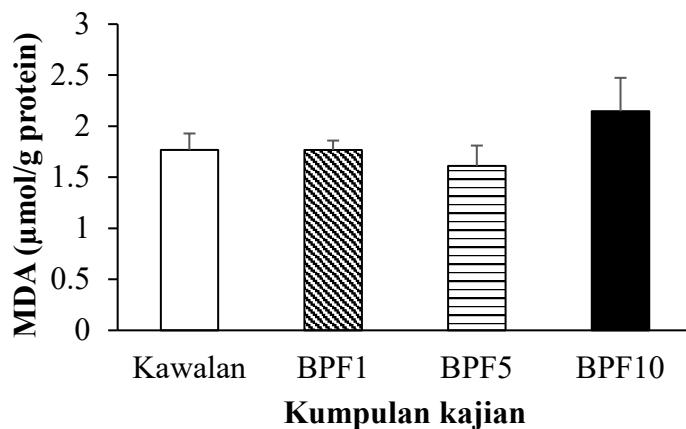
RAJAH 3 Perbandingan aras MDA ginjal tikus antara kumpulan kajian (n=7).
Setiap data dinyatakan dalam purata ± SEM.
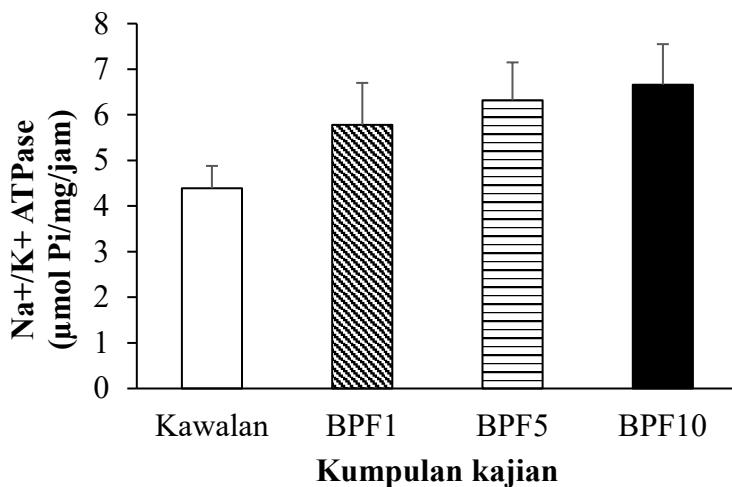
RAJAH 4 Perbandingan aktiviti Na+/K+ ATPase ginjal tikus antara kumpulan kajian (n=7).
Setiap data dinyatakan dalam purata ± SEM.

PEMERHATIAN HISTOLOGI

Rajah 5 menunjukkan purata diameter saiz glomerulus ginjal tikus bagi semua kumpulan kajian. Kumpulan BPF10 (0.091 ± 0.0038) μm menunjukkan diameter glomerulus yang lebih kecil secara signifikan berbanding kumpulan kawalan (0.108 ± 0.0035) μm (p<0.05). Tiada perbezaan yang signifikan diperhatikan bagi kumpulan BPF1 (0.096 ± 0.0044) μm dan BPF5 (0.093 ± 0.006) μm dengan semua kumpulan kajian.

Rajah 6 menunjukkan purata diameter tubul proksimal ginjal tikus bagi semua kumpulan kajian. Purata diameter lumen tubul proksimal kumpulan kawalan ialah (0.066 ± 0.0035) μm, kumpulan BPF1 ialah (0.067 ± 0.0038) μm, kumpulan BPF5 ialah (0.068 ± 0.0012) μm, dan kumpulan BPF10 ialah (0.060 ± 0.0014) μm. Tiada perbezaan yang signifikan diperhatikan pada diameter lumen tubul proksimal antara semua kumpulan kajian (Rajah 6(a)). Rajah 6(b) menunjukkan purata ketebalan epitelium tubul proksimal ginjal tikus kajian. Purata

ketebalan epitelium tubul proksimal kumpulan kawalan ialah (0.013 ± 0.0014) μm, kumpulan BPF1 ialah (0.014 ± 0.0009) μm, kumpulan BPF5 ialah (0.011 ± 0.0004) μm, dan kumpulan BPF10 ialah (0.012 ± 0.0008) μm. Tiada perbezaan yang signifikan diperhatikan pada ketebalan epitelium tubul proksimal antara semua kumpulan kajian.

Rajah 7 menunjukkan purata diameter tubul distal ginjal tikus bagi semua kumpulan kajian. Purata diameter lumen tubul distal kumpulan kawalan ialah (0.030 ± 0.0017) μm, kumpulan BPF1 ialah (0.027 ± 0.0012) μm, kumpulan BPF5 ialah (0.030 ± 0.0014) μm, dan kumpulan BPF10 ialah (0.030 ± 0.0026) μm. Tiada perbezaan yang signifikan diperhatikan pada diameter lumen tubul distal antara semua kumpulan kajian (Rajah 6(a)). Rajah 6(b) menunjukkan purata ketebalan epitelium tubul distal ginjal tikus kajian. Purata ketebalan epitelium tubul distal kumpulan kawalan ialah (0.0075 ± 0.0001) μm, kumpulan BPF1 ialah
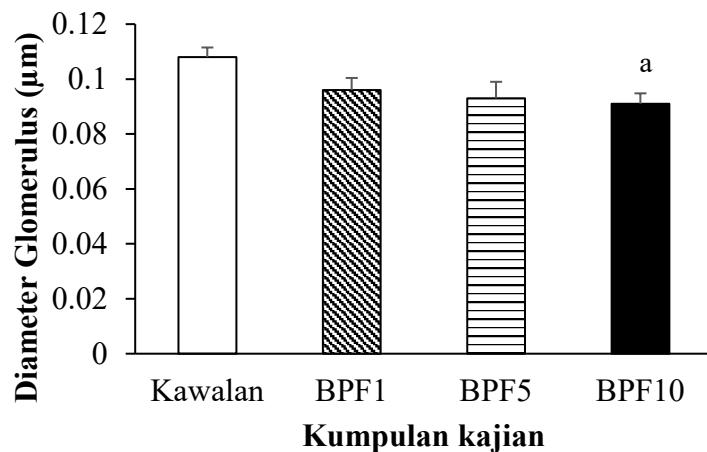
RAJAH 5 Perbandingan diameter glomerulus ginjal tikus antara kumpulan kajian (n=7). Setiap data dinyatakan dalam purata ± SEM. a: Signifikan berbanding kumpulan kawalan ($p<0.05$)
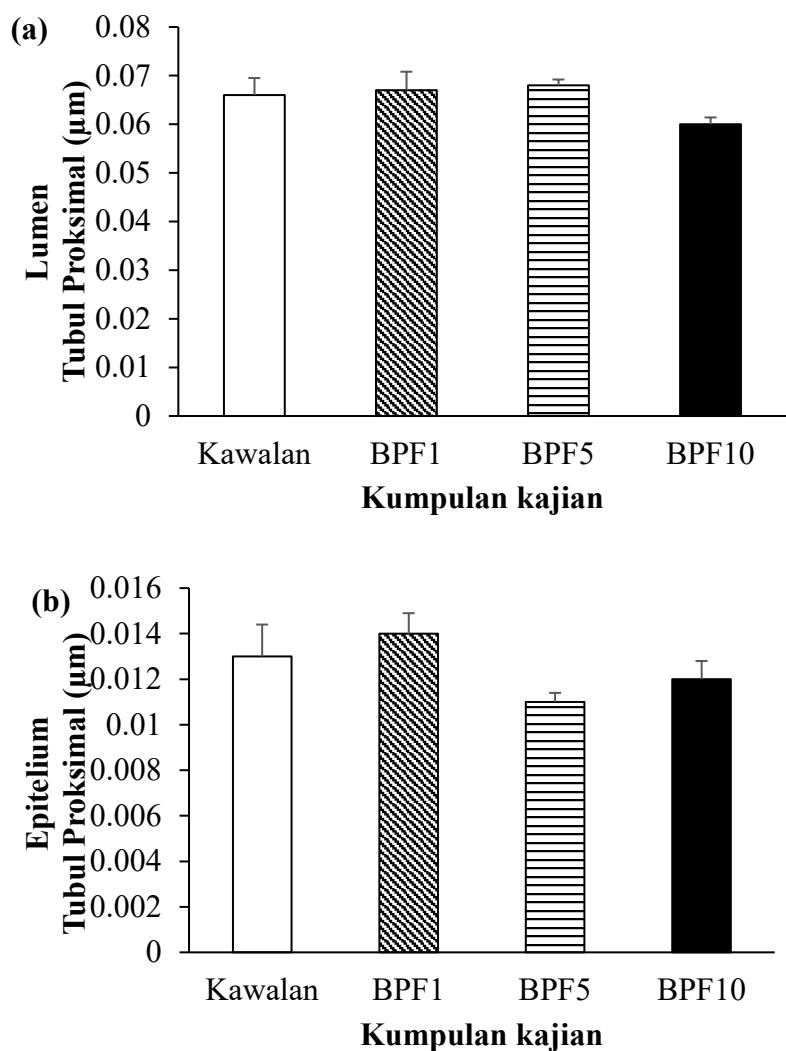
RAJAH 6 Perbandingan tubul proksimal ginjal tikus antara kumpulan kajian (n=7). (a)Diameter lumen tubul proksimal; (b) Ketebalan epitelium tubul proksimal. Setiap data dinyatakan dalam purata ± SEM.

(a)

(b)

RAJAH 7 Perbandingan tubul distal ginjal tikus antara kumpulan kajian (n=7). (a) Diameterlumen tubul distal; (b) Ketebalan epitelium tubul distal. Setiap data dinyatakan dalam purata ± SEM.
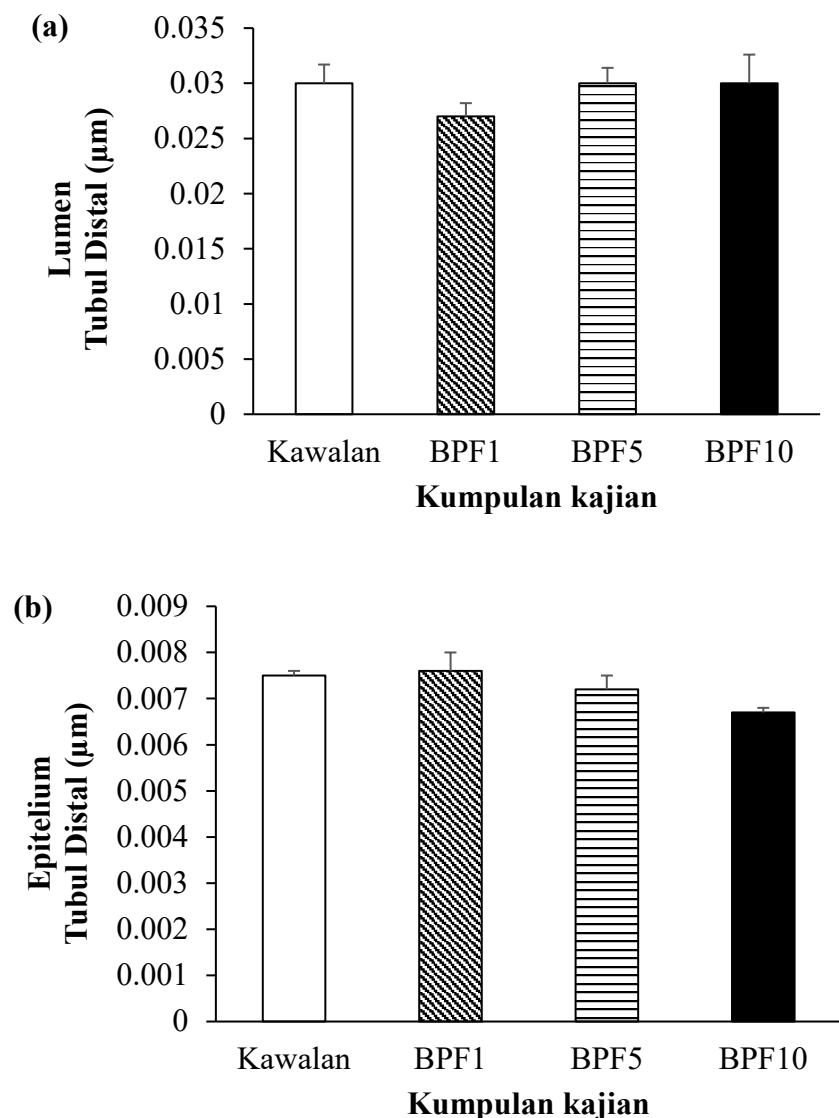
0.0076 ± 0.0004) μm, kumpulan BPF5 ialah (0.0072 ± 0.0003) μm, dan kumpulan BPF10 ialah (0.0067 ± 0.0001) μm. Tiada perbezaan yang signifikan diperhatikan pada ketebalan epitelium tubul distal antara semua kumpulan kajian.

Pemerhatian histologi ginjal tikus kajian menggunakan mikroskop cahaya ditunjukkan pada Rajah 8. Histologi glomerulus serta tubul proksimal dan distal kumpulan kawalan menunjukkan struktur yang normal. Tikus kumpulan BPF10 menunjukkan saiz glomerulus yang lebih kecil berbanding kumpulan kawalan. Histologi tubul proksimal dan distal tikus aruhan BPF menunjukkan struktur yang masih normal seperti kumpulan kawalan.

PERBINCANGAN

Penggunaan BPF secara meluas telah menyebabkan bahan kimia ini ditemui di persekitaran termasuklah dalam urin manusia (Bousoumah et al. 2021; Liu et al. 2021). Ini menunjukkan ginjal berpotensi menjadi salah satu organ sasaran BPF. Oleh itu, data awalan kesan BPF terhadap ginjal telah dilakukan dengan menilai status tekanan oksidatif, aktiviti Na+/K+ ATPase serta morfologi ginjal selepas pendedahannya secara berturutan selama 60 hari. Pendedahan berterusan sesuatu bahan xenobiotik boleh menyebabkan berlakunya peningkatan penghasilan spesis oksigen reaktif (ROS) yang akhirnya mengganggu sistem pertahanan antioksidan (Garcia-Caparros et al. 2021). Keadaan ini seterusnya akan menyebabkan berlakunya tekanan oksidatif yang boleh menyebabkan kerosakan struktur ginjal. Pemberian BPF secara berterusan dalam kajian ini menggambarkan pendedahan yang berlaku dalam kehidupan seharian

manusia dengan anggaran dos sebanyak ~1.6 mg/kg/hari. Dos pendedahan ini dikira berdasarkan peratus BPF yang boleh disingikirkan melalui urin sebanyak ~54%. Oleh itu, berdasarkan pengiraan, dos 1.6 mg/kg pada manusia adalah bersamaan 10 mg/kg tikus kajian.

Hasil kajian mendapati BPF pada dos 10 mg/kg telah menyebabkan aras GSH dan aktiviti SOD yang lebih tinggi secara signifikan berbanding kawalan, namun tidak menyebabkan perbezaan pada aras MDA. Hasil kajian ini tidak selari dengan kajian terdahulu yang mana pendedahan BPA pada dos 50 mg/kg/sehari selama 5 minggu secara suntikan intraperitoneal telah menyebabkan penurunan aras GSH dan aktiviti SOD serta peningkatan aras MDA ginjal tikus kajian (Kobroob et al. 2018). Kajian yang dijalankan oleh Ishtiaq et al. (2022) turut menunjukkan BPA pada dos 10 mg/kg telah menyebabkan penurunan pada aras GSH dan aktiviti SOD serta peningkatan aras MDA ginjal tikus kajian selepas 56 hari pendedahannya. Perbezaan hasil penemuan ini mungkin disebabkan oleh perbezaan cara pemberian BPA serta dos yang digunakan adalah lebih tinggi berbanding dos kajian. Peningkatan aras GSH dan aktiviti SOD serta tiada pembentukan peroksidasi lipid pada ginjal tikus kajian aruhan BPF menunjukkan tekanan oksidatif yang berlaku adalah pada peringkat permulaan. Ini mungkin menunjukkan berlakunya kompensasi mekanisme pertahanan antioksidan pada ginjal tikus kajian.

Pendedahan BPF secara berterusan turut dilaporkan menyebabkan berlakunya peningkatan ROS (Shamhari et al. 2021). Ketidakseimbangan antara ROS dan pertahanan antioksidan telah menyebabkan tekanan oksidatif dan seterusnya boleh menyebabkan kerosakan ginjal. Unit berfungsi ginjal yang dikenali sebagai nefron terdiri daripada glomerulus dan tubul. Antara fungsi utama nefron adalah penyerapan semula air dan ion ke dalam saluran darah serta rembesan sisa toksik dan ion ke dalam urin. Kedua-dua proses ini dilakukan oleh Na+/K+ ATPase yang mempunyai kepekatan yang tinggi pada ginjal, terutamanya tubul proksimal dan tubul distal (Schwartz & Rashid 2021). Hasil kajian menunjukkan tiada perbezaan yang signifikan antara semua kumpulan kajian bagi aktiviti Na+/K+ ATPase. Hal ini bercanggah dengan keputusan kajian oleh Yoo et al. (2022) yang mendapati bahawa BPA mampu mengganggu fungsi ginjal dan mengurangkan pengekspresan Na+/K+ ATPase pada tubul ginjal tikus progeni Sprague Dawley. Dalam kajian ini, Yoo et al (2022) telah memberikan sebanyak 250 mg/kg BPA secara oral kepada tikus neonatal dari hari ketujuh sehingga hari ke-21. Penyelidik terdahulu menunjukkan terdapat pengurangan pengekspresan Na+/K+ ATPase selepas pendedahan kepada BPA dalam jangka masa yang panjang (Yoo et al. 2022). Satu lagi kajian oleh Macczak et al. (2017) membandingkan kesan BPA,

bisfenol S (BPS), BPF dan bisfebol AF (BPAF) terhadap nilai ATP dan Na+/K+ ATPase pada membran sel darah merah manusia. BPA dan analognya mampu mengurangkan aktiviti Na+/K+ ATPase dan tahap ATP intraselular pada sel darah merah dengan signifikan selepas terdedah kepada BPA dan analognya pada kepekatan 0.1 hingga 25 μg/mL. BPAF dan BPA mempunyai keupayaan yang lebih tinggi untuk mengurangkan aktiviti Na+/K+ ATPase. Bagi BPF pula, kepekatan yang tinggi diperlukan untuk mengurangkan aktiviti Na+/K+ ATPase secara signifikan (Maczack et al. 2017). Hal ini mungkin menjelaskan keputusan kajian yang menunjukkan tiada perbezaan signifikan terhadap aktiviti Na+/K+ ATPase pada ginjal antara semua kumpulan kajian dengan aruhan BPF.

Aktiviti Na+/K+ ATPase yang tidak berubah turut ditunjukkan melalui pemerhatian dan pengukuran histologi struktur tubul proksimal dan distal. Kajian oleh Bosch-Panadero et al. (2018) menunjukkan BPA mengakibatkan kecederaan mitokondria dan menyebabkan kematian pada sel tubul selepas pendedahan secara akut dan kronik. Pada tahap akut, viabiliti tubul proksimal didapati menurun dengan ketara selepas pendedahan BPA pada kepekatan yang tinggi iaitu ≥50 μM sementara pada tahap kronik, pendedahan BPA pada dos yang lebih rendah selama 7 hari menunjukkan tubul proksimal kehilangan sedikit viabiliti yang tidak boleh dikesan melalui pemerhatian histologi sahaja (Bosch-Panedero 2018). Pendedahan jangka panjang BPF pada dos yang rendah mungkin telah menyebabkan perubahan nanomolar pada sel tubul ginjal namun tidak dapat dilihat melalui pemerhatian histologi. Selain itu, pendedahan BPF turut menyebabkan berlakunya pengecutan pada struktur glomerulus tikus kajian. Pemberian BPA secara kombinasi dengan plumbum dan endosulfan telah menyebabkan glomerulus mengecil pada tikus jantan albino Wistar melalui mekanisme tekanan oksidatif (Dökmeci et al. 2022). Ini mungkin menerangkan pengecutan glomerulus pada tikus kajian akibat aruhan BPF adalah disebabkan oleh peningkatan pembentukan ROS dalam ginjal tikus kajian.

KESIMPULAN

Pemberian BPF pada dos 10 mg/kg telah menyebabkan berlakunya tekanan oksidatif pada ginjal tikus kajian. Selain itu, BPF tidak menyebabkan gangguan pada aktiviti Na+/K+ ATPase ginjal tikus kajian. Namun begitu, BPF telah menyebabkan pengecutan struktur glomerulus tikus kajian yang diaruh BPF pada dos 10 mg/kg.
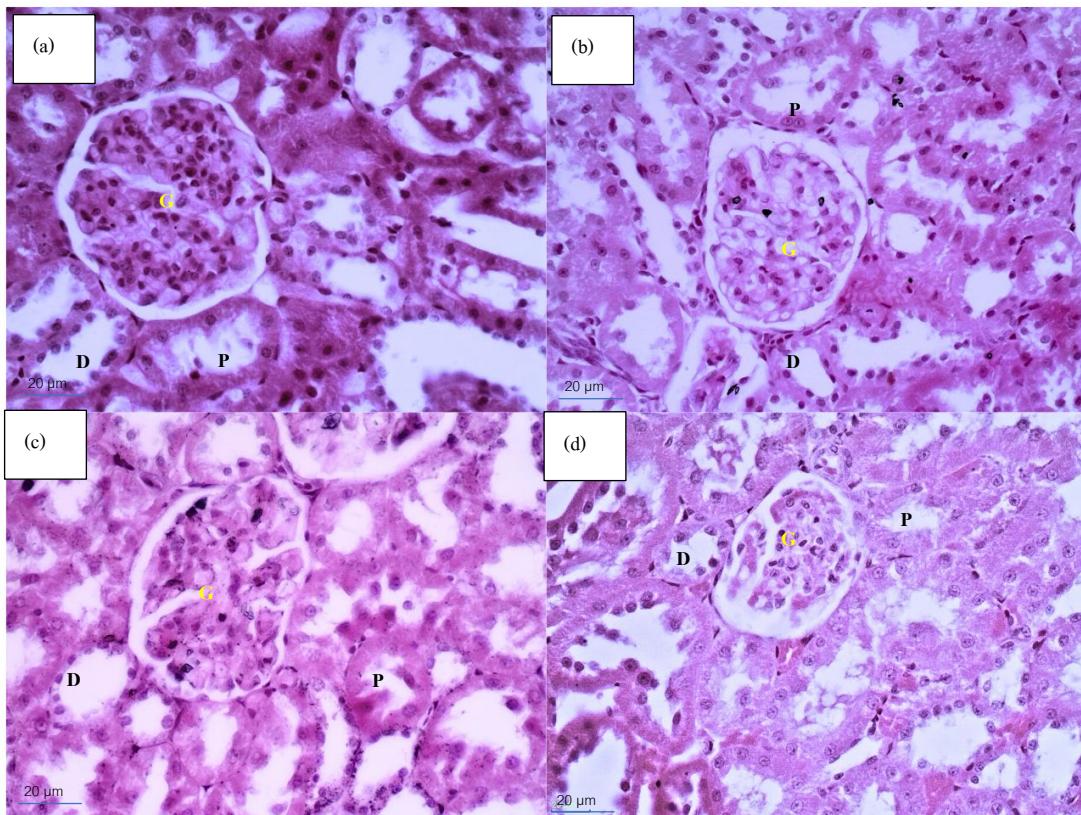
RAJAH 8 Histologi ginjal tikus kumpulan kajian di bawah pembesaran X40 dengan skala: 20 μm menggunakan mikroskop cahaya. (a) Kumpulan kawalan; (b) Kumpulan BPF1; (c) Kumpulan BPF5; (d) Kumpulan BPF10. Glomerulus (G) kumpulan kawalan, BPF1 dan BPF5 menunjukkan struktur yang normal yang dicirikan dengan struktur kapilari yang kompleks dan saiz kapsul Bowman yang normal. Glomerulus (G) kumpulan BPF10 menunjukkan pengecutan seperti yang ditunjukkan dengan tanda*. Tubul proksimal (P) untuk semua kumpulan tidak menunjukkan sebarang perubahan yang dicirikan dengan lapisan epitelium yang bersilia menjadikan lumen kurang jelas (P). Tubul distal (D) untuk semua kumpulan tidak menunjukkan sebarang perubahan yang dicirikan dengan lapisan epitelium yang tidak bersilia menjadikan lumen lebih luas (D).

Tiada perubahan dikesan pada tubul proksimal dan distal. Oleh itu, pengecutan struktur glomerulus adalah disebabkan oleh peningkatan ROS pada ginjal tikus aruhan BPF. Kajian seterusnya perlu dilakukan bagi menilai fungsi ginjal dengan mengukur aras kreatinin dan urea serta kadar filtrasi glomerulus dalam tikus aruhan BPF.

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Laporan Kes / Case Report

Addressing Failure to Thrive in a Preterm Infant with Respiratory Syncytial Virus Pneumonia and Poor Weight Gain: A Case Report

Mengatasi Kegagalan Tumbesaran pada Bayi Pramatang dengan Pneumonia Virus Pernafasan Sinsitial dan Peningkatan Berat Badan yang Lemah: Laporan Kes

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ABSTRACT

A 1-year-1-month-old premature Chinese male infant with respiratory syncytial virus (RSV) pneumonia, on a background of bronchopulmonary dysplasia (BPD) was referred to a dietitian for nutritional optimization due to failure to thrive (FTT). Since discharge from the neonatal intensive care unit (NICU), he demonstrated suboptimal weight gain, gaining only 1.58 kg (approximately 7 g/day). During admission, his weight was 7.08 kg (below the 5th percentile, indicating underweight) and length was 70.5 cm (10th–25th percentile) based on the CDC growth chart. Biochemical Data revealed high WBC (19.4×10^9/L) indicating an infection, low Sodium (135 mmol/L) suggesting electrolyte imbalance and elevated Potassium (4.8 mmol/L) suggesting hyperkalemia risk, necessitating further investigations. He experienced constipation for one week before admission due to antibiotics and was noted to be on goat milk formula based on family belief that it aids digestion and relieves constipation. The primary goal was to optimize oral intake to meet at least 75% of energy and nutrient requirements, support immune function and recovery, and achieve appropriate weight gain. Long-term goals included minimizing potassium overload to protect renal function and promoting optimal growth and development. This case highlights the importance of individualized nutrition intervention in infants with FTT, particularly those on alternative formulas such as goat milk and concurrently managing viral infections.

Keywords: Failure to Thrive (FTT), Goat Milk Formula, Respiratory Syncytial Virus (RSV), Nutritional Optimization

ABSTRAK

Seorang bayi lelaki pramatang berusia 1 tahun 1 bulan berbangsa Cina dengan pneumonia respiratory syncytial virus (RSV) dan latar belakang bronchopulmonary dysplasia (BPD) dirujuk kepada pakar dietetik akibat kegagalan tumbesaran (failure to thrive, FTT). Sejak discaj daripada NICU, beliau hanya meningkat 1.58 kg (±7 g/hari). Semasa kemasukan, berat badan 7.08 kg (< persentil ke-5) dan panjang 70.5 cm (persentil ke-10–25, CDC). Ujian biokimia menunjukkan kiraan WBC tinggi (19.4×10^9/L) menandakan jangkitan, natrium rendah (135 mmol/L) serta kalium tinggi (4.8 mmol/L) yang berisiko hiperkalemia. Pesakit mengalami sembelit seminggu akibat antibiotik dan mengambil susu formula kambing berasaskan kepercayaan keluarga bahawa ia membantu penghadaman. Matlamat pemakanan adalah memastikan pengambilan sekurang-kurangnya 75% keperluan tenaga dan nutrien, menyokong fungsi imun dan pemulihan, serta meningkatkan pertumbuhan. Jangka panjang, intervensi memberi tumpuan kepada kawalan kalium bagi melindungi fungsi buah pinggang dan menyokong

perkembangan optimum. Kes ini menekankan kepentingan intervensi pemakanan individu pada bayi dengan FTT, khususnya yang mengambil formula alternatif seperti susu kambing, di samping pengurusan jangkitan virus.

Kata Kunci: Failure to Thrive (FTT), Susu Formula Kambing, Respiratory Syncytial Virus (RSV), Pengoptimuman Pemakanan

INTRODUCTION

The term 'faltering growth' (previously called 'failure to thrive') is widely used to refer to a slower rate of weight gain in childhood than expected for age and sex. The term faltering growth is preferred as periods of slow growth may represent temporary variation from the expected pattern and the word 'failure' may be seen as pejorative (NICE 2017). It is characterized by poor physical growth, where a child's weight, height, or head circumference falls below standard growth charts, typically defined as weight below the 3rd percentile or more than 20% below ideal weight for height. Growth may also slow or stop entirely, often due to inadequate nutritional intake or underlying medical conditions (Kaneshiro 2023).

In Malaysia, Respiratory Syncytial Virus (RSV) is one of the most common respiratory infections, primarily affecting children under three years of age. It is a highly contagious virus that targets the nose, throat, and lungs, often leading to flu-like symptoms and breathing difficulties. RSV is the leading cause of hospitalisation among infants, with higher risk observed in children with congenital heart disease (CHD) and bronchopulmonary dysplasia (BPD). RSV often causes a mild, cold-like illness, it can lead to severe complications such as bronchiolitis and pneumonia. (CDC: RSV in Infants and Young Children. 2024; Suganthi. et al. 2023).

Most infant formulas are based on cow milk proteins. However, due to multiple factors, including consumer interest in alternatives, goat milk has gained popularity for manufacturing infant, follow-on, and young child formulas over the past 30 years (Gallier et al. 2020). The use of goat-milk-based formulas (GMF) is rising globally, largely due to their unique compositional benefits. Recently, goat-milk-based infant formulas (GMF) are available in several countries and have been approved by regulatory agencies such as the European Food Safety Authority (EFSA). According to the EFSA Panel (2012), goat milk protein can be considered a suitable protein source for infant and follow-on formulas, provided that careful attention is given to the protein content and nutrient composition.

CASE PRESENTATION

A 1-year-1-month-old Chinese boy, born prematurely at 27 weeks and 5 days (extreme prematurity) with corrected age of 10 months, was admitted with Respiratory Syncytial Virus (RSV) pneumonia on a background of bronchopulmonary dysplasia (BPD) and isolated gross motor delay with resolved Head-Only Control (HOC) plateau. He is the second child of the family with one older brother presented with a history of faltering growth. Main caregiver is the mother, who is a housemaker whereas the father works as a CEO in an industry setting with stable financial status. Medically, he had been unwell for the past two weeks and was previously admitted to another hospital for BPD, where he received intravenous penicillin and a 10-day course of oral amoxicillin prior to discharge. However, he was readmitted to this hospital due to worsening cough, rapid breathing, and fever. Given his suboptimal growth trajectory and persistent poor oral intake, he was referred to a dietitian for nutritional optimization to address failure to thrive (FTT).

NUTRITION ASSESSMENT

ANTHROPOMETRY MEASUREMENTS

The patient was born with a very low birth weight of 1.08 kg and weighed 7.08 kg (below the 5th percentile) upon admission. During his stay in the neonatal intensive care unit (NICU), his weight steadily increased from 1.08 kg to 5.5 kg, placing him at the 50th percentile on the CDC growth chart. At that time, he was on nasogastric tube feeding due to being ventilated for nosocomial bronchopneumonia. This allowed him to meet his energy and protein requirements, resulting in an expected growth rate. However, after discharge from the NICU and returning home, his weight gain slowed significantly, leading to a growth rate below expectations. His weight progression was as follows:

- 4.5 months: 6.1 kg (on 10th percentile)
- 7 months: 6.4 kg (below 5th percentile)
- 8.5 months: 6.85 kg (below 5th percentile)
- 10 months: 7.08 kg (below 5th percentile)

Since his last NICU discharge 7 months ago, the patient has gained only 1.58 kg (7g/day). highlighting concerns regarding his growth trajectory. His weight initially showed optimal growth at the 50th percentile during discharge (5kg). However, recently his weight gain trajectory has slowed, placing him below 5th percentile, whereas the same goes to length trajectory placing him between 10th and 25th percentile after discharge. Hence, the target weight for this patient is 8.0 kg, aligning with the 5th percentile on the growth chart)..
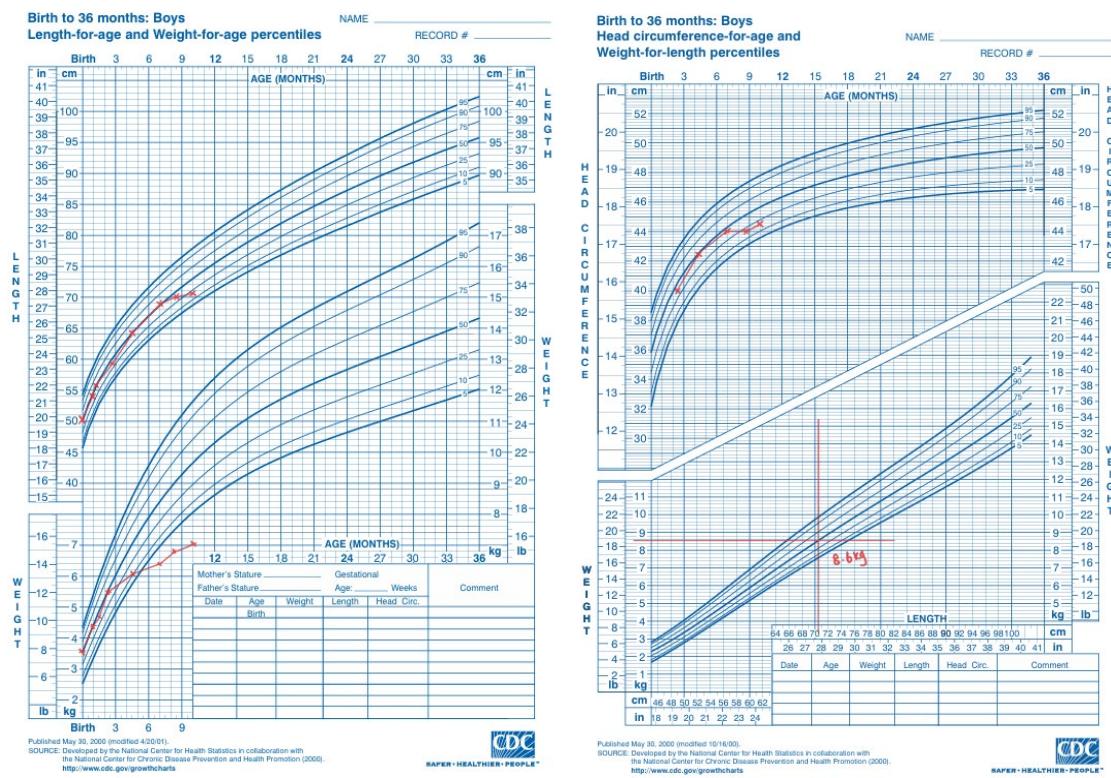
FIGURE 1 CDC Growth Chart 2001

TABLE 1 Dietary History at Home

In Ward	
Milk Formula Regime	• 1 scoop *Purenat Gold* + 50ml H2O, 2x/day (8am and 10am) • 2 scoops *Purenat Gold* + 100ml H2O, 3x/day (1pm, 4.30pm and 7.45pm) • Energy: 361.2kcal; Protein: 7.56g; Potassium: 960.8mg (exceeded recommendation of 700mg/day from RNI 2017) • No solid food intake
The total intake in ward was **361.2kcal (51 kcal/kg BW)** and **23.5g protein (3.3g/kg BW).**	
At Home	
Milk Formula Regime	• 2 scoops *Purenat Gold* + 100ml H2O, 5x/day • Energy: 425kcal; Protein: 22g • Potassium: 1201mg/day (exceeded recommendation of 700mg/day from RNI 2017)
Oral Regime	• 40-60ml porridge + minced chicken/1 whole egg yolk + 1 drop MCT oil (12pm and 7pm) • Energy: 125kcal; Protein: 1.5g • Reported the porridge was watery and the chicken/egg were not mixed well during feeding. • The mother reported limited knowledge of nutrient-dense diets and lack of varieties of food provided.
The total daily intake at home was **550kcal (77.7kcal/kg BW)** and **23.5g protein (3.3g/kg BW).**	

TABLE 2 Nutrition intervention and follow-ups

Dietitian First Visit	
Although the importance of standard post-discharge formulas like Similac Neosure was emphasized and parental education provided, the family strongly preferred goat milk formula (GMF), citing improved stool patterns and constipation with Similac Neosure. Suggested to change to a complete, balanced catch-up growth goat milk formula (*Resurge Junior*) due to the high potassium content of the current formula, which poses a risk of hyperkalemia if continued. Other than that, *Purenat Gold* Goat Milk does not support catch-up growth, which might cause inadequate nutrient consumption to improve development. MCT oil was suggested to add into the milk instead of food for better acceptance. Mother was informed to measure the volume of MCT oil precisely using a syringe before adding into the milk formula.	
Suggested milk formula feeding regime	• Step 1: 2 scoops *Resurge Junior* + 100ml H2O, 5x/day + 1ml MCT oil in each feeding • Step 2: 2.5 scoops *Resurge Junior* + 100ml H2O, 5x/day + 1ml MCT oil in each feeding • Advance to Step 2 once tolerated Step 1 for 24 hours. • Energy: 547.5kcal; Protein: 16.8g, Calorie density: 1.1kcal/ml • Potassium: 500mg (within safe range 700mg/day)
Suggested oral regime	• A pureed diet was indented, including fruit puree during lunch and dinner and baby *Cerelac* during afternoon tea. • Nutrition education was given to the mother focusing on nutrient-dense diet by ensuring each spoonful of food contains a balanced mix of porridge, protein, and fiber during feeding. • Encourage orally as tolerated. • Aiming the remaining requirements from solid foods.
Monitoring and Evaluation:	
The patient's intake was documented in terms of volume and nutrient adequacy, and the tolerance to the goat milk formula introduced, such as vomiting, regurgitation, stool pattern and abdominal discomfort was monitored daily to ensure well compliance and adherence. Weight status was monitored.	
First Follow Up **(3 days after initial visit)**	
The patient's current body weight was 7.17kg, increased 0.1kg (1.3%) within 3 days. Bowel movements normalized to once daily (Bristol Type 6) following Ravin enema, resolving prior constipation. The patient's appetite improved. A detailed 24-hour dietary recall was conducted as follows: 2.50am: 2.5 scoop *Resurge Junior* + 100ml H2O + 1ml MCT oil 9.30am: Pureed porridge ¾ exchanges 12.40pm: Pureed porridge ¼ exchanges 2.50pm: 2.5 scoops *Resurge Junior* + 1ml MCT oil 4.45pm: 2.5 scoops *Resurge Junior* + 1ml MCT oil 9.15pm: 2.5 scoops *Resurge Junior* + 1ml MCT oil 11.30pm: ½ teaspoon fruit puree Estimated total intake: **545 kcal (achieved 51% from EER)** and **15.4g (2.1g/kg/d) of protein (achieved 62% from requirement).** **Nutrition Diagnosis:** [Active] Inadequate protein energy intake related to physiological causes (failure to thrive and RSV pneumonia) resulting in increased protein and energy needs [Physiologic Metabolic etiology] as evidenced by weight gain 1.3% within 3 days, diet assessment in ward shows energy and protein intake only achieves 51% and 62% from requirement respectively.	

[Resolved] Excessive mineral intake (potassium) related to food- and nutrition-related knowledge deficit concerning appropriate food and supplemental sources of minerals [Knowledge etiology] as evidenced by dietary assessment shows high amounts of potassium consumption compared to reference intake standard from RNI 2017 (700mg/day).

Adjusted milk formula feeding regime	Continue complete, balanced catch-up growth goat milk formula: • 2.5 scoops *Resurge Junior* + 100ml H2O, 5x/day + 1ml MCT oil in each feeding once tolerated well during hospitalization. • Energy: 547.5kcal; Protein: 16.8g, Calorie density: 1.1kcal/ml

Adjusted oral regime	1. Encourage orally as tolerated.
	2. Weaning diet education (10–12 months).
	• Introduce variety of soft foods such as cut noodles or kuey teow.
	• Encourage variety by introducing one new food every 3–5 days; repeat if initially refused (e.g., fish, chicken with different cooking methods).
	• Promote regular meal timing.
	• Provide home food preparation examples and a sample menu plan.
	3. Nutrient-dense diet education.
	• Suggest *Cerelac* with mashed banana or fruit puree during teatime to increase fiber.
	• Emphasize balanced feeding: each spoonful should include carbohydrates, protein, and fiber.
	• Recommend calorie-enhancing methods:
	   o Stir-fry meat before mincing and adding to porridge
	   o Add starchy vegetables (e.g., pumpkin, potato).
	   o Include MCT oil or olive oil in porridge.
	• Recommend protein-boosting strategies:
	   o Mix *Cerelac* with goat milk/yogurt.
	   o Blend chicken, fish, or egg into porridge.
	4. Encourage adequate water and fiber intake.
	5. Feeding environment to stimulate appetite.
	• Promote family mealtimes without distractions to enhance bonding and eating behaviour.
	6. Feeding skills development.
	• Encourage self-feeding with soft finger foods to support motor skills and independence.

Second Follow-up
(3 days after first follow-up contacted via WhatsApp)

The mother reported watery stools (Bristol Type 7) after introducing *Resurge Junior*, prompting a request to alternate with *Similac Neosure*. This may be a post-effect of the earlier Ravin enema, though further evaluation is warranted.

Milk formula regime provided by mother:
Similac Neosure 2scp + 120ml water + 1ml MCT oil, 2x/day (0.84kcal/ml)
Resurge Junior 3scp + 120ml water + 1ml MCT oil, 3x/day (1.1kcal/ml)
Total intake from formula:
Energy: 200.48 + 394.2 + 40 = 634.7kcal
Protein: 5.2g + 12.06 = 17.3g

Current diet intake at home:
1.5 exc porridge + 1 exc Chicken + vege + oil, 2x/day, fruit puree 1 exc and yogurt finger foods as snack.

	Total intake from diet: 327.5kcal, 10g protein Estimated total intake: **962.2kcal (achieved 91% from requirement), 27.3g protein (achieved 100% from requirement)** The mother reported in the next two day, the patient's bowel movements, occurring 1–2 times per day, improved to Bristol Stool Chart types 4–5 after combining *Similac Neosure* and *Resurge Junior*, indicating better stool pattern and consistency. Noted well adherence to the nutrition education provided. **Nutrition Diagnosis:** [Resolved] Inadequate protein energy intake related to physiological causes (failure to thrive and RSV pneumonia) resulting in increased protein and energy needs [Physiologic Metabolic etiology] as evidenced by dietary assessment at home shows energy intake achieved 91% from EER and protein intake achieved 100% from requirement.
Adjusted milk formula feeding regime	Continue current feeding regime: • 3 scoops *Resurge Junior* + 120ml H2O + 1ml MCT oil, 3x/day and 2 scoops *Similac Neosure* + 120ml H2O + 1ml MCT oil, 2x/day • Energy: 634.7kcal; Protein: 17.3g • Calorie density: 0.84kcal/ml (*Similac Neosure*);1.1kcal/ml (*Resurge Junior*) • Potassium: 636.7mg/day (within recommendation of 700mg/day) • Suggested to increase feeding regime for *Resurge Junior* to 4x/day and reduce *Similac Neosure* to 1x/day, with close monitoring of stool pattern to rechallenge back to full *Resurge Junior*. • Keep in view to revert to the previous feeding regime if watery stools are observed.
Adjusted oral intake regime	Encourage orally as tolerated.

In addition, the patient's head circumference was 44.5cm, placed between 10th and 25th percentile, whereas the weight for length was 8.6kg (on 50th percentile).

BIOCHEMICAL ASSESSMENTS

The latest full blood count (FBC) profile revealed an elevated white blood cell (WBC) count of $19.4×10^9$/L (normal: $6-18×10^9$/L), indicating an infection associated with RSV pneumonia. For the renal profile, sodium was low at 131 mmol/L (normal: 133-145 mmol/L), suggesting electrolyte imbalance likely due to poor oral and fluid intake. Additionally, potassium was at the borderline of the upper limit at 4.8 mmol/L (normal: 3.5-5.1 mmol/L), raising concerns about excessive potassium intake as the patient had a medical history of hyperkalemia (Simon, L. V. et al. 2023), potentially linked to the current goat milk formula consumption.

NUTRITION-FOCUSED PHYSICAL FINDINGS

In the ward, the patient was observed lying in bed, ambulating freely, and crying with persistent coughing noted. His Glasgow Coma Scale (GCS) score was full, and he was on nasal prong oxygen at 2L/min. His vital signs showed elevated blood pressure (105/55 mmHg), normal heart rate (159 bpm) and respiratory rate (40 rpm), and febrile temperature (38°C). The patient had experienced constipation one week before admission with no bowel output, might be due to oral amoxicillin and was administered Ravin enema for relief. Subjective Global Nutritional Assessment (SGNA) scoring indicated moderate malnutrition. The input-output (I/O) chart showed positive balance of +223 ml.

DIETARY ASSESSMENTS

This is the patient's first-time seeing dietitian in a pediatrics ward. Upon assessment, he was on Purenat Gold Goat Milk Powder for 3 weeks as the mother believed it was better for digestion and aided in bowel opening, since the patient developed constipation after consumption of Similac Neosure for post-discharge from NICU. Low appetite was noted as the patient refused to eat. The mother reported that medium-chain triglyceride (MCT) oil had been added to the patient's meals since the last discharge from the NICU; however, she was unable to specify the exact amount used, as it was added based on estimation. It was also noted that the patient occasionally refused food, potentially due to the presence of MCT oil.

NUTRITION DIAGNOSIS

[New] Excessive mineral intake (potassium) related to food- and nutrition-related knowledge deficit concerning appropriate food and supplemental sources of minerals [Knowledge etiology] as evidenced by dietary assessment shows current milk formula contributed to high amounts of potassium consumption compared to reference intake standard from RNI 2017 (700mg/day). [New] Inadequate protein energy intake related to physiological causes (failure to thrive and RSV pneumonia) resulting in increased protein and energy needs [Physiologic Metabolic etiology] as evidenced by current weight below 5th percentile, diet assessment in ward shows energy and protein intake only achieves 34% and 30% from requirement respectively.

NUTRITION INTERVENTION

The short-term goal for this patient was to prevent excessive potassium intake to avoid potential strain on renal function, to achieve optimal nutritional status by achieving at least 75% of estimated energy and protein requirements through adequate oral intake, and to support immune function and recovery. In the long term, efforts were also directed to achieve as near to normal weight gain and growth by achieving at least 5th percentile and targeting for further development. Nutrition education and counselling was provided to the mother throughout the hospital stay.

ESTIMATED ENERGY REQUIREMENT (EER):

Based on Dorothy for Sick Children (Dorothy E. M. Francis, 1987) guidelines for children aged 6 to 12 months, an energy requirement of 150 kcal/kg body weight was applied to support higher energy intake. This was necessary as the patient was ill, experiencing persistent coughing and viral infection, leading to increased energy expenditure. Additionally, due to failure to thrive (FTT), an increased energy intake was essential to promote adequate growth and weight gain. 50kcal x 7.08kg = 1062kcal/day

ESTIMATED PROTEIN REQUIREMENT:

Based on the Dorothy for Sick Children (Dorothy . & Francis 1987) guidelines for children aged 6 to 12 months, a protein requirement of 3.5 g/kg body weight was applied to support optimal growth and strengthen the immune system to help combat the viral infection. 3.5g x 7.08kg = 24.8g/day

There was no total fluid intake determined by the pediatrician. There were two follow-ups done after the first visit and the intervention plans were summarized in the

DISCUSSION

Optimizing nutritional status in a preterm infant with failure to thrive and RSV pneumonia is challenging, influenced by factors such as prematurity, prolonged inadequate energy and protein intake post-NICU discharge, and strong family preference for a specific formula.

Infants with faltering growth often face feeding difficulties such as food refusal, crying, and vomiting (Shaw 2020). In RSV pneumonia, symptoms like poor intake, lethargy, and coughing further impair appetite and growth (Drysdale et al. 2016). Additionally, respiratory distress increases energy expenditure due to the extra effort required for breathing, further worsening nutritional deficits. Preterm infants are especially vulnerable, with higher risks of poor weight gain, longer hospital stays, and mortality. Following NICU discharge, the mother lacked appropriate knowledge on preparing a nutrient-dense diet, which contributed to the infant's poor weight gain.

Despite strong family preference for goat milk formula (GMF), current evidence is insufficient to confirm its superiority over cow milk formula (CMF), although some studies suggested potential benefits. GMF increase the rate of gastric emptying and gastrointestinal transit compared to CMF, probably due to the coagulation properties and alteration on short-chain fatty acid (SCFA) profiles (Dalziel et al. 2020). Improvements in stool consistency have been observed, with infants fed GMF showing softer stools on the Bristol Stool Scale after 3 weeks intervention and experiencing more frequent, softer bowel movements (Infante et al. 2018). However, these benefits are primarily related to digestive tolerance rather than growth outcomes. Xu et al. (2015) found no significant differences in growth outcomes between infants fed GF and CMF. On the other hand, GMF might pose risks of nutrient imbalances, particularly elevated potassium and phosphate levels which may burden the immature kidneys of infants and increase the risk of electrolyte disturbances such as hyperkalemia and hyperphosphatemia (Jankiewicz et al. 2023). Hence, parental education is essential to ensure caregivers understand the potential risks and the importance of using nutritionally appropriate formulas to prevent nutrient deficiencies and support optimal growth.

A challenge arose during this case when transitioning the infant to a new nutritionally balanced goat milk formula (Resurge Junior), resulting in watery stools (Bristol Type 7). Resurge Junior contains A2 β-casein proteins, MCTs, and prebiotic fibers, which may accelerate GI transit and cause loose stools in some infants while promoting digestion (Łoś-Rycharska et al. 2016; Meng et al. 2023; Vandenplas et al. 2014). Additionally, the loose stool could be partially attributed to the residual effects of the Ravin enema administered

earlier, as infants with sensitive gastrointestinal systems may experience transient changes in stool consistency for up to 1–2 days post-enema. To manage this, a combined feeding approach using Resurge Junior and Similac Neosure (a nutrient-enriched cow milk-based formula for preterm infants) was introduced. This strategy balanced digestive comfort with nutritional adequacy, improving stool consistency while meeting dietary needs. As the infant approaches a corrected age of 12 months, it is appropriate to gradually transition back to Resurge Junior alone as Similac Neosure is intended for use up to 12 months, while Resurge Junior is formulated to support catch-up growth in children aged one year and above.

This case underscores the importance of individualized nutritional interventions, particularly in managing feeding intolerances and promoting growth in infants with failure to thrive and concurrent viral infections. It also highlights the value of tailored formula selection—initially combining different formula types to achieve digestive comfort and nutritional adequacy, followed by a gradual transition to a single appropriate formula, with close monitoring on stool pattern and to avoid excessive intake of mineral. Despite milk formula, oral diet also played an important role in optimization nutritional status. The caregiver played an active role in ensuring proper feeding regime, food preparation and adherence to dietary recommendations. As a result, the patient's appetite increased, weight improved and successfully achieved > 75% of the protein and energy requirements.

Limitations included the inability to assess the latest renal profile for potassium levels and obtain the most recent weight during the second follow-up, as the patient had already been discharged.

CONCLUSION

Dietitians play a crucial role in supporting the recovery and developmental outcomes of vulnerable pediatric patients through patient-centered interventions, including formula adjustment, nutrient-dense diet strategies, and tailored caregiver guidance. This case reinforces the critical role of individualized nutrition intervention in managing failure to thrive in a preterm infant with RSV pneumonia and poor weight gain. It highlights the need for ongoing caregiver education and close monitoring when alternative formulas are used.

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Artikel Asli /*Original Article*

Status Kesihatan Mental Dan Penggunaan Bahan Dalam Kalangan Ibu Remaja Di Selangor, Malaysia: Kajian Rintis

Mental Health Status and Substance Use Among Teenage Mothers in Selagor, Malaysia: A Pilot Study

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ABSTRACT

The issue of teenage pregnancy in Malaysia remains a public health concern, influenced by limited access to sex education and prevailing social norms. This study aimed to assess the mental health status and substance use among teenage mothers in Selangor. A quantitative cross-sectional study was conducted in two shelter homes in Selangor, involving 13 participants through total sampling. Data were collected using questionnaires on depression, anxiety, suicidal behavior, and a module from the National Health and Morbidity Survey on substance use. Results showed that 61.5% of participants experienced depressive symptoms and 76.9% had anxiety. Alarmingly, 38.5% had attempted suicide, and 92.3% were classified as high risk. In terms of substance use, 30.8% reported having used alcohol or illicit substances. This pilot study highlights the urgent need for more comprehensive research in this population. Mental health and substance use prevention interventions are crucial to address the vulnerabilities of teenage mothers in Malaysia.

Keywords: Adolescent pregnancy, depression, anxiety, suicidal ideation, suicide attempt, drug abuse, alcohol use

ABSTRAK

Isu kehamilan remaja di Malaysia kekal sebagai masalah kesihatan awam, dipengaruhi oleh akses terhad kepada pendidikan seks dan norma sosial. Kajian ini menilai kesihatan mental dan penggunaan bahan terlarang dalam kalangan ibu remaja di Selangor. Kajian keratan rentas kuantitatif melibatkan 13 peserta dari dua pusat perlindungan menggunakan pensampelan menyeluruh. Data dikumpul melalui soal selidik kemurungan, kecemasan, tingkah laku bunuh diri, dan modul dari Kajian Kesihatan dan Morbiditi Kebangsaan. Dapatan menunjukkan 61.5% mengalami simptom kemurungan, 76.9% kecemasan, dan 38.5% pernah mencuba membunuh diri. Sebanyak 92.3% diklasifikasikan sebagai berisiko tinggi. Dari segi penggunaan bahan, 30.8% pernah mengambil alkohol dan bahan terlarang. Kajian ini menekankan keperluan intervensi kesihatan mental dan pencegahan penyalahgunaan bahan bagi menangani kerentanan ibu remaja. Kajian masa depan perlu melibatkan sampel lebih besar dan pelbagai untuk memahami isu ini dengan lebih mendalam serta memaklumkan dasar dan program yang berkesan.

Kata Kunci: Kehamilan remaja, kemurungan, kecemasan, pemikiran untuk membunuh diri, cubaan membunuh diri, penyalahgunaan dadah, penggunaan alkohol.

PENGENALAN

Kehamilan dalam kalangan remaja merujuk kepada keadaan di mana seorang gadis atau remaja hamil ketika berumur antara 13 hingga 19 tahun (Cook & Cameron 2017). Di Malaysia, menurut statistik rasmi, lebih daripada 500,000 kelahiran luar nikah telah direkodkan dari tahun 2005 hingga 2015 (Ahmad & Dahlan 2019), yang menunjukkan betapa seriusnya keperluan untuk menangani isu ini. Laporan menunjukkan peningkatan permulaan aktiviti seksual secara awal, dan hubungan seks tanpa perlindungan (Hamzah 2020). Menurut Kajian Kesihatan dan Morbiditi Nasional 2017, sebanyak 7.3% daripada remaja Malaysia melaporkan pernah menjalani hubungan seks sebelum umur 14 tahun (Institut Kesihatan Umum 2018), dan kajian menunjukkan ada yang memulainya seawal usia 13 tahun (Panting & Siu Mien 2020).

Perbuatan hubungan seks sebelum berkahwin memberikan implikasi yang signifikan terhadap ibu remaja. Selain risiko fizikal seperti keguguran yang tidak selamat, ramai yang berdepan dengan stigma, pengasingan sosial, serta cabaran psikologikal termasuk kegelisahan dan kemurungan (Sejati & Mufida 2021; Hodgkinson et al. 2014). Kesannya dari segi sosial boleh meliputi berhenti sekolah, penolakan oleh keluarga, serta kelemahan ekonomi dalam jangka panjang (Hayward 2011). Tambahan pula, mereka sering mengalami rasa malu, diskriminasi, dan pengasingan disebabkan oleh norma masyarakat (Hussein & Ferguson 2019). Tekanan sosial ini, berpotensi memperburuk cabaran kesihatan mental mereka.

Memandangkan kecemasan yang semakin meningkat berkenaan dengan kesihatan reproduktif remaja, adalah penting untuk menilai status kesihatan mental dan penggunaan bahan terlarang dalam kalangan ibu remaja. Kajian ini bertujuan untuk mengisi kekurangan maklumat tersebut dengan mengumpul data awal mengenai tahap kemurungan, kegelisahan, tingkah laku membahayakan diri sendiri dan bunuh diri, serta penggunaan bahan terlarang dalam kalangan ibu remaja di Selangor, Malaysia.

BAHAN DAN METODOLOGI

REKA BENTUK KAJIAN DAN LOKASI

Kajian ini merupakan kajian keratan rentas menggunakan pendekatan kuantitatif bagi mengumpul data perintis. Dua pusat perlindungan di Selangor, Malaysia disampel untuk tujuan kajian ini.

PESERTA KAJIAN

Peserta-peserta direkrut melalui pensampelan menyeluruh (universal sampling), yakni kesemua ibu remaja di pusat perlindungan yang memenuhi kriteria kemasukan dan pengecualian telah dijemput untuk menyertai kajian ini. Kriteria inklusi adalah

seperti berikut: (1) warganegara Malaysia, (2) belum pernah berkahwin, (3) berumur antara 16 hingga 18 tahun, (4) kini berdaftar di bawah jagaan pusat perlindungan di Selangor, Malaysia, , dan (5) mampu membaca dan memahami Bahasa Malaysia. Kriteria penolakan pula termasuk: (1) telah bercerai dan (2) berstatus duda/janda.

INSTRUMENTASI KAJIAN

DATA DEMOGRAFIK

Maklumat demografi peserta dikumpulkan, yang merangkumi umur, bangsa, tahap pendidikan, bilangan anak, agama, pendapatan keluarga, negeri asal, dan kawasan penempatan.

KEMURUNGAN DAN KECEMASAN

Soal Selidik Kesihatan Pesakit-4 (Patient Health Questionnaire-4; PHQ-4) merupakan satu set empat soalan dengan skor jenis Likert, iaitu dari 0 = "Tidak Sama Sekali" ke 3 = "Hampir Setiap Hari" (Löwe et al. 2010). Dengan menggabungkan ukuran dua-item (PHQ-2), yang mengandungi kriteria utama untuk kemurungan, serta ukuran dua-item Gangguan Kecemasan Umum-2 (Generalised Anxiety Disorder-2; GAD-2) untuk kecemasan, kedua-duanya telah terbukti secara berasingan sebagai alat saringan ringkas yang berkesan. Jumlah skor > 2 menunjukkan hasil saringan positif bagi simptom kemurungan dan keresahan. Versi Bahasa Melayu PHQ-4 menunjukkan kebolehpercayaan yang sangat baik dengan nilai Alfa Cronbach sebanyak 0.90 (Tan et al. 2024).

PERILAKU BUNUH DIRI

Soal Selidik Tingkah Laku Bunuh Diri-Semakan (Suicidal Behaviors Questionnaire-Revised; SBQ-R, Osman et al. 2001) direka untuk menilai fikiran dan tingkah laku bunuh diri. Skala SBQ-R mempunyai nilai Alfa Cronbach sebanyak 0.74 bagi golongan dewasa muda (Hamza & Willoughby 2013). Skor melebihi 6 menunjukkan adanya risiko bunuh diri. Dalam konteks Malaysia, versi Bahasa Melayu SBQ-R telah divalidasi dengan nilai Alfa Cronbach sebanyak 0.81 (Siau et al. 2024).

PENGGUNAAN TEMBAKAU, VAPE, ALKOHOL DAN DADAH

Penggunaan Tembakau, Vape, Alkohol dan Dadah diukur menggunakan set soal selidik yang dipilih daripada Kajian Kesihatan dan Morbiditi Kebangsaan 2019 (Institut Kesihatan Umum, 2020). Modul-modul CE, CF dan CG ini digunakan untuk menilai keberadaan penggunaan bahan terlarang dalam kalangan responden, termasuk merokok, vaping, pengambilan alkohol, dan pengambilan

dadah. Item-item yang berasal daripada Modul CE, CF, dan CG dalam Kajian Kesihatan dan Morbiditi Kebangsaan 2019 telah diuji dan terbukti sah digunakan dalam populasi Malaysia (Institut Kesihatan Umum, 2020)..

PROSEDUR KAJIAN

Ibu remaja yang belum berkahwin telah didekati dari pusat perlindungan yang dipilih untuk mendapatkan kebenaran mereka bagi menyertai kajian ini. Penyelidik telah memberikan penjelasan secara teliti mengenai matlamat dan kaedah kajian kepada mereka. Setelah menerima izin daripada penjaga and remaja terlibat, mereka diberikan satu siri soal selidik bercetak yang perlu dilengkapkan, yang dianggarkan mengambil masa sekitar 25 minit. Setiap responden diberikan nombor pengenalan bagi memastikan identiti mereka kekal rahsia.

ANALISIS DATA

Analisis deskriptif digunakan untuk menilai tahap status kesihatan mental (kemurungan, kegelisahan, dan tingkah laku bunuh diri) serta penggunaan bahan terlarang.

ETIKA KAJIAN

Kelulusan etika telah diperoleh daripada Jawatankuasa Etika Penyelidikan Universiti Kebangsaan Malaysia (JEP-2024-910). Semua peserta dan penjaga mereka telah diberikan borang kebenaran bermaklum (*informed consent*) dan persetujuan (*assent*) pada permulaan pengumpulan data.

HASIL KAJIAN DAN PERBINCANGAN

Jadual 1 menunjukkan profil demografi peserta. Kajian ini melibatkan 13 peserta berumur antara 16 tahun hingga 18 tahun, dengan kebanyakan (53.8%) berumur 17 tahun. Golongan ini kebanyakannya berbangsa Melayu (92.3%) dan semuanya beragama Islam. Kebanyakan daripada mereka telah menamatkan pengajian sekolah menengah (61.5%), manakala yang lain mempunyai pendidikan sekolah rendah (30.8%) atau tidak bersekolah secara formal (7.7%). Kebanyakan peserta tinggal di kawasan bandar (84.6%). Peserta berasal dari pelbagai negeri di Malaysia, terutamanya Selangor (38.5%), diikuti oleh Wilayah Persekutuan, Negeri Sembilan, dan Perak (masing-masing 15.4%), serta Terengganu dan Kedah (masing-masing 7.7%). Dari segi pendapatan keluarga, kebanyakan keluarga (30.8%) memperoleh pendapatan antara RM1,001 hingga RM2,000. Lebih separuh daripada ibubapa peserta (53.8%) bercerai, 30.8% berkahwin, dan 15.4% berpisah (rujuk Jadual 1).

Berdasarkan data dalam Jadual 2, kebanyakan peserta melaporkan masalah kesihatan mental, di mana 61.5% mengalami simptom kemurungan dan 76.9% melaporkan simptom kegelisahan. Kira-kira 38.5% pernah cuba membunuh diri dalam hidup mereka, dan jumlah yang sama melaporkan pemikiran bunuh diri yang sangat kerap (lima kali atau lebih) dalam tahun lalu. Berkaitan kemungkinan tindakan bunuh diri di masa hadapan, 23.1% menyatakan "agak berkemungkinan" dan 7.7% menyatakan "sangat berkemungkinan," manakala 15.4% tidak melihat sebarang peluang. Skor risiko bunuh diri purata adalah 12.31 (SD = 3.521), dengan 92.3% dikategorikan sebagai berisiko tinggi. Dari segi penggunaan bahan terlarang, 30.8% pernah minum arak, tetapi hanya 15.4% melakukannya dalam tahun lalu. Penggunaan bahan terlarang sepanjang hayat turut dilaporkan oleh 30.8%. Bagi merokok dan vaping, 30.8% pernah merokok pada suatu ketika, dan 53.9% pernah mencuba vaping. Kebanyakan peserta (92.3%) kini vaping kurang daripada setiap hari (rujuk Jadual 2).

Kajian ini melaporkan hasil awal daripada tiga belas ibu remaja di Selangor mengenai kesihatan mental dan penggunaan bahan terlarang. Keputusan menunjukkan kadar kemurungan dan kegelisahan yang tinggi, dengan semua peserta mengalami ideasi bunuh diri dalam tahun lalu. Sepertiga melaporkan penggunaan bahan terlarang dan merokok, manakala lebih separuh pernah mencuba vaping. Dapatan ini menekankan keperluan kajian lanjutan yang lebih menyeluruh.

Dua pertiga peserta disaring positif bagi kemurungan, manakala tiga perlima bagi kegelisahan. Simptom serupa turut dilaporkan dalam negara berpendapatan rendah dan sederhana seperti Cameroon, dengan kadar kemurungan antara 60.9% hingga 70% (Miafo et al. 2024; Nicolet et al. 2021). Kajian di Sabah menunjukkan remaja yang aktif secara seksual cenderung mengalami kemurungan dan kegelisahan (Khan & Idris 2024). Ini dikaitkan dengan isu harga diri dan strategi daya tindak yang lemah. Kajian di Filipina turut mendapati menjadi ibu pada usia muda boleh menimbulkan tekanan psikologi, terutamanya jika diburukkan oleh konflik keluarga atau kesukaran ekonomi (Galleposo, 2024). Pengalaman negatif semasa kanak-kanak juga dikaitkan dengan risiko kehamilan remaja secara *dose-response*.

Status kesihatan mental yang merosot boleh mencetuskan tingkah laku bunuh diri. Satu pertiga daripada peserta pernah mencuba membunuh diri, melebihi kadar populasi remaja umum di Malaysia (Institut Kesihatan Umum, 2023). Kehamilan remaja sendiri merupakan faktor risiko kepada kematian awal, termasuk bunuh diri. Kajian kohort terhadap 2.2 juta remaja perempuan melaporkan kadar kematian awal sebanyak 1.9 per 10,000 tahun manusia bagi mereka yang tidak hamil, 4.1 bagi

yang hamil sekali, dan 6.1 bagi yang hamil dua kali atau lebih (Ray et al. 2024). Tingkah laku serupa turut dilaporkan di Ghana (Quarshie et al. 2025) dan Bangladesh (Li et al. 2020), menguatkan keperluan kajian lanjutan di Malaysia.

Percubaan bunuh diri selalunya didahului oleh ideasi bunuh diri (Large et al. 2020). Semua peserta dalam kajian ini melaporkan ideasi bunuh diri dalam tahun lalu. Ini mungkin berkait rapat dengan jumlah peserta yang mempunyai kemurungan dan kegelisahan yang tinggi. Coelho et al. (2014) mendapati remaja dengan kemurungan utama dan kecemasan umum mempunyai kemungkinan lebih tinggi untuk mengalami ideasi bunuh diri, masing-masing 2.41 dan 2.63 kali ganda. Oleh itu, penilaian ideasi bunuh diri serta sokongan psikososial amat diperlukan bagi ibu remaja.

Dari segi penggunaan bahan, hampir sepertiga peserta melaporkan pernah mengambil alkohol dan bahan terlarang, bertentangan dengan norma Islam dan sosial. Ini mencadangkan penglibatan dalam tingkah laku menyimpang. CDC (2021) menyatakan terdapat kaitan antara penggunaan dadah dan alkohol dengan kehamilan remaja. Di Scandinavia, remaja yang mula merokok dan minum alkohol lebih awal berisiko tinggi mengalami kehamilan remaja, melibatkan 11% populasi (Bennetsen et al. 2024). Hal ini menunjukkan keperluan kepada intervensi menyeluruh yang melibatkan kesihatan reproduktif dan pencegahan penyalahgunaan bahan secara serentak.

Penemuan awal ini memberi beberapa implikasi penting. Pertama, kajian lanjutan perlu dijalankan untuk menilai kelaziman dan faktor penyumbang terhadap isu kesihatan mental dan penggunaan bahan dalam kalangan ibu remaja. Di samping itu, kajian kualitatif juga boleh mendalami tema atau faktor yang menyumbang kepada ideasi membunuh diri dalam kalangan golongan ibu remaja dengan lebih lanjut. Kajian kuantitatif boleh dijalankan menggunakan sampel yang mewakili populasi lebih besar, manakala kajian kualitatif dapat menyelami pengalaman individu. Penyelidikan ini penting untuk membentuk dasar dan program yang responsif terhadap keperluan kumpulan ini.

Namun, terdapat beberapa kekangan. Disebabkan batasan masa dan akses, hanya tiga belas peserta dapat direkrut, menjadikan dapatan ini bersifat eksploratori. Tambahan pula, potensi bias laporan diri tidak dapat dielakkan kerana sifat soalan yang sensitif dan latar pusat perlindungan berasaskan Islam. Justeru, hasil kajian harus ditafsir dengan berhati-hati dan digunakan untuk membentuk protokol kajian yang lebih besar pada masa hadapan.

JADUAL 1 Profil Demografi Peserta ($N = 13$).

Pemboleh Ubah	*n*	%	Min (Sisih Piawai)
Umur (Tahun)			16.69 (0.630)
16	5	38.5	
17	7	53.8	
18	1	7.7	
Bangsa			
Melayu	12	92.3	
Bumiputera Lain	1	7.7	
Tahap Pendidikan Tertinggi			
Pendidikan Sekolah Menengah	8	61.5	
Pendidikan Sekolah Rendah	4	30.8	
Tiada Pendidikan Formal	1	7.7	
Negeri Asal			
Kedah	1	7.7	
Perak	2	15.4	
Terengganu	1	7.7	
Selangor	5	38.5	
Wilayah Persekutuan Kuala Lumpur	2	15.4	
Negeri Sembilan	2	15.4	
Kawasan Penempatan			
Bandar	11	84.6	
Luar Bandar	2	15.4	
Pendapat Isi Rumah Bulanan			

RM501-RM1000	3	23.1
RM1001-RM2000	4	30.8
RM2001-RM3000	1	7.7
RM3001-RM4000	3	23.1
RM4001-RM5000	1	7.7
RM5001 and above	1	7.7
Status Perkahwinan Ibu Bapa		
Berkahwin	4	30.8
Bercerai	7	53.8
Berpisah	2	15.4

JADUAL 2 Status Kesihatan Mental dan Penggunaan Bahan Peserta ($N = 13$).

Pemboleh Ubah	*n*	%	Min (Sisih Piawai)
Simptom Kemurungan			3.23 (1.964)
Ya	8	61.5	
Tidak	5	38.5	
Simptom Kecemasan			3.62 (1.981)
Ya	10	76.9	
Tidak	3	23.1	
Percubaan Membunuh Diri Seumur Hidup			
Ya	5	38.5	
Tidak	8	61.5	
Ideasi Membunuh Diri Tahun Lepas			
Tidak Pernah	0	0.0	
Jarang (1 kali)	2	15.4	
Kadang-kala (2 kali)	2	15.4	
Kerap (3-4 kali)	4	30.8	
Amat Kerap (5 kali atau lebih)	5	38.5	
Kebarangkalian Tingkah Laku Membunuh Diri Pada Masa Hadapan			
Tidak Pernah	2	15.4	
Tidak Berkemungkinan Langsung	1	7.7	
Agak Tidak Berkemungkinan	1	7.7	
Tidak Berkemungkinan	3	23.1	
Berkemungkinan	2	15.4	
Agak Berkemungkinan	3	23.1	
Amay Berkemungkinan	1	7.7	
Risiko Membunuh Diri			12.31 (3.521)
Tinggi	12	92.3	
Rendah	1	7.7	
Status Merokok Seumur Hidup			
Setiap Hari	2	15.4	
Kurang Daripada Setiap Hari	2	15.4	
Langsung Tidak	9	69.2	
Status Penggunaan Rokok Elektronik Semasa			
Setiap Hari	1	7.7	
Kurang Daripada Setiap Hari	12	92.3	
Langsung Tidak			
Pernah Menggunakan Rokok Elektronik			
Setiap Hari	3	23.1	
Kurang Daripada Setiap Hari	4	30.8	
Langsung Tidak	5	38.5	

Pernah Menggunakan Minuman Beralkohol		
Ya	4	30.8
Tidak	8	61.5
Tidak Tahu	1	7.7
Penggunaan Minuman Beralkohol Tahun Lepas		
Ya	2	15.4
Tidak	10	76.9
Tidak Tahu	1	7.7
Penggunaan Bahan Terlarang Seumur Hidup		
Ya	4	30.8
Tidak	9	69.2

KESIMPULAN

Kajian perintis ini mendapati bahawa terdapat satu peratusan yang membimbangkan dalam kalangan remaja yang menunjukkan status kesihatan mental dan penggunaan bahan yang bermasalah. Ini termasuk kemungkinan gangguan kesihatan mental, tingkah laku membahayakan diri, serta penggunaan alkohol dan dadah. Terdapat keperluan mendesak untuk menjalankan kajian berskala besar yang lebih lengkap terhadap populasi ini pada masa hadapan.

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Optimizing Pediatric Brain CT Scans: A Retrospective Study on Enhancing Image Quality and Minimizing Radiation Exposure Using Acceptable Quality Doses (AQD)

Mengoptimumkan Imbasan CT Kepala Pediatrik: Kajian Retrospektif Mengenai Peningkatan Kualiti Imej dan Pengurangan Pendedahan Radiasi Menggunakan Dos Kualiti Boleh Terima (AQD)

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ABSTRACT

This study introduces the Acceptable Quality Dose (AQD) concept as an alternative to Diagnostic Reference Levels (DRLs) for optimizing radiation exposure in pediatric CT imaging. The AQD approach focuses on analyzing radiation dose indices ($CTDI_{vol}$ and DLP) only for diagnostically acceptable images, as assessed using the Image Quality Scoring Criteria (IQSC). Pediatric patients (0 to 18 years) who underwent CT brain scans were evaluated by two evaluators. Only images with an IQSC score of 3 were included in the AQD determination, categorized by age group. Results showed that younger patients generally received lower $CTDI_{vol}$ values, whereas DLP varied primarily with scan length. Mean $CTDI_{vol}$ (mGy) and DLP (mGy·cm) were: neonates (0–27 days), 21.00 ± 0.00 and 258.00 ± 0.00; infants (28 days–12 months), 21.86 ± 3.05 and 320.56 ± 451.70; toddlers (13 months–2 years), 24.10 ± 5.31 and 190.23 ± 166.31; early childhood (3–5 years), 25.07 ± 4.47 and 391.01 ± 384.76; middle childhood (6–11 years), 38.32 ± 13.25 and 550.60 ± 540.50; and adolescents (12–18 years), 46.30 ± 15.84 and 370.62 ± 370.20. Statistical analysis demonstrated significant differences in $CTDI_{vol}$ across age groups ($p < 0.05$), while no significant variation was observed in DLP. The findings also demonstrated that $CTDI_{vol}$ had a stronger correlation with image quality compared to DLP, suggesting it is a more reliable metric for optimizing radiation dose. The study concludes that the AQD approach effectively prioritizes diagnostically acceptable images over strict radiation limits, and $CTDI_{vol}$l is essential for ensuring optimal pediatric CT imaging.

Keywords: Image quality, Radiation dose exposure, Pediatric brain CT, Acceptable quality doses.

ABSTRAK

Kajian ini memperkenalkan konsep dos kualiti boleh terima (AQD) sebagai alternatif kepada aras rujukan diagnostik (DRL) bagi mengoptimumkan pendedahan radiasi dalam pengimejan CT pediatrik. Pendekatan AQD menumpukan kepada analisis indeks dos radiasi ($CTDI_{vol}$ dan DLP) hanya untuk imej yang diterima secara diagnostik, seperti yang dinilai menggunakan kriteria penskoran kualiti imej (IQSC). Pesakit pediatrik (0 hingga 18 tahun) yang menjalani imbasan CT otak telah dinilai oleh dua penilai. Hanya imej dengan skor IQSC 3 dimasukkan dalam penentuan AQD, dikategorikan mengikut kumpulan umur. Keputusan menunjukkan bahawa pesakit yang lebih muda secara amnya menerima nilai $CTDI_{vol}$ yang lebih rendah, manakala DLP berbeza terutamanya berdasarkan panjang imbasan. Purata CTDIvol (mGy) dan DLP (mGy·cm) bagi neonat (0–27 hari) Adalah 21.00 ± 0.00 dan 258.00 ± 0.00, bayi (28 hari–12 bulan): 21.86 ± 3.05 dan 320.56 ± 451.70, kanak-kanak kecil (13 bulan–2 tahun): 24.10 ± 5.31 dan 190.23 ± 166.31, awal kanak-kanak (3–5 tahun): 25.07 ± 4.47 dan 391.01 ± 384.76, pertengahan kanak-kanak (6–11 tahun): 38.32 ± 13.25 dan 550.60 ± 540.50 dan remaja (12–18

tahun): 46.30 ± 15.84 dan 370.62 ± 370.20. Analisis statistik menunjukkan perbezaan signifikan bagi CTDIvol antara kumpulan umur (p < 0.05), manakala tiada variasi ketara diperhatikan bagi DLP. Dapatan kajian turut menunjukkan bahawa CTDI$_{vol}$ mempunyai korelasi yang lebih kuat dengan kualiti imej berbanding DLP, menunjukkan bahawa ia merupakan ukuran yang lebih boleh dipercayai untuk pengoptimuman dos radiasi. Kajian ini menyimpulkan bahawa pendekatan AQD secara berkesan mengutamakan imej yang diterima secara diagnostik berbanding had radiasi yang ketat, dan CTDI$_{vol}$ adalah penting untuk memastikan pengimejan CT pediatrik yang optimum.

Kata kunci: Kualiti imej, Pendedahan dos radiasi, CT kepala pediatrik, Dos kualiti boleh terima.

INTRODUCTION

Computed tomography (CT) is a vital diagnostic tool, offering high-resolution imaging for various medical conditions, including neurological disorders, trauma, and cancer. However, its use involves ionizing radiation, which poses significant health risks, particularly for pediatric patients (Abuelhia & Alghamdi 2020). Unlike adults, children have a longer life expectancy and are more radiosensitive due to their ongoing growth and development (Smith-Bindman et al. 2019). Studies have demonstrated an association between pediatric CT radiation exposure and an increased risk of radiation-induced malignancies, such as leukemia and brain tumors (Meulepas et al. 2019). Therefore, minimizing radiation exposure while preserving diagnostic accuracy remains a critical challenge in pediatric imaging.

To address radiation safety concerns, the International Commission for Radiological Protection (ICRP) introduced Diagnostic Reference Levels (DRLs) in 1990. DRLs serve as benchmark values to guide radiation dose optimization in medical imaging, assisting healthcare institutions in implementing safe imaging protocols (Tan et al. 2023). However, DRLs are typically established based on surveys of radiation dose metrics (CTDI$_{vol}$ and DLP) across multiple institutions, without considering whether the resulting images meet or exceed diagnostic quality standards (Malik et al. 2024). They do not account for variations in pediatric anatomy, clinical indications, or image quality requirements. Moreover, the assumption that operating below DRLs automatically reflects optimal dose management may lead to inconsistencies in both image quality and radiation safety (Kharita et al. 2021).

To overcome these limitations, the Acceptable Quality Dose (AQD) concept has been introduced. AQD prioritizes both image quality and dose optimization by assessing radiation indices exclusively for diagnostically acceptable images (Yaseen et al. 2024). This approach, guided by the Image Quality Scoring Criteria (IQSC), ensures a balanced evaluation of radiation exposure and diagnostic efficacy (Padole et al. 2019). By integrating objective image quality assessment with dose metrics, AQD minimizes the risk of underquality or overquality, supports consistent diagnostic confidence, and facilitates continuous quality improvement across imaging departments (Kharita et al. 2021). Furthermore, AQD aligns with the ALARA (As Low As Reasonably Achievable) principle by identifying the minimum radiation dose required to maintain diagnostic quality, thereby reducing unnecessary exposure while preserving clinical accuracy.

In Malaysia, standardized pediatric CT protocols remain limited, contributing to variability in image quality and radiation dose management. By evaluating AQD, this study seeks to establish an optimized framework for balancing image quality and radiation exposure in pediatric brain CT scans. Additionally, it will analyze radiation dose indices, specifically CTDI$_{vol}$ and DLP, across different pediatric age groups to assess their impact on dose optimization and diagnostic performance.

This study aims to investigate the application of AQD in pediatric brain CT imaging, a crucial modality for diagnosing congenital anomalies, trauma, and neurological disorders. Given the heightened sensitivity of children to ionizing radiation, achieving high diagnostic accuracy with minimal exposure is essential.

MATERIALS AND METHODS

STUDY DESIGN

This retrospective study aimed to optimize image quality while minimizing radiation exposure in pediatric brain CT imaging. The Acceptable Quality Dose (AQD) concept, first introduced in Qatar, was adopted to evaluate radiation dose parameters based exclusively on diagnostically acceptable images. This study received approval from the Research Ethics Committee Universiti Kebangsaan Malaysia (RECUKM) (Ref. JEP-2025-656).

STUDY POPULATION AND SAMPLING

The study population included pediatric patients (neonates to 18 years old) who underwent plain CT brain examinations in Hospital Tunku Ampuan Besar Tuanku Aishah Rohani (N=43). A sample size of 39 (n=39) data was determined based on a

population size of 43, with a 5% margin of error and a 95% confidence level. Inclusion and exclusion criteria were carefully established to ensure the study's relevance and reliability. A purposive sampling method was used to recruit two experienced evaluators, each with over five years of expertise, for the subjective assessment of image quality using the Image Quality Scoring Criteria (IQSC). Evaluators independently reviewed randomly selected brain CT scans to assess interobserver agreement and consistency in image quality evaluation.

METHODE OF DATA SELECTION

CT brain images were retrieved from Syngo Plaza vb.40, a radiology database used at Hospital Tunku Ampuan Besar Tuanku Aishah Rohani, UKM. To minimize selection bias, 39 pediatric CT examinations were randomly selected without consideration of patient demographics or radiation dose parameters. Only scans performed using pediatric-specific protocols; 01_Head_Below_2YO (Child), 01_Head_Below_5YO (Child), and 01_Head_Below_15YO (Child) were included to ensure standardization. All images were acquired in the axial plane with a soft tissue window, utilizing a section thickness of 1.0 mm and an interval of 0.8 mm for high-resolution imaging. Patient demographic data, including age, gender, and radiation dose indices ($CTDI_{vol}$ and DLP), were recorded for subsequent analysis. To facilitate the evaluation process, CT images were systematically organized in a dedicated Google Drive worklist. Each image was assigned a unique code (CT_AA to CT_BM) for efficient retrieval and assessment.

IMAGE QUALITY ASSESSMENT

Image quality was subjectively assessed using the Image Quality Scoring Criteria (IQSC), with scores ranging from 0 to 4. A score of 0s indicates that the desired anatomical features are not visible, while 0i signifies that the relevant anatomy is not included in the image. A score of 1 represents unacceptable quality, where the image is non-diagnostic. Limited quality, characterized by diagnostic usability but high noise levels, is assigned a score of 2. A score of 3 denotes adequate quality, meaning the image is acceptable for diagnosis. Lastly, a score of 4 indicates excessively high resolution, surpassing the necessary quality for diagnostic purposes. Evaluators used RadiAnt DICOM Web for image analysis, ensuring consistency in assessment. The dataset was shared via Google Drive, enabling offline evaluation. Image quality scores were documented in structured evaluation sheets to maintain data integrity and facilitate subsequent statistical analysis.

ACCEPTABLE QUALITY DOSE (AQD) ESTIMATION

AQD estimation was performed exclusively on images with an IQSC score of exactly 3, representing the lowest diagnostically acceptable image quality. In this study, IQSC=3 images were defined as those providing sufficient anatomic detail, adequate contrast enhancement, and acceptable noise levels to enable accurate clinical interpretation without repeat scanning. IQSC ≤2 was excluded due to suboptimal diagnostic quality, while IQSC=4 images, although meeting or exceeding quality standards, were also excluded because they represent unnecessarily high image quality achieved at higher radiation doses. Including such images would shift the reference dose upward, potentially normalizing overexposure and contradicting the ALARA principle. This approach ensures that AQD reflects the minimum radiation exposure capable of producing diagnostically sufficient images. AQD therefore accepts the lowest dose that maintains diagnostic confidence and rejects any higher doses that do not provide additional clinical value. The selected data were categorized into six pediatric age groups include neonates (0–27 days), infants (28 days–12 months), toddlers (13 months–2 years), early childhood (3–5 years), middle childhood (6–11 years), and adolescents (12–18 years) (Yang & Gao 2024). Radiation dose indices ($CTDI_{vol}$ and DLP) were recorded for each group, and median values were calculated to establish AQD benchmarks. These values served as representative measures of optimal radiation dose for pediatric brain CT imaging (Kharita et al. 2021).

DATA ANALYSIS

Statistical analysis was conducted to assess interobserver variability, image quality scores, and radiation dose indices across age groups. The Kappa statistic was utilized to assess interobserver agreement, with value of 0 or less indicates no agreement, while values between 0.01 and 0.20 suggest slight agreement. Fair agreement is represented by a range of 0.21 to 0.40, whereas moderate agreement falls between 0.41 and 0.60. Substantial agreement is indicated by values from 0.61 to 0.80, and a Kappa score between 0.81 and 1.00 signifies almost perfect agreement. Data analysis was performed using SPSS version 25.0. Descriptive statistics was express as mean, standard deviation and frequency distributions of IQSC scores, were computed for each age group. For normally distributed data, a one-way Analysis of Variance (ANOVA) was conducted to compare dose indices across age groups. To control the risk of Type I error arising from multiple pairwise comparisons across 6 age groups, the Bonferroni correction was applied. The significance level (p-

value=0.05) was divided by the number of pairwise comparisons (n=15), resulting in a new threshold of p=0.0033. Only p-values below this adjusted threshold were considered statistically significant.

RESULTS

The evaluation of all 39 pediatric brain CT images was conducted by two independent evaluators using the Image Quality Scoring Criteria (IQSC). According to the IQSC scale [0s – Desired features not visible; 0i – Anatomy not included in images; 1 – Unacceptable quality (non-diagnostic images); 2 – Limited quality (diagnostic with high noise); 3 – Adequate quality (acceptable for diagnosis); and 4 – Higher than necessary quality (excessively high resolution)], only images with scores of 3 or 4 were included for further assessment, specifically for radiation dose measurements.

Based on this criterion, 74% of the evaluated images were deemed acceptable, with 29 out of 39 images meeting the inclusion threshold. The median image quality score for pediatric brain CT examinations was found to be 3. The mean percentage of image quality scores assigned by the two evaluators indicated that 47% of the assessed scans received a score of 3, signifying an acceptable diagnostic standard. Additionally, 27% of the images were assigned a score of 4, reflecting higher-than-necessary image quality, while 26% were rated with a score of 2, indicating suboptimal but still interpretable image quality.

The findings demonstrate that a score mean of 3 suggests most scans achieved an adequate diagnostic standard. Both evaluators exhibited consistency in their assessments, particularly in determining which images were diagnostically useful. The distribution of subjective image quality scores shows that most pediatric head CT scans were assigned a score of 3, accounting for nearly half of the total examinations. The clustering of scores around 3 further supports the conclusion that the overall image quality was within an acceptable range, ensuring sufficient detail for reliable diagnostic interpretation. Figure 1 show the frequency distribution (%) of subjective image quality scores assigned by two independent evaluators.

The interobserver variability between the two evaluators was assessed using the kappa statistic, which yielded a value of 0.76, indicating a high level of agreement. This result suggests minimal disagreement between the evaluators, despite some variations in the subjective image quality scores assigned. Notably, both evaluators consistently concurred on images classified as diagnostically useful, particularly those assigned a score of 3.

In alignment with the Acceptable Quality Dose (AQD) framework, which necessitates the inclusion of images with sufficient diagnostic quality for radiation dose assessment, analysis revealed that 29 out of 39 CT scans met the required criteria. Consequently, only these 29 scans were considered for AQD estimation. To facilitate a comprehensive evaluation, the selected examinations were stratified into 6 distinct pediatric age groups. Table 1 shown the mean and standard deviation (SD) of $CTDI_{vol}$ and DLP across different pediatric age groups.

The results show variability in dose indices among the groups. $CTDI_{vol}$ demonstrates a trend in which younger patients generally receive lower radiation doses compared to older patients, likely due to their smaller head size and reduced scanning range. In contrast, the DLP demonstrated a non-uniform trend across the different age groups, indicating variability in cumulative radiation exposure among the classifications. Statistical analysis revealed a statistically significant variation in $CTDI_{vol}$ among the different age groups because p-value was 0.00 less than 0.05 (p=0.00, p<0.0033), indicating that age-related factors influence volumetric dose exposure. However, no statistically significant differences were observed in DLP values across age groups because p-value was 0.16 more than 0.05 (p=0.16, p>0.0033), suggesting that scan length and acquisition parameters may contribute to dose variability independently of patient age.

The scatter plot as shown in Figure 2 demonstrates a positive correlation and the data points tend to cluster around a trendline. This suggests a stronger relationship between $CTDI_{vol}$ and image quality. The scatter plot analysis reveals that data points tend to cluster around an IQSC score of 3, which represents adequate image quality, sufficient for accurate diagnostic interpretation. This pattern suggests a threshold beyond which increasing $CTDI_{vol}$ does not necessarily enhance image quality.

The scatter plot plot as shown in Figure 3 also demonstrates a positive correlation however, the presence of outliers and a weak clustering pattern suggests that DLP is not a strong or consistent predictor of image quality compared to $CTDI_{vol}$. This suggests that DLP does not strongly correlate with IQSC compared to $CTDI_{vol}$. While $CTDI_{vol}$ directly measures radiation dose per scan, DLP is a cumulative metric influenced by both $CTDI_{vol}$ and scan length.

DISCUSSION

The AQD was introduced as a bottom-up approach to radiation dose optimization, in contrast to Diagnostic Reference Levels (DRLs), which use a top-down methodology. Unlike DRLs, which are based on the 75th percentile of dose distributions and may include both underexposed and overexposed images, AQD focuses exclusively on images that meet predefined diagnostic acceptability criteria (Kharita et al. 2021; Yaseen et al. 2024). By doing so, AQD ensures that dose analysis is based

on clinically useful images rather than on a broad range of exposures that may not reflect optimal practice (Tsapaki 2020). In clinical practise, AQD helps to identify opportunities for significant dose reduction while maintaining diagnostic integrity. It also supports the development of tailored imaging protocols for different patient groups, such as pediatrics, where radiation sensitivity is higher and dose management is critical. Furthermore, AQD can be used as a benchmarking tool for continuous quality improvement, enabling healthcare facilities to monitor their performance over time, compare results across institutions, and harmonize imaging practices. The findings of this study demonstrate an uneven distribution of patients across six pediatric age groups in the 29 head CT examinations analyzed. Age group classification plays a crucial role in AQD assessment as it facilitates the adjustment of scan parameters according to patient size and anatomical characteristics, thereby ensuring
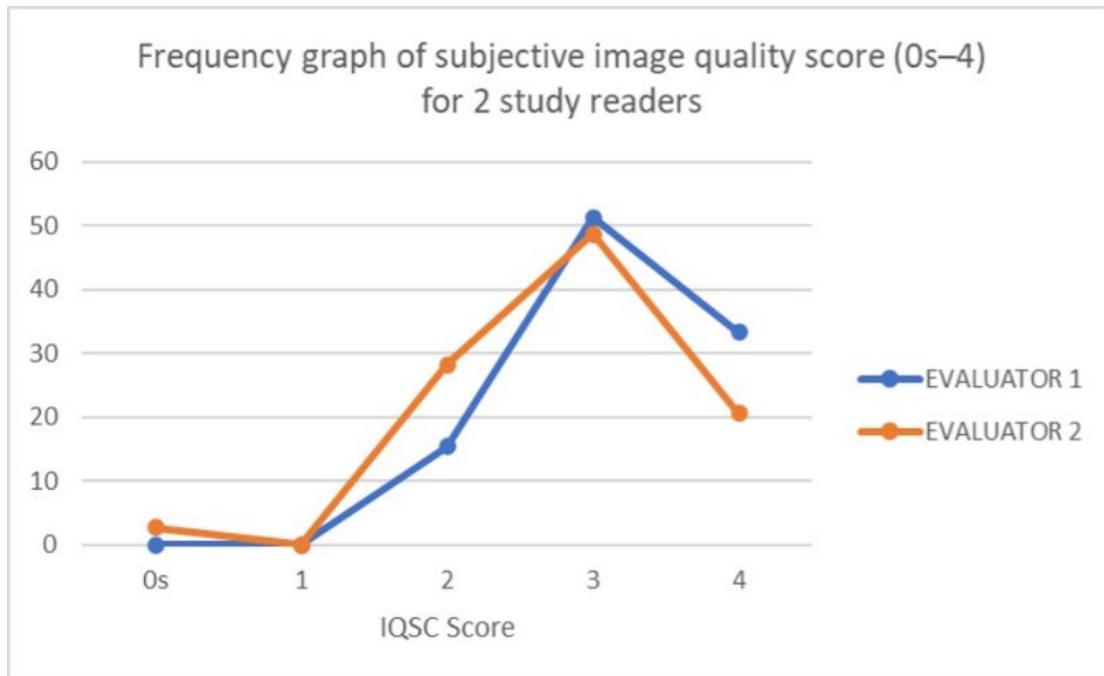
FIGURE 1 Frequency distribution (%) of subjective image quality scores assigned by two independent evaluators. The graph illustrates the percentage of images categorized according to the IQSC scoring criteria. Approximately half of the evaluated images received a score of 3, indicating an acceptable diagnostic quality based on assessments by both evaluators.
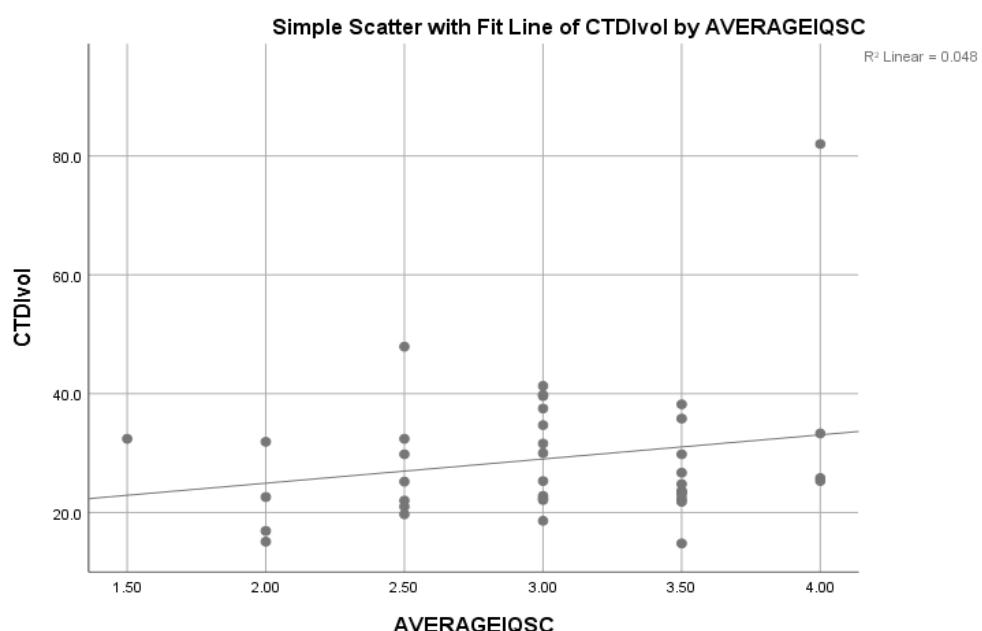
FIGURE 2 Correlation graph between $CTDI_{vol}$ and average image quality score
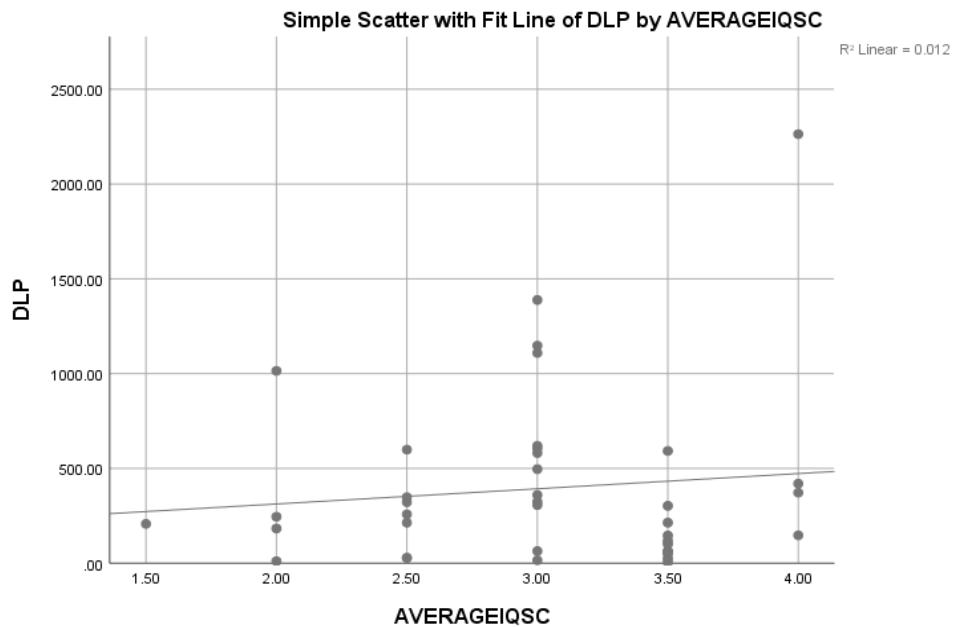
FIGURE 3 Correlation graph between DLP and average image quality score

TABLE 1 Comparison of radiation dose parameters across six pediatric age groups, as defined by the National Institute of Child Health and Human Development. The analyzed dose metrics include the volumetric CT dose index ($CTDI_{vol}$) and dose-length product (DLP) for pediatric brain CT examinations.

Age group (patients)	0-27D (n=2)	28D-12M (n=9)	13M- 2Y (n=2)	3-5Y(n=4)	6-11Y(n=10)	12-18Y(n=2)	P-value
Average age (YY, MM, WW, DD)	00,00,00,17	00,07,00,09	02,00,00,00	04,00,00,00	08,08,00,00	14,00,00,00	-
$CTDI_{vol}$ (Mean±SD)	21.00±0.00	21.86±3.05	24.10±5.31	25.07±4.47	38.32±13.25	46.30±15.84	0.00
DLP (Mean±SD)	258.00±0.00	320.56±451.70	190.23±166.31	391.01±384.76	550.60±540.50	370.20±370.62	0.16

D= day, W= week, M= month, Y= year

adequate radiation protection for younger children who are more sensitive to ionizing radiation (Poosiri et al. 2024). This classification also enables more consistent comparison of dose data between age groups and supports the development of tailored imaging protocols. In growing children, variations in skull thickness and brain tissue composition substantially influence image contrast and noise, necessitating appropriate adjustments to technical parameters to achieve optimal image quality (Nagy et al. 2023). Failure to perform such modifications may result in suboptimal imaging and reduced diagnostic confidence. Furthermore, as children mature, higher radiation doses are often required to maintain diagnostic image quality, underscoring the need for a careful balance between image quality and radiation exposure, with dose escalation applied only when clinically justified (Inoue, Itoh, Waga, et al. 2022). The findings of this study show a progressive increase in $CTDI_{vol}$ with advancing patient age. This pattern can be attributed to both anatomical and technical factors. As children grow, head circumference and skull thickness increase, resulting in greater X-ray attenuation and requiring higher tube current or voltage to achieve adequate image penetration. Modern CT systems equipped with automatic exposure control (AEC) respond to this increased attenuation by proportionally raising radiation output, thereby contributing to higher $CTDI_{vol}$ values among older children (Inoue, Itoh, Miyatake, et al. 2022; Nagy et al. 2023). In addition, diagnostic requirements in older pediatric patients often demand clearer anatomical detail, which is achieved through higher exposure settings to reduce image noise and improve contrast resolution. Previous studies have shown that pediatric imaging protocols are systematically adjusted according to patient size, particularly for younger children who

have smaller skulls and less dense anatomical structures (Karappara et al. 2020; Nagy et al. 2023; Padole et al. 2019). Therefore, lower radiation doses are generally sufficient to achieve diagnostically acceptable image quality in younger patients, as reduced attenuation allows clearer imaging with minimal exposure (Ploussi et al. 2020). From a clinical perspective, slightly higher radiation doses are considered acceptable in older children because their radiosensitivity is lower compared to infants, thereby reducing the relative risk of radiation-induced stochastic effects.

Interestingly, the DLP values in this study show varied results, with increases or decreases that are inconsistent and not proportional to age groups. DLP, calculated as the product of $CTDI_{vol}$ and scan length, provides an estimate of the total radiation burden for each scan (Smith-Bindman et al. 2019). The total DLP is highly influenced by the scanning range. Theoretically, younger patients should have smaller head sizes and, consequently, shorter scanning ranges, which would result in lower DLP values (Inoue et al. 2023). However, this was not observed in our study, most likely because younger patients often underwent longer scan coverage, possibly due to a wider margin of safety applied by radiographers to ensure complete anatomical coverage. In addition, younger pediatric patients are generally more difficult to position with the skull base parallel to the X-ray beam, which can lead to an extended scan range. Time constraints and concerns about patient movement may further discourage gantry angulation, resulting in longer coverage and potentially higher DLP despite smaller head size. These sources of variability likely contributed to the absence of a statistically significant difference in DLP across age groups. While DLP remains a clinically relevant measure of overall radiation burden, its strong dependence on scan length and operator technique may limit its value as a consistent comparative metric, particularly in studies with small sample sizes or heterogeneous patient populations.

An increase in $CTDI_{vol}$ has been shown to reduce image noise, thereby improving anatomical detail and diagnostic confidence (Malik et al. 2024). However, the clustering of image quality scores around 3 on the IQSC scale suggests that once adequate diagnostic quality has been achieved, further increases in $CTDI_{vol}$ do not provide significant improvements in image interpretation. Instead, excessive radiation exposure without a corresponding enhancement in image quality becomes a major concern, particularly in pediatric imaging, where children are more sensitive to ionizing radiation (Meulepas et al. 2019). The study by Smith-Bindman et al. (2019) highlights the complex relationship between $CTDI_{vol}$ and DLP, showing that DLP is influenced by scan length and patient size, which can lead to variations in image quality even when $CTDI_{vol}$ values are the same. This means that even scans with identical $CTDI_{vol}$ values may produce different levels of image quality due to variations in anatomical coverage. Furthermore, scatter plot analysis revealed the presence of outliers, indicating that an increase in DLP does not necessarily correlate with improved image quality. This can be explained by the fact that DLP is highly dependent on scan length rather than image acquisition parameters alone, extended coverage increases DLP even if it does not contribute to diagnostic value or reduce noise (Inoue 2023). Additionally, patient motion, positioning errors, or reconstruction settings can still degrade image quality regardless of the radiation dose delivered, which explains why higher DLP values may sometimes be associated with images of only average or even suboptimal quality (Varghese et al. 2024).

The relationship between these radiation dose metrics and AQD is particularly relevant in optimizing pediatric imaging. AQD represents the optimal radiation dose required to maintain acceptable image quality while minimizing unnecessary radiation exposure (Kharita et al. 2021; Yaseen et al. 2024). The stronger correlation between $CTDI_{vol}$ and image quality aligns with AQD principles, as $CTDI_{vol}$ directly measures the radiation dose associated with each scan. This suggests that $CTDI_{vol}$ s a more reliable metric for assessing whether the administered radiation dose is sufficient for diagnostic purposes while remaining within safe exposure limits (Malik et al. 2024). In contrast, the weaker correlation between DLP and image quality implies that DLP may not be the most accurate parameter for determining AQD. Since DLP reflects total radiation usage without accounting for scan length variations and patient size, it may not reliably indicate whether a scan meets AQD standards (Arfat et al. 2024). To ensure adherence to AQD principles, radiation dose and image quality must be carefully balanced, with $CTDI_{vol}$ serving as a more precise metric for evaluating dose optimization in pediatric CT imaging.

The present study has several limitations that may affect the generalizability of its findings. First, the relatively small sample size limits the ability to draw definitive conclusions and impacts the statistical power of the analysis. A larger sample would allow for more robust data and a deeper understanding of the relationship between radiation dose and image quality. Second, the study was conducted with a limited number of patients who underwent CT brain scans using a specific imaging protocol at a single institution. Consequently, the results may be influenced by the imaging techniques, equipment, and protocols unique to this setting, reducing the broader applicability of the findings to other institutions using different

technologies or protocols. Moreover, there is a lack of sufficient comparable studies in the existing literature, making it challenging to directly compare and validate our results. While similar studies exist, the limited body of research in this area highlights the need for more extensive investigations to strengthen the evidence. Future studies should include larger and more diverse patient cohorts across multiple centers, exploring a wider range of CT protocols and patient populations. Such multicenter investigations would provide a more comprehensive understanding of the relationship between radiation dose and image quality in pediatric brain CT, enhancing the generalizability and robustness of the findings.

CONCLUSION

This study highlights that the AQD approach provides a balanced framework by integrating image quality, radiation dose, and patient body composition, thereby prioritizing diagnostically acceptable images over simple dose reduction. Furthermore, our findings indicate that $CTDI_{vol}$ is a more reliable parameter than DLP for evaluating radiation dose adequacy, as it better reflects the factors that influence image quality. Collectively, these results support the adoption of AQD-guided protocol optimization to ensure safe, consistent, and diagnostically robust pediatric CT imaging.

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Laporan Kes / Case Report

Nutrition Management in Older Adults with Dysphagia and Underlying Possible Cognitive Decline: A Case Report

Pengurusan Pemakanan Warga Emas yang Mengalami Disfagia dan Kemerosotan Kognitif: Laporan Kes

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ABSTRACT

Aging is a complex biological process posing various physiological, psychological, and functional changes which impacts one's overall health and quality of life. This case report discusses the comprehensive management of an 88-year-old Malay man admitted due to acute kidney injury secondary to urinary retention and urinary tract infection along with significant weight loss, poor oral intake. The patient was further diagnosed with oropharyngeal dysphagia. Incorporating texture-modified diets (IDDSI Level 5), oral nutritional supplements, and caregiver education regarding safe feeding plus continuous monitoring were implemented to align with the patient's preferences, swallowing ability and health improvement. This case highlights the importance of early identification, individualized nutritional support, and collaborative care among dietitians, speech therapist and geriatric specialist in addressing dysphagia in elderly individuals to optimize health outcomes and improve quality of life.

Keywords: older adults, dysphagia, IDDSI, texture modification

ABSTRAK

Penuaan adalah proses semula jadi kompleks yang menyebabkan pelbagai perubahan fisiologi, psikologi dan keupayaan seseorang, dan boleh menjejaskan kesihatan dan kualiti hidup. Laporan kes ini membincangkan tentang seorang lelaki Melayu berusia 88 tahun dimasukkan ke wad disebabkan kecederaan buah pinggang akibat kesukaran membuang air kecil dan jangkitan saluran kencing beserta penurunan berat badan yang ketara serta kurang pengambilan makan. Pesakit juga didiagnosis dengan masalah menelan (disfagia orofarinks). Pendekatan yang diambil bagi kes ini melibatkan pemberian makanan bertekstur lembut (IDDSI Tahap 5), suplemen pemakanan, serta pendidikan kepada penjaga mengenai cara memberi makan dengan selamat, di samping pemantauan berterusan. Kes ini menunjukkan kepentingan mengenal pasti masalah dari awal, menyediakan sokongan pemakanan yang sesuai, dan kerjasama dalam penjagaan pesakit di antara pakar dietetik, terapis pertuturan dan pakar geriatrik bagi meningkatkan kesihatan dan kualiti hidup warga emas.

Kata Kunci: warga emas, disfagia, IDDSI, ubah suai tekstur

INTRODUCTION

Aging is a natural process that brings about various physiological, psychological, and functional changes, often taking a significant toll on overall health. As individuals age, their bodies undergo a decline in cellular regeneration and organ function, leading to reduced metabolic rates and alterations in the physicochemical properties of cells, resulting in impaired self-regulation and regeneration (Militello

et al. 2024). Muscle mass and bone density gradually decrease, increasing the likelihood of frailty and fractures (Sharma & Morishetty 2022) while the immune system becomes less efficient, making older adults more susceptible to infections. Cognitive changes, including memory loss and reduced processing speed, are also common, alongside sensory impairments that can affect vision and hearing (Virvescu & Fratila 2022). Furthermore, aging is often accompanied by social and emotional challenges, such as isolation and reduced independence, which can negatively impact mental health and quality of life (Gaspar et al. 2024). Older adults often face loneliness, social isolation, depression, anxiety, sleep disturbances, and stigma in seeking help, while also struggling with chronic diseases, physical limitations, low socioeconomic status, and poor living environments. These factors significantly reduce their mental health and overall quality of life (WHO 2023; Tan 2022).

Unintentional weight loss and poor appetite are common in older adults, with studies reporting that about 15–30% of community-dwelling elders experience appetite loss, 20% among frail or pre-frail groups, and nearly one in five older men showing significant weight loss over three years (Beaumont et al., 2024; Hernández-Galiot & Goñi 2017; Houston et al. 2021). Poor appetite often precedes unintentional weight loss, as reduced intake can lead to a decline in body weight, though some maintain weight due to lower energy expenditure; conversely, others lose weight despite normal appetite because of disease or malabsorption (Morley 2021; de van der Schueren et al. 2021).

Similarly, dysphagia is another critical concern among older adults in Asia, with prevalence rates varying across populations and settings. Recent studies in Asia have confirmed that dysphagia is a significant and growing problem among older adults. In Malaysia, a 2024 study at the Speech Pathology Clinic, Hospital Universiti Sains Malaysia reported a prevalence of 5.5% among adult clinic attendees, with markedly higher risk in those aged 61 years and above (Nordin et al. 2024). Another recent cross-sectional study among nursing home residents in Kuala Lumpur and Selangor identified swallowing difficulty in 50% of participants when assessed with the Standardised Swallowing Assessment tool (Siew & Chan 2023). Beyond Malaysia, a 2023 systematic review and meta-analysis reported that dysphagia affects about 40.6% of nursing home residents in Asia, reflecting a high regional burden compared with global pooled estimates (Chen et al. 2023). These findings underscore that dysphagia, much like appetite loss and weight loss, is highly prevalent among older adults and strongly associated with ageing, institutionalization, and chronic disease, ultimately compounding risks of malnutrition, frailty, and poorer quality of life.

Dysphagia, or difficulty swallowing, is one of the common conditions among the older adults, often resulting from age-related physiological changes, neurological disorders, or chronic illnesses. Dysphagia affects approximately 11.8% of community-dwelling older adults (Qiu et al. 2024). This condition poses significant challenges to nutritional intake, hydration, and overall quality of life, increasing the risk of malnutrition, dehydration, and aspiration-related complications (Yurt 2024, Hunter & Tulunay-Ugur 2024). Reduced appetite especially in older adults requires careful management to ensure adequate nutrition and safety. Early identification and intervention are essential to reduce risks associated with dysphagia (Liang et al. 2024). While dysphagia is often perceived as a normal part of aging, it is critical to recognize it as a significant health concern that requires proactive management to prevent serious complications and improve the quality of life for older adults.

The nutrition care process (NCP) for managing weight loss and dysphagia in older adults involves assessment, diagnosis, intervention, and monitoring. Assessment covers anthropometric measures, dietary intake, swallowing ability, comorbidities, and social factors, followed by diagnoses such as unintended weight loss due to inadequate intake or swallowing difficulty related to dysphagia. Interventions include energy- and protein-dense meals, oral nutrition supplements, texture-modified diets guided by the International Dysphagia Diet Standardisation Initiative (IDDSI), safe swallowing strategies, and collaboration with speech-language therapists, along with caregiver education and oral health management. Monitoring and evaluation focus on tracking weight, intake adequacy, tolerance to diet texture, hydration, and overall quality of life to support effective and individualized care (Academy of Nutrition and Dietetics 2020; Cederholm et al. 2022; IDDSI 2019).

The general objective of this paper is to present a comprehensive nutritional management approach for an older adults patient with dysphagia, emphasizing the importance of individualized care, multidisciplinary collaboration, and tailored dietary interventions to optimize nutritional status and enhance quality of life.

CASE REPORT

PATIENT PROFILE

Mr. A, an 88-year-old Malay man, was brought to the hospital over urinary incontinence as referred by his general practitioner and presented to the Emergency Department (ED) with a combination of symptoms that had gradually worsened over recent weeks. He reported a loss of appetite lasting two weeks, significant unintentional weight loss over the past year, and poor oral intake over the last week

TABLE 1 Full biochemical results.

Parameter	Date				Unit	Normal range
	Day 1	Day 2	Day 3	Day 4		
Full Blood Count						
WBC	7.58 (N)	5.71 (N)	5.87 (N)	-	$x10^9$/L	4.0-11.0
Hb	11.6 (L)	12.6 (N)	10.9 (L)	-	g/dL	12-15
Plt	235 (N)	223 (N)	222 (N)	-	$x10^9$/L	110-450
Renal Profile						
Urea	38.6 (H)	14.9 (H)	7.0 (H)	4.3 (N)	mmol/L	2.5-6.7
Sodium	132 (L)	140 (N)	142 (N)	139 (N)	mmol/L	136-145
Potassium	5.1 (N)	4.6 (N)	5.0 (N)	4.5 (N)	mmol/L	3.5-5.1
Chloride	92 (L)	105 (N)	106 (N)	107 (N)	mmol/L	98-107
Creatinine	792(H)	155(H)	88 (N)	77 (N)	mmol/L	50-98
Calcium	2.30 (N)	2.34 (N)	2.18 (N)	2.16 (N)	mmol/L	2.1-2.55
Phosphate	1.94 (N)	0.73 (L)	0.61 (L)	0.59 (L)	mmol/L	0.74-1.52
Magnesium	1.10 (H)	0.99 (N)	0.88 (N)	0.76 (N)	mmol/L	0.66-1.07
Liver Function Test						
Total protein	76 (N)	81 (N)	-	-	g/U	64-83
Albumin	29 (L)	29 (L)	-	23 (L)	g/L	35-50
Total bilirubin	19 (N)	15 (N)	-	-	Ummol/L	3.4-20.5
ALP	120 (N)	181 (N)	-	-	U/L	40-150
ALT	40 (N)	49 (N)	-	-	U/L	0-55
AST	-	75 (N)	-	-	U/L	5-34

Additionally, he experienced a fever for three days, abdominal pain, and an inability to pass urine for one week.

Mr. A was diagnosed with acute urinary retention (AUR) secondary to a urinary tract infection (UTI) and acute kidney injury (AKI) caused by the AUR. Notably, Mr. A had no prior history of medical illnesses and no previous hospital admission. He remained physically mobile and independent in most activities of daily living, such as feeding, dressing, bathing, and toileting. However, he has had visual and hearing impairments for the past two years.

He is married with 5 children and lives together with his 78-year-old wife, who is ADL-independent despite being on a pacemaker, and his second son, a 59-year-old with a mental disability who is also ADL- independent. His wife prepares his meals and serves them for him to eat. Currently, he is financially supported by his children and a government fund.

He was accompanied by his daughter in the ward, with his wife alternating visits to provide support. He was able to communicate effectively and respond to questions during interactions. However, he exhibited signs of forgetfulness,

particularly regarding his location, providing inconsistent answers when asked where he was. Further evaluation revealed possible underlying cognitive decline, evidenced by a history of short-term memory loss, such as forgetting meals, misplacing belongings, and occasionally struggling with his signature. This information was obtained through the Comprehensive Geriatric Assessment (CGA) with input from family members. The Mini-Mental State Examination (MMSE) was also attempted but could not be completed due to the patient's lack of cooperation.

ANTHROPOMETRY

Mr. A was unable to undergo standard weighing due to instability and a high risk of falls. As an alternative, knee height and mid-upper arm circumference (MUAC) measurements were used to estimate his height and weight (BAPEN 2011, Shahar & Pooy 2003). His estimated height is 158 cm, confirmed by his daughter, and his estimated weight is 40 kg. Estimated values were used as the patient was at high risk of falls, and direct measurement of weight and height was not conducted during admission. Although his daughter could not quantify his previous weight, she observed significant weight loss over the past year, particularly since last week. Based on the ideal body weight for older adults, defined as a BMI of 24 kg/m² according MDG for Older Persons 2023, his target weight was calculated to be 59.9 kg.

BIOCHEMICAL DATA

Mr. A's biochemical data upon admission reflected several abnormalities that progressively improved during his hospital stay. His full blood count showed fluctuating hemoglobin levels, with mild anemia occasionally noted, while platelet counts and white blood cell counts remained within normal ranges. Renal function tests revealed severe acute kidney injury (AKI) on the first day of admission with a markedly elevated creatinine level of 792 μmol/L, which progressively normalized to 77 μmol/L by the next two days. Similarly, urea levels were initially elevated at 38.6 mmol/L but improved to 4.3 mmol/L within three days. Electrolyte imbalances were evident, with low sodium (132 mmol/L) and chloride (92 mmol/L) on the first day, which normalized by the next day, while potassium remained within normal limits throughout.

His phosphate levels were consistently low (0.73-0.59 mmol/L) during admission, and albumin levels were persistently low (23-29 g/L), indicating poor nutritional status or chronic inflammation. Liver function tests showed normal total protein and bilirubin levels but revealed a slight elevation in ALT (49 U/L) and AST (75 U/L), which remained within acceptable limits. Alkaline phosphatase (ALP) was elevated at 181 U/L, reflecting possible underlying liver or bone involvement. Magnesium levels were slightly elevated initially (1.10 mmol/L) but normalized over subsequent days (Refer Table 1).

NUTRITION-FOCUSED PHYSICAL FINDINGS

Mr. A exhibited moderate muscle and fat loss, with no edema. His blood pressure of 144/56 mmHg is relatively high, while other vital signs are stable, with a heart rate of 83 bpm, oxygen saturation of 98% on room air, and a temperature of 37°C. On day 5 of admission, his input-output balance showed a deficit of -521 mL (I/O: 1279/1800). He had one bowel output classified as type 7 on Bristol Stool Chart the day before, which might be due to the lactulose prescribed. It was confirmed by the nurse and family members that the patient has had no bowel output since admission. Other than that, there was no evidence of vomiting. According to his daughter, Mr. A had poor oral intake and reduced appetite for the past 2 weeks. Mr. A was noted to have dentures for over 10 years and a hoarse voice, which had been present for the past five years. He had no trouble as his dentures were intact. His daughter also reported no history of choking episodes or pain during swallowing. The doctor did suggest an endoscopy to further examine his hoarse voice, but his daughter firmly stated that the children had discussed and disallowed the procedure due to their father's old age.

FOOD AND NUTRITION HISTORY

Mr. A has been on a soft diet since day 1 of admission. The texture was consistent with his usual intake, as the patient usually has his fish deboned or shredded. However, he only managed to finish 3-4 tablespoons of porridge and occasionally finished ¼ of the protein sources, mainly egg or fish. His daughter reported that Mr. A prefers fish and eggs to chicken. Additionally, it is noted that his daughter and wife often bring outside food such as biscuits, red bean pau, and milk tea. However, his beverage choices are predominantly sugary drinks, including milk tea purchased daily by his daughter, while plain water consumption is minimal. During his stay, the nurse prepared 200 ml of oral nutritional milk upon his request for a sugary drink the previous night, which he could finish. In the past, his daughter said that his father did not drink milk. His favorite food is fried noodles (mee), and he often buys a pack, finishing gradually at lunch until dinner.

The estimated daily intake from oral consumption in the ward is approximately 300 kcal and 10.5 g of protein, supplemented by 262 kcal and 10.5 g of protein from oral nutritional support (ONS). This results in a total daily intake of 562 kcal and 21 g of protein. Considering his ideal body

weight (IBW) of 54 kg, his total intake falls significantly below his estimated requirements. His energy needs are 1485-1650 kcal/day (27-30 kcal/kg/day), and his protein needs are 64.8-81 g/day (1.2-1.5 g/kg/day) (ESPEN Geriatric 2021). As his renal profile is currently improving, the protein requirements are only considered for geriatric patients and not for acute kidney disease. Additionally, his fluid requirements are approximately 2.0 litres per day, emphasizing the gap between his intake and nutritional requirements.

NUTRITION DIAGNOSIS

Inadequate protein-energy intake related to decreased ability to consume sufficient intake due to reduced as evidenced by estimated energy intake only achieved 37% of energy requirement, and protein intake only achieved 31% of protein requirement.

NUTRITION INTERVENTION

The nutrition intervention aims to provide quality of life and minimize nutritional impact symptoms. The patient will be provided with a soft diet at IDDSI Level 6, which includes soft and bite-sized, and with additional protein to make it high protein. A cup of high-protein jelly will also be included during lunch to enhance protein intake meeting the requirement.

The International Dysphagia Diet Standardisation Initiative (IDDSI) provides a standardized framework for classifying food textures and liquid consistencies to ensure safe swallowing and adequate nutrition for individuals with dysphagia. The IDDSI framework consists of eight levels (0–7), ranging from thin liquids (Level 0) to regular foods (Level 7). The patient's prescribed IDDSI Level 6 diet, known as Soft and Bite-Sized, includes tender and moist foods cut into small pieces that are easy to chew and swallow, reducing the risk of choking while maintaining meal enjoyment and nutritional adequacy.

To further support the patient's nutritional needs, oral nutritional supplement (standard dilution) will be incorporated into the feeding plan, with three servings per day: one at breakfast (8 a.m.), one during evening tea (3 p.m.), and one pre-bed (10 p.m.). Each serving will consist of 6 scoops ONS of 185 ml of water, providing a total volume of 230 ml per serving. This will contribute an estimated 786 kcal/day, 31.5 g of protein/day, and approximately 700 ml of fluid/day. This also achieved 50% of his requirement plus fluid intake from the ONS will help maintain hydration and electrolyte balance.

NUTRITION MONITORING AND EVALUATION

Key parameters for monitoring include his dietary intake to assess whether he can tolerate and consume the provided meals. Additionally, adherence to the prescribed oral nutritional supplements (ONS) will be evaluated, ensuring they are administered at the recommended times and in the prescribed volumes. Finally, regular monitoring of his biochemical data, such as renal profile and full blood count, will be conducted to track his nutritional and overall health status.

OUTCOME AND FOLLOW-UP

During follow-up day 1, Mr. A was reviewed by the speech therapist and diagnosed with oropharyngeal phase dysphagia, exacerbated by behavioral issues, particularly food refusal. The assessment revealed several challenges during the oral and pharyngeal phases of swallowing. During the oral phase, Mr. A exhibited anterior loss while drinking from a cup and prolonged oral holding. In the pharyngeal phase, he experienced delayed swallowing, coughing when consuming thin liquids, and throat clearing after drinking milk. However, Mr. A was uncooperative and refused to eat bread, only having a minimal amount, which resulted in an incomplete assessment. The speech therapy team plans on allowing a minced-moist diet and thin, liquid at IDDSI Level 1. They also planned to educate on safe swallowing strategies and safe hand-feeding techniques.

Mr. A had received a soft diet (IDDSI Level 6) and 1 cup of ONS as prescribed in the morning. According to his daughter, he had finished the milk. During lunch, it was observed that he consumed only 25% of the hospital-provided diet, complaining of a dislike for the taste and describing it as too plain. The patient did, however, successfully finish the high-protein jelly provided. After that Mr. A consumed a home cooked meal brought by their wife, consisting of moist rice with shredded fish. He was able to finish around 1.5 exchanges of rice and ½ exchanges of the fish, indicating a preference for familiar, well-seasoned foods.

The observation also revealed Mr. A's eating behavior. It was noticed that Mr. A had difficulty visually perceiving the food on the plate, leading to scooping large portions of food at a time, which sometimes he did not scoop anything at all. The daughter had to lead her father to identify the food beforehand. The patient also ate at a fast pace, frequently taking bites at short gaps which another one before finishing chewing or swallowing previous ones. Similarly, drinking was observed to be rushed, with the patient not pausing between sips. Apart from that, there was no other significant anthropometric or biochemical data.

A new nutritional diagnosis did emerge which is, Swallowing difficulty related to motor causes associated with aging as evidenced by oro-

pharyngeal dysphagia and speech therapy findings resulting in prolonged oral hold and delayed swallowing.

Through a multidisciplinary discussion, the nutritional goals of Mr. A remain to optimize energy and protein intake, prevent further weight loss, and maintain hydration and electrolyte balance with an additional goal which is to encourage proper feeding techniques to avoid aspiration, coughing or choking episodes.

A soft, high-protein diet at IDDSI Level 5 was intended for Mr. A to accommodate his swallowing needs. This included the addition of one cup of high-protein jelly daily. The prescribed feeding regimen of oral nutritional supplements (ONS) was to be continued, requiring six scoops of Ensure Gold mixed with 185 ml of water, producing a total volume of 230 ml per serving, to be provided three times a day. A constant monitoring was needed to look out for any signs of aspiration or choking episodes. As Mr. A was on plan to be discharged, a practical and feasible plan is needed to ensure nutritional needs are met at home. This could be achieved by discussing with the caregivers, mainly his wife and daughter, so it is within their capability. Firstly, his wife and daughter were instructed to ensure that all foods provided adhere strictly to IDDSI Level 5 standards, focusing on texture and consistency to support safe and comfortable swallowing. Foods must be soft and moist but free from any liquid leaking or dripping. They should not require biting and need minimal chewing, ensuring Mr. A can consume them with ease. Any lumps present should be no larger than 4mm and small enough to be mashed easily with the tongue. Plus, the food should be soft enough to be mashed effortlessly with a fork using minimal pressure and should hold its shape when scooped onto a fork without crumbling or dripping. For liquid, his current drink, such as milk tea and balanced formula, could both be considered as already slightly thick liquids, which is IDDSI level 1.

For example, to modify the texture of his favorite food, fried noodles (mee) to meet IDDSI Level 5 standards, cook the noodles until they are very soft and tender, slightly overcooking if necessary to ensure they can be mashed with minimal effort. Cut or chop the noodles into short, uniform lengths no larger than 4mm or use a food processor to achieve a consistent texture. Add a small amount of broth, sauce, or water to keep the noodles soft and moist, ensuring no liquid leaks or drips from the dish.

If the caregivers could not perfectly adhere to the texture modification, safe feeding techniques and safe swallowing strategies should be emphasized and given extra detail (Cichero et al. 2017; Swan et al., 2023). Firstly, it is encouraged that Mr. A should be supervised at all mealtimes to monitor his swallowing safety and ensure that any signs of difficulty, such as coughing or throat clearing, can

be promptly addressed. Feeding should be conducted at a slow and controlled pace, with small amounts of food or liquid offered per swallow. Using a teaspoon to deliver food or a small straw for liquids was advised to regulate the volume and prevent overloading his mouth. It is encouraged for Mr. A to be fed to effectively control both volume and eating rate. Mr. A should always be seated upright at a 90-degree angle during meals, with his head and neck aligned to reduce the risk of aspiration. Supportive cushions or devices could be used if he requires additional postural stability. After eating, he should remain in the upright position for at least 30 minutes to allow sufficient time for digestion and to minimize the risk of reflux or choking (Cichero et al. 2017).

All in all, it is strongly encouraged that adherence to IDDSI Level 5 food preparation at home, along with the consistent practice of safe swallowing and feeding strategies, be carried out together to achieve better, greater outcomes. Moreover, it is recommended that Mr. A be provided with Oral Nutritional Supplements (ONS) at least twice daily to help top up his nutritional intake. These combined efforts will support his dietary needs and enhance his safety and quality of life.

DISCUSSION

Mr. A's case highlights the complexities of managing oropharyngeal dysphagia, a condition characterized by impaired swallowing mechanisms that increase the risk of aspiration, malnutrition, and dehydration. In such cases, a multidisciplinary approach involving dietitians, speech-language pathologists (SLPs), and caregivers is vital to ensure both nutritional adequacy and swallowing safety.

Dysphagia often leads to reduced oral intake due to discomfort, fear of choking, or fatigue during meals, making nutritional intervention crucial. For Mr. A, adopting a diet consistent with IDDSI Level 5 (Minced & Moist) ensured that food was soft and easily mashable, reducing the effort required for chewing and swallowing while minimizing aspiration risks. Thickened liquids were also employed to slow liquid flow, providing better control and facilitating safe swallowing.

The use of The International Dysphagia Diet Standardization Initiative (IDDSI) framework is beneficial and truly crucial as it provides a standardized approach to texture-modified diets and thickened liquids, ensuring that food and fluids are specifically per Mr. A's needs. The IDDSI framework reduces confusion associated with non-standardized texture classifications, ensuring that patients receive appropriate food textures that match their swallowing capabilities (Sella- Weiss 2022). Studies indicate a 46% increase in overall IDDSI compliance post-intervention in aged care settings, demonstrating its effectiveness in enhancing meal

safety (Wu et al. 2022). Practical methods like the syringe flow test and fork drip test are also user-friendly for caregivers and patients, although they may lack precision for industrial applications (Hadde et al. 2022).

Despite its advantages, implementing IDDSI guidelines comes with challenges. Preparing texture-modified meals that adhered strictly to IDDSI standards required careful attention and effort from caregivers, thus ensuring that Mr. A's wife and daughter were adequately trained to prepare IDDSI Level 5 meals and recognize swallowing risks which needed significant time and resources. Misinterpretation of texture requirements or improper thickening could risk Mr. A's safety. According to Chadwick et al. (2006), caregivers often struggle with modifying food and drink consistencies, achieving proper positioning during meals, and using appropriate support and prompting strategies. Limited staff awareness, insufficient training, and lack of regular auditing also hinder effective IDDSI adoption in aged-care facilities (Wu et al. 2021). Mealtimes can also be time-consuming, requiring caregivers to invest time and energy in supervision. Namely, time pressures, staff turnover, and inadequate review of management strategies have always been significant factors complicating adherence to dysphagia care recommendations (Low et al. 2022; Lim et al. 2023; Miles et al. 2024).

Finally, enhanced caregiver support is essential for sustaining long-term care. Support groups or counselling services can address the emotional and physical challenges caregivers face when managing a dysphagia patient. Providing this support is critical for maintaining adherence to complex feeding regimens and preventing caregiver burnout, ultimately ensuring better outcomes for both the patient and their family.

A collaborative multidisciplinary approach plays a vital role in ensuring the effectiveness of dysphagia management among older adults. In this case, the speech therapist was responsible for assessing the patient's swallowing function and recommending the appropriate IDDSI diet level to ensure the food texture matched his swallowing ability. The geriatric specialist oversaw the patient's overall medical condition, hospitalization plan, and coordinated best practices to support recovery. Meanwhile, the staff nurses contributed significantly by assisting during feeding sessions and preparing nutritional formulas such as milk mixtures according to the prescribed texture and portion. Consistent communication among these disciplines helps ensure that nutrition, safety, and comfort are maintained throughout the patient's care (Cichero et al. 2017; Swan et al. 2023).

The patient's cognitive decline further complicated his feeding process. He was often unable to remember his eating pattern, leading to irregular intake and confusion during meals. On some occasions, he scooped food portions that were too large or attempted to feed himself when the spoon was empty, likely due to memory loss and visual impairment. These behaviors highlight the importance of close supervision, patience, and providing verbal or visual cues during mealtime to guide safe swallowing and ensure adequate food consumption (Chen et al. 2021; Swan et al. 2023).

Moving forward, reinforcing staff and caregiver education on feeding techniques, portion control, and texture consistency is essential. Regular review by the dietitian and speech therapist, along with family involvement, can enhance adherence and safety. Internationally, countries such as Japan and the United Kingdom have demonstrated success through structured dysphagia care models. Japan's Dysphagia Rehabilitation Program integrates dietitians, nurses, and speech-language pathologists in daily meal supervision, while the UK's NHS Dysphagia Pathway emphasizes early screening, standardized IDDSI implementation, and interdisciplinary collaboration (Japanese Society of Dysphagia Rehabilitation, 2021; National Health Service [NHS] 2023). Adapting similar practices within local healthcare settings could improve the quality, safety, and continuity of dysphagia care for older adults with cognitive decline.

CONCLUSION

Mr. A's case highlights the management of dysphagia within the framework of IDDSI guidelines. Ensuring adherence to texture-modified diets and safe feeding practices is crucial for maintaining his safety and optimizing his nutritional status. A multidisciplinary approach that includes personalized care plans, collaboration with caregivers, and support from innovative technologies can significantly enhance both patient outcomes and caregiver well-being. However, barriers such as caregiver fatigue, inadequate training, and limited resources must be addressed in the implementation of IDDSI. Ultimately, improving dysphagia management in Malaysia requires greater investment in training, awareness, and infrastructure to ensure that patients like Mr. A receive comprehensive, sustainable, and culturally appropriate care.

CONSENT

Verbal consent has been obtained from the patient.

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DECLARATION OF CONFLICT OF INTERESTS

The authors declared no potential conflicts of interest concerning the preparation and publication of this article.

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Laporan Kes / Case Report

Managing Nutritional Transition from Total Parenteral Nutrition to Enteral Nutrition in a Paediatric Patient

Pengurusan Peralihan Pemakanan daripada Nutrisi Parenteral Total ke Nutrisi Enteral dalam Pesakit Pediatrik

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ABSTRACT

This case report discusses the nutritional challenges and management strategies in a 2-year-old boy with gastrointestinal issue that is severe enterocolitis, experiencing complications such as perforated ileus, hence needing an ileostomy. Nutrition assessment revealed that the patient's highest recorded weight was under the 3rd percentile, with no recent measurements available. The growth status was assessed using the WHO Child Growth Standards (2006), weight for age. On the day of the stoma closure procedure, the patient experienced high stoma output and was reliant on both total parenteral nutrition (TPN) and enteral nutrition (EN). EN was first introduced at minimal volumes alongside TPN, and later increased as tolerated. At the time of assessment, EN provided 47% and TPN provided 53% of total energy. The nutrition diagnosis was identified as inadequate energy intake related to severe enterocolitis with postoperative recovery (stoma closure) and co-existing HIE leading to increased metabolic demands and feeding limitations, as evidenced by current intake meeting only 69% of energy requirements. Nutrition intervention included increasing the amount of catch-up formula to optimize energy and protein intake and introducing solid foods when deemed safe by the speech and language pathologist (SLP). This case highlights the complexities of nutrition management in pediatric patients with gastrointestinal conditions, particularly the transition from TPN to EN, requiring careful planning, monitoring and collaborations from other healthcare professionals.

Keywords: gastrointestinal function, severe enterocolitis, total parenteral nutrition, transition.

ABSTRAK

Laporan kes ini membincangkan cabaran dan strategi pengurusan pemakanan bagi seorang kanak-kanak lelaki berumur 2 tahun dengan masalah gastrousus yang teruk, iaitu enterokolitis, yang mengalami komplikasi seperti ileus perforasi dan memerlukan ileostomi. Penilaian pemakanan menunjukkan berat badan tertinggi yang direkodkan berada di bawah peratus ke-3, dan tiada ukuran terkini didapati. Status pertumbuhan dinilai menggunakan Standard Pertumbuhan Kanak-Kanak WHO (2006), berat mengikut umur. Pada hari prosedur penutupan stoma, pesakit mengalami pengeluaran stoma yang tinggi dan bergantung kepada nutrisi parenteral (TPN) dan nutrisi enteral (EN). EN diperkenalkan pada jumlah minima bersama TPN, dan kemudian ditingkatkan mengikut kemampuan pesakit. Pada masa penilaian, EN menyumbang 47% manakala TPN menyumbang 53% daripada jumlah tenaga. Diagnosis pemakanan adalah pengambilan tenaga yang tidak mencukupi disebabkan oleh enterokolitis teruk dengan pemulihan selepas pembedahan (penutupan stoma) dan HIE yang wujud bersama, menyebabkan peningkatan keperluan metabolik dan had pemakanan, seperti yang dibuktikan oleh pengambilan semasa hanya memenuhi 69% keperluan tenaga. Intervensi pemakanan termasuk meningkatkan jumlah susu

formula untuk pertumbuhan semula bagi mengoptimumkan pengambilan tenaga dan protein serta memperkenalkan makanan pejal apabila dimaklumkan selamat oleh ahli patologi pertuturan dan bahasa (SLP). Kes ini menekankan kerumitan pengurusan pemakanan dalam kalangan pesakit pediatrik dengan masalah gastrousus, terutamanya peralihan dari TPN ke EN, yang memerlukan perancangan, pemantauan dan kerjasama rapi dengan profesional kesihatan lain.

Kata Kunci: fungsi gastrousus, enterokolitis teruk, nutrisi parenteral, peralihan.

INTRODUCTION

Hypoxic-ischemic encephalopathy (HIE) refers to a type of brain injury caused by insufficient oxygen supply to the brain, often occurring around the time of birth (Campellone 2022). This condition primarily affects the central nervous system and can result in neurological and developmental issues. Babies born with HIE may experience long-term challenges such as motor and cognitive impairments, affecting their overall development and quality of life (Campellone 2022). HIE in early life can compound feeding intolerance and growth faltering, often necessitating staged transitions between TPN and EN. In this patient, severe enterocolitis secondary to rotavirus AGE, together with HIE and postoperative status, created sustained challenges to achieving adequate intake and growth.

Severe enterocolitis secondary to rotavirus acute gastroenteritis (AGE) is a common condition in pediatric populations, often resulting in significant morbidity. Enterocolitis is a medical condition that causes inflammation of the small intestine and colon. This inflammation may result from a variety of causes, including infections, autoimmune diseases, or inflammatory conditions. The most common causes of enterocolitis are bacterial or viral infections, which often lead to complications such as diarrhea, fever, nausea, vomiting, and abdominal pain (Sharmin 2023). This condition can be particularly serious for individuals in vulnerable populations, including infants, the elderly, and those with weakened immune systems. The inflammation associated with enterocolitis can disrupt the normal functioning of the gastrointestinal system, leading to significant discomfort and potential long-term health problems if not treated promptly and effectively (Sharmin 2023). The condition of enterocolitis can either be acute or chronic. The complications of severe enterocolitis in this case includes septic and hyponatraemic hypovolemic shock, disseminated intravascular coagulation (DIVC), acute kidney injury (AKI), and even perforated ileum. Additionally, the patient developed a pressure sore over the occipital region as a consequence of prolonged immobility and critical illness.

Intestinal perforation, defined as a loss of continuity in the bowel wall, is one of the more serious complications of enterocolitis and other gastrointestinal conditions (Hafner et al. 2020). The perforation, in this case is perforation in the ileum, requiring an ileostomy to divert the intestinal contents and allow for healing, reducing the risk of further complications, including infection and systemic shock (Hafner et al. 2020). TPN is one of the options for nutrition management as feeding and absorption could be affected.

Carbapenem-resistant Enterobacterales (CRE) infections present a significant challenge in healthcare settings, particularly in hospitals and intensive care units (ICUs) (Yin et al. 2021). These infections are caused by bacteria that have developed resistance to a broad spectrum of antibiotics, including carbapenems, which are considered the drugs of last resort for treating severe bacterial infections. CRE infections are often associated with high morbidity and mortality rates, particularly in immunocompromised patients and those with underlying medical conditions (Yin et al. 2021).

CASE BACKGROUND

The patient is a 2-year-old Malay boy with the date of birth on 6/11/2022 and was admitted under the paediatric unit of a government hospital in Kuala Lumpur on 9/8/2024 for ongoing management of multiple complex medical issues. This case represents his seventh follow-up visit. The patient's current issue was severe enterocolitis secondary to AGE, which was complicated with septic and hyponatraemic hypovolemic shock, DIVC, AKI, and a perforated ileum. He also developed a pressure sore over the occipital region. The patient was currently post-operative day 7 following stoma closure surgery on 5/11/2024, performed after an ileostomy for the perforated ileum in August 2024. Additionally, the patient had a history of severe HIE during infancy, with early signs of left hemiplegia noted in the current admission. Underlying medical conditions include a complex congenital heart defect comprising double outlet right ventricle, transposition of the great arteries, pulmonary stenosis, and a criss-cross heart with a single ventricle pathway. He was also a known CRE colonizer. Current medications include oral spironolactone 6.25 mg twice daily, intravenous (IV) omeprazole twice daily, IV metronidazole three times daily, IV cefotaxime three times daily, and zinc

oxide cream applied topically three times daily. During this visit, the patient was in an isolation room. The patient's mother, who accompanied him, was called out from the room to discuss his condition as direct interaction with the patient was not possible.

During this visit, it is the patient's seventh dietetic follow-up since admission. Nutritional management began on 12/8/2024, during the first dietetic visit, when the patient was transitioning from TPN to EN. At that time, he was on perfusor feeding with a catch-up formula at 30 ml/hour, 3 hours run and 1 hour rest (3+1). This provides a total of 810 kcal/day and 21 g of protein/day, with a fluid intake of 80 ml/kg/day. The feeding plan during this visit involved continuing this regime 4 hourly, 6 times per day. By the first follow-up on 13/8/2024, the patient tolerated the previous feeding plan well, and the perfusor rate was increased to 35 ml/hour at 1.5 kcal/ml of dilution. This provides 950 kcal/day and 24.7 g of protein/day, with a total fluid intake of 90 ml/kg/day.

The second follow-up was on 21/8/2024 where the plan was to further increase the feeding rate to 40 ml/hour which give the dilution of 1.45 kcal/ml, providing 1055 kcal/day and 27.3 g of protein/day, while maintaining a total fluid intake of 90 ml/kg/day. By the third follow-up on 23/9/2024, the patient continued to tolerate the feeding regimen, prompting a transition from perfusor to bolus feeding. The new regime involved 90 ml per bottle for every three hours, equal to 8 times daily. This provides 1065 kcal/day, 27.6 g of protein/day and 720 ml/day of total fluid.

At the fourth follow-up on 30/9/2024, the patient passed bowel movements 5 times daily (including two episodes of soft stools) without vomiting. A lactose-free formula was introduced at 20 ml/hour via perfusor feeding with plans to increase to 30 ml/hour if gastrointestinal losses stabilized. This regimen provided 1065 kcal/day and 27.6 g of protein/day. By the fifth follow-up on 23/10/2024, the patient was nil by mouth (NBM) and dependent on TPN at 80% maintenance. During the visit in the evening on the same day, the plan was a gradual introduction of feeding with 1 ml of Neocate every 3 hours using standard dilution.

At the sixth follow-up on 5/11/2024, the primary concern was high stoma output, although the patient showed no signs of vomiting. He remained NBM and on TPN in preparation for stoma closure on the same day. Previously, the patient had tolerated 9 ml/hour of Neocate, providing 108 kcal/day and a total fluid volume of 162 ml/day.

CASE REPORT

The patient's latest recorded weight was 7.6 kg, placing him below the 3rd percentile for his age. His highest recorded weight was 8 kg, which, despite being used as the reference weight for nutritional requirement calculations, remains under the 3rd percentile. Since admission, the patient's weight has fluctuated, reflecting the complexities of his medical condition and the challenges in achieving consistent nutritional stability. No recent anthropometric data were available at the time of this follow-up. Recent biochemical investigations revealed a hemoglobin (Hb) level of 16.4 g/dL, indicating a high reading, while the white cell count (WCC) was within normal range at 9.1 x 10^9/L. Renal profile (RP) results showed a low urea level of 3 mmol/L and sodium (Na) at 137 mmol/L, while potassium (K) and creatinine (Cr) were within normal limits at 4.6 mmol/L and 18 μmol/L, respectively. Liver function tests (LFT) highlighted a high total protein (TP) of 89 g/L, though albumin (Alb) was normal at 45 g/L. Electrolyte analysis revealed a low magnesium (Mg) level of 0.82 mmol/L, with calcium (Ca) and phosphate (PO_4) levels within normal limits at 2.58 mmol/L and 1.44 mmol/L, respectively. The high Hb (16.4 g/dL) may reflect hemoconcentration meanwhile the low urea (3 mmol/L) may indicate low protein intake. The Mg level is low (0.82 mmol/L), which may affect gastrointestinal tolerance and neuromuscular function. Sodium, potassium, creatinine, calcium and phosphate are within acceptable ranges. In addition, the albumin level is normal despite high total protein, which may also reflect hemoconcentration. For this patient, electrolyte repletion (Mg) and close trend monitoring alongside feeding advancement are planned.

During the latest follow-up, direct physical examination of the patient was not possible as the patient remained in isolation. Communication with the patient's mother revealed that the patient exhibited poor sucking ability, requiring milk feeding via a Ryle's tube (RT) if unable to finish orally. Input-output (I/O) monitoring showed a positive balance of +366 mL, with a total intake of 1000 mL and output of 634 mL. On 30/9/2024, the patient passed bowel movements 5 times/day (two soft stools). In contrast, during the last 24 hours of this assessment, there was one large bowel movement. In addition, the patient had no episodes of vomiting, and maintained a blood pressure of 108/64 mmHg and heart rate of 131 beats per minute. Oxygen saturation (SpO_2) was recorded at 85% under room air, consistent with the clinical goal to maintain levels above 75%.

TABLE 1 Summary of TPN/EN/Bottle Feeding Across Visits.

Date (2024)	Regimen	Energy (kcal/day)	Protein (g/day)	Fluid	Notes
12/8	Perfusor Catch-up formula 30 mL/h, (3+1)	810	21.0	80 mL/kg/day	Start EN while transitioning off TPN.
13/8	Perfusor 35 mL/h, 1.5 kcal/mL	950	24.7	90 mL/kg/day	Tolerated escalation.
21/8	Perfusor 40 mL/h, 1.45 kcal/mL	1055	27.3	90 mL/kg/day	Continued tolerance
23/9	Bolus 90 mL/bottle, 3 hourly, 8x/day	1065	27.6	720 mL/day	Transition to bolus
30/9	Perfusor Lactose-free formula 20 mL/h (plan to increase to 30 mL/h)	1065	27.6	-	BO 5x/day (two soft stools)
23/10	NBM, TPN 80% maintenance, Trial Neocate 1 mL, 3 hourly	-	-	-	Re-initiate minimal EN
5/11	High stoma output, TPN ongoing, Previously Neocate 9 mL/h	108	-	162 mL/day	High stoma output, day of stoma closure
Current 24 hours	TPN 24 mL/h (445 kcal, 22.8 g protein) + Dugro Sure Plus 1.5 scoops, 8x/day (388 kcal, 10.1 g protein)	833.3	32.9	-	EN:TPN = 47:53 by energy

The patient is currently on a combination of bottle feeding, RT feeding, and TPN, all of which are being well-tolerated. The mother prepares the catch-up formula using a dilution of 2 scoops in 90 ml water which the mother has diluted the milk accordingly as concerned for constipation. She plans to increase the volume to 120 ml per feed using standard dilution, waiting for approval from the medical team. If the patient is unable to finish feeding orally due to fatigue or refusal, the mother will administer the milk via the RT. For the past 24 hours, the patient received TPN at 24 ml/hour, delivering 445.01 kcal/day and 22.8 g/day of protein. Additionally, the patient consumed 1.5 scoops of Dugro Sure Plus mixed with water (30 ml per feed), 8 times daily, providing 388.3 kcal/day and 10.12 g/day of protein. The combined intake from TPN and enteral nutrition (EN) totaled to 833.32 kcal/day (104 kcal/kg body weight/day), meeting 69% of energy requirements. Other than

that, 32.92 g/day of protein (4 g/kg body weight/day), meeting 100% of protein requirements. The current EN-to-PN ratio is 47:53. Solid food intake remains restricted as awaiting assessments by the speech therapist. Table 1 shows the summary of feeding across visits.

NUTRITION DIAGNOSIS

The nutrition diagnosis for this patient in this session was:

[New] Inadequate energy intake related to severe enterocolitis with postoperative recovery (stoma closure) and co-existing HIE leading to increased metabolic demands and feeding limitations, as evidenced by total intake meeting ~ 69% of energy requirements over the last 24 hours (833.3/1200 kcal/day).

NUTRITION INTERVENTION

The primary objectives of the nutrition intervention were to optimize the patient's energy and protein intake to support growth and development, as well as to promote overall growth progression. Based on the patient's best weight of 8 kg, and using the guidelines from *Dorothy E.M. Francis, Diet for Sick Children* (1987), for children aged 1-3 years, the estimated daily requirements for the patient are 1200 kcal/day (150 kcal/kg body weight/day), 24-36 g of protein/day (3-4.5 g/kg body weight/day), and 760 mL of fluid (100 mL/kg body weight/day). To meet these nutritional goals, the feeding plan was adjusted to provide an adequate balance of calories, protein, and fluid.

Firstly, the feeding strategy involves administering 32 scoops of catch-up formula mixed with water, which will provide 960 ml of milk per day. This volume is then divided into 8 bottles, each containing 120 ml of formula to be fed every 3 hours throughout the day. This feeding regimen will provide the patient with 1130 kcal/day (141 kcal/kg body weight/day), which meets approximately 94% of the patient's estimated energy requirements (ER). Additionally, this plan provides 29.44 g of protein/day (3.7 g/kg body weight/day), meeting 100% of the patient's protein requirements. Fluid intake will be 960 ml/day (130 ml/kg body weight/day), which is above the required fluid intake, ensuring adequate hydration.

Secondly, the mother was advised on the importance of using the standard dilution for the formula, as diluting the milk further is not recommended. It was explained to the mother that standard dilution should not cause constipation, addressing her concerns about the patient's bowel movements. This clarification aims to reassure the mother and prevent any future adjustments that may compromise the patient's nutritional intake. Thirdly,

the patient was currently awaiting a swallowing assessment, which will determine whether the introduction of solid foods can be considered. If the swallowing assessment is successful, a plan will be made to introduce mixed porridge as part of the diet. However, solid food intake will not be introduced until the speech therapist provides approval, ensuring that the patient's swallowing function is adequately assessed for safety.

Lastly, in the event that the patient can tolerate full enteral feeding and consume the required amounts orally, it is suggested to discontinue TPN. This would further support the patient's long-term growth and nutritional status. If the patient is unable to consume the full amount of milk orally due to fatigue or refusal, the mother is allowed to continue using the RT to ensure that the required amounts of formula are administered. This approach will provide flexibility in feeding while ensuring that the patient receives the full nutritional support needed for recovery and growth. For nutrition monitoring and evaluation, it is important to monitor the patient's feeding tolerance towards the regime planned and his growth progression to ensure there is no decrease in weight.

DISCUSSION

In many cases, enterocolitis is caused by infections that affect the gastrointestinal tract, either through bacterial or viral pathogens. The symptoms of enterocolitis vary, but they typically include abdominal pain, diarrhea, nausea, vomiting, and fever (Sharmin 2023). This could directly affect dietary intake where it causes low appetite and low energy and protein intake. In the case of this patient, enterocolitis is secondary to AGE. The condition was further complicated by septic shock, hyponatremic hypovolemic shock, DIVC, AKI, and a perforated ileum. Intestinal perforation, defined as a loss of continuity in the bowel wall, allows for the leakage of intestinal contents into the abdominal cavity, which could lead to peritonitis, a life-threatening infection of the abdominal lining (Hafner et al. 2023). In the case of a perforated ileum, prompt surgical intervention is required to manage the perforation and prevent further deterioration which is ileostomy. Other medical issues such as severe HIE with early signs of left hemiplegia, MRCONS bacteremia, heart problems and CRE colonizer could also directly or indirectly affect the patient's nutritional status as each issue has their own complications.

Nutritional assessment and intervention are crucial in critically ill patients, as they can significantly impact their recovery. Anthropometric assessment is conducted to evaluate growth progress, including weight gain and height increase. Biochemical data are analyzed to assess electrolyte balance and organ functions, such as liver and

kidney performance. Clinical assessment focuses on identifying nutrition-related symptoms, which in this case include bowel movements and other gastrointestinal functions. Lastly, dietary assessment is performed to evaluate the patient's nutritional intake and ensure it meets their requirements. Lian et al. (2023) highlighted that early nutritional treatment may be vital to the patient's recovery, especially in preventing complications such as surgical site infections. Malnutrition increases the risk of infections and impairs the immune response, making it essential for healthcare providers, especially dietitians, to evaluate and address nutritional needs immediately (Lian et al. 2023). TPN and EN are two ways to optimize nutritional intake among patients with these conditions where gastrointestinal tract functions were affected.

On 23/10/2024, the patient was kept NBM and was administered TPN at 80% maintenance. As Hamdan & Puckett (2023) explains, TPN is designed to provide essential nutrients when enteral feeding is not feasible. The decision to initiate TPN and the formulation of the TPN solution must be personalized based on the patient's diagnosis and nutritional status, to avoid both undernutrition and overnutrition (Hamdan & Puckett 2023). TPN serves as a vital intervention when the digestive system is non-functional or inaccessible and is typically indicated for patients with impaired gastrointestinal function or contraindications to EN (Hamdan & Puckett 2023). It is used to manage and treat malnutrition in critically ill patients when oral or enteral feeding cannot meet the nutritional requirements. Despite its benefits, TPN carries inherent risks such as metabolic disturbances, infections, and mechanical complications, underscoring the importance of careful monitoring during administration (O'Hanlon et al. 2015).

Transitioning from parenteral to enteral feeding is a crucial step in the recovery process, typically given once the patient is stable. However, using both routes simultaneously increases the risk of exceeding nutritional requirements, which can lead to overfeeding and its associated complications (O'Hanlon et al. 2015). While enteral feeding is generally preferred over parenteral nutrition due to its benefits for gut health, full nutritional support through the enteral route is not always achievable in critically ill patients, necessitating the continued use of parenteral nutrition in some cases (O'Hanlon et al. 2015). It is well-documented that prolonged bowel rest due to exclusive TPN use can negatively impact the intestinal mucosa's structure and function, further complicating the patient's condition (Perez Cordon et al. 2022). As such, transitioning to enteral feeding should be done gradually over 48–72 hours, with close monitoring of both caloric and protein intake to prevent overnutrition. This process should continue until the patient is able to tolerate at least 60–75% of their prescribed enteral diet for a minimum of 48–72 hours (Perez Cordon et al. 2022).

In this case, during transitioning from TPN to EN, the dietitian in charge suggested introducing a few products to the patient which are Neocate and Peptamen Junior. Neocate is a semi-elemental, infant formula (0-12 months old) administered for special medical purposes for diet management of severe or complex cow's milk allergy, multiple food protein allergy and other indications where an amino acid is recommended. On the other hand, Peptamen Junior is a peptide-based enteral nutrition product (1-10 years old) for diet management of gastrointestinal impairment. Peptide-based formulas were recommended as they are easier to digest and improve immune function, help to enhance nutritional status and reduce complications in critically ill patients (Lian et al. 2023).

CONCLUSION

This case emphasizes the importance of effective nutrition management, particularly when gastrointestinal conditions compromise a patient's ability to meet their nutritional needs. Complications such as reduced appetite, irregular bowel movements, or vomiting can significantly impact nutritional status, often requiring the use of EN to achieve dietary goals. In some cases, TPN becomes essential to fulfill unmet nutritional requirements. Transitioning from TPN to EN presents its own challenges, such as deciding on the appropriate product, determining the optimal quantity, and setting the duration of administration. This process must be personalized to meet the unique needs of each patient, as no two cases are alike. Continuous monitoring and adjustments based on the patient's current condition are vital to ensure successful nutritional management. Moreover, this effort requires a collaborative approach involving various healthcare professionals, including dietitians, doctors, and nurses, to address the patient's overall health and recovery comprehensively. By implementing a well-coordinated plan, patients can receive the nutrition they need to support their recovery and improve their quality of life.

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Laporan Kes /*Case Report*

Addressing Nutritional Challenges In Chemoradiotherapy for Nasopharyngeal Carcinoma: A Case Report

Mengatasi Isu Pemakanan dalam Pesakit Kanser Nasofarinks semasa Menerima Rawatan Kemoradioterapi: Laporan Kes

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ABSTRACT

Concurrent chemoradiotherapy (CCRT) is the standard treatment for advanced nasopharyngeal carcinoma (NPC). Side effects of CCRT can significantly impair nutritional intake. This case report discusses a nutritional management of a 38-year-old, Malay, male, diagnosed with Stage IV. He was admitted for CCRT with weekly intravenous cisplatin and radiotherapy. The patient experienced poor oral intake, weight loss, mucositis, xerostomia and chemotherapy-induced electrolyte imbalances, including low sodium, potassium and chloride levels. Nutrition interventions were implemented, starting with texture-modified diets and oral nutrition supplements (ONS), to manage side effects and support dietary intake. This case report emphasizes the importance of appropriate food texture and patient-centred care in encouraging nutritional intake. However, persistent weight loss and insufficient oral intake led to the consideration of enteral nutrition via nasogastric tube feeding to ensure adequate energy and protein intake and prevent treatment disruption. This case highlights the importance of addressing nutritional challenges during CCRT to optimize patient outcomes and treatment success.

Keywords: head and neck cancer, nutrition, nasopharyngeal, cancer, chemoradiotherapy

ABSTRAK

Kemoradioterapi serentak (CCRT) adalah rawatan standard yang diberikan kepada pesakit kanser nasofarinks (NPC) tahap lanjut. Kesan sampingan rawatan CCRT boleh menjejaskan pengambilan pemakanan secara ketara. Laporan kes ini membincangkan mengenai seorang pesakit lelaki Melayu berusia 38 tahun yang didiagnosis dengan NPC Tahap IV. Pesakit ini dimasukkan ke wad bagi menjalani rawatan CCRT dengan pemberian cisplatin secara intravena setiap minggu serta rawatan radioterapi. Pesakit mengalami kekurangan pengambilan makanan, penurunan berat badan secara drastik, mukositis oral, mulut kering serta ketidakseimbangan elektrolit (tahap natrium, kalium dan klorida yang rendah) disebabkan kesan sampingan kemoterapi. Intervensi pemakanan telah dilaksanakan dengan diet bertekstur lembut dan pemakanan sokongan secara oral (ONS) diberikan kepada pesakit bagi meyokong pengambilan makanan. Laporan kes ini menekankan kepentingan pemelihan tesktur makanan yang sesuai serta penjagaan berpusatkan pesakit dalam menggaalakkan pengambilan pemakanan. Namun bergitu, pesakit masih mengalami penurunan berat badan yang berterusan dan pengambilan makanan secara oral masih kurang daripada paras optimum. Oleh itu, pemakanan secara enteral melalui tiub nasogastrik dipertimbangkan bagi memastikan pesakit menerima tenaga dan protein yang mencukupi serta mengelakkan gangguan terhadap rawatan yang dijalankan. Kes ini menunjukkan kepentingan menangani kesan sampingan CCRT bagi mencapai pengambilan pemakanan yang mencukupi dan memberikan hasil rawatan yang optimum kepada pesakit.

Kata kunci: kanser kepala dan leher, nutrisi, nasofarinks, kanser, kemoradioterapi..

INTRODUCTION

Nasopharyngeal carcinoma (NPC) is a malignancy of the nasopharyngeal epithelium. It ranks among Malaysia's top 10 cancers, accounting for 5.1% of cases with higher incidence in men (National Cancer Institute 2022). Risk factors include infections, family history and lifestyle choices. According to the Investigation of occupational and environmental Causes of Respiratory cancers (ICARE) study, the risk of head and neck cancer is increased 3.5 times among patients with a first-degree relative affected by the disease (Alrfaei et al. 2023; Radoï et al. 2013).

Moreover, tobacco use is also a key risk factor for NPC (Lander et al. 2024). According to the American Cancer Society (2024), tobacco contributes to 26% of global cancer deaths and is linked to lung, esophageal, stomach and colorectal cancers. In Malaysia, 19% of the population smokes, with the highest prevalence among male aged 35-44 years (Insitute for Public Health 2023). Smoking remains common in Asia due to aggressive marketing, economic growth, weak tobacco policies (American Cancer Society 2024). Common symptoms include neck masses, nasal discharge, ear issues (blockage, deafness, tinnitus) and neurological symptoms (Rafiq et al. 2018).

Stage I NPC is treated with radiotherapy, while advanced stages (II to IVB) require concurrent chemoradiotherapy (CCRT) and sometimes neoadjuvant chemotherapy to shrink tumors (Chen et al. 2021; Chua et al. 2025). CCRT can cause side effects such as nausea, vomiting, altered taste, infection, anemia, mouth sores, lethargy and hair loss. These symptoms can impact nutrition intake and lead to weight loss (Bhutani et al. 2024; Wang et al. 2021).

NUTRTITION ASSESSMENT

CLIENT HISTORY

The patient is a 38-years-old, Malay, mal with a known diagnosis of Stage IV nasopharyngeal carcinoma (NPC), diagnosed in early 2024. He has a background of a 10-year history of cigarette smoking, which he had stop at age 33 He was electively admitted to the oncology ward on 13 October 2024 for CCRT. The treatment plan includes radiotherapy to facio-cervical region (70Gy in 35 fractions over 7 weeks) in combination with weekly intravenous (IV) Cisplatin (50 mg/m^2). At the time of referral to the dietitian, the patient had completed 11 out of 35 planned radiotherapy fractions. The referral was made due to poor oral intake and significant weight loss observed over the preceding two weeks, raising concerns about nutritional status and treatment tolerance.

ANTHROPEMETRIC MEASUREMENTS

As part of the hospital protocol, the weight of cancer patients is monitored weekly. The patient's weight was measured using weighing scales available in oncology ward. Table 1 presents the recorded patient's weight.

BIOCHEMICAL DATA

The latest available biochemical data, recorded on 18 November 2024, is shown in Table 2. Renal profile and liver function tests were performed and show no significant changes compared to renal profiles test conducted on 13 October 2024. Electrolyte imbalances, including hyponatremia (132 mmol/L), hypokalemia (3.2 mmol/L) and hypochloremia (90 mmol/L) were detected, likely due to side effect of chemotherapy drug Cisplatin (Alrfaei et al. 2023; Oronsky et al. 2017).

NUTRITION-FOCUSED PHYSICAL FINDINGS

The patient was assessed with Patient-Generated Subjective Global Assessment (PG-SGA) on the first visit and assessment was repeated on the last visit as patient's condition worsening. The score of both PG-SGA was summarized in Table 3.

FOOD AND NUTRITION-RELATED HISTORY

The patient received a high-protein, normal-texture diet but struggled to finish meals provided due to swallowing difficulty caused by dry mouth. He consumed only a quarter of each hospital-provided meal and began oral nutrition supplements (ONS) with one scoop of standard polymeric formula 1-2 times daily, which he tolerated well. Energy intake was estimated at 1200-1500 kcal/day (58% of the requirement), and protein intake was 30-40g/day (42% of the requirement).

NUTRITION DIAGNOSIS

Inadequate energy and protein intake is related to physiological causes that increase energy and protein needs due to ongoing CCRT treatment as evidenced by current estimated energy and protein intake (58% of energy requirement and 42% of protein requirement) is less than estimated energy (2000-2400 kcal/day) and protein (80-96 g/day) requirement and 2% of weight loss in 2 weeks.

NUTRITION INTERVENTION

The aims are to optimize oral nutritional intake, maintain the current weight and support the ongoing CCRT treatment. Using dosing weight of 80 kg (at a BMI of 30 kg/m^2) for weight maintenance and to avoid overestimation, energy requirements are set at 2000-2400 kcal/day (25-30 kcal/ kg /day) and protein at 80-96g/day (1.0-1.5g/kg/ day) (Muscaritoli et al. 2021). A high protein intake is targeted to prevent sarcopenic obesity (Arends et al. 2017).

Intervention strategies included providing a blended diet to address swallowing difficulties, prescribing a standard polymeric formula as an oral nutrition supplement (ONS) with regime a regime dilution of 6 scoops in 200ml water, 3 times daily and accompanied with nutrition counselling to encourage meal completion and ONS compliance. Additionally, patients were advised to consume ONS two hours before or after meals to optimize intake. The ONS prescription was estimated to provide 792 kcal/day and 31.5g of protein/day. The nutrition intervention primarily focused on increasing dietary intake and supporting energy and protein intake with ONS as per the recommendation by Muscaritoli et al. (2021).

MONITORING AND EVALUATION

The main parameters that needed to be monitored for this patient were his biochemical data (including full blood count, renal profile and liver function test), weekly weight, dietary intake, tolerance and compliance towards ONS regimen provided and gastrointestinal (GI) symptoms (such as diarrhea, constipation, nausea, swallowing problems, sore at mouth and throat).

FIRST FOLLOW-UP (7 NOVEMBER 2024)

The patient maintained a body weight of 109.1 kg. Diet recall showed improved intake, with the patient being able to finish a blended diet and adhere to the ONS regimen. The estimated intake was 1900-2000 kcal/day with 73.5 g of protein per day.

The nutritional diagnosis remained unchanged. The intervention was adjusted to continue the blended diet and increase the ONS regimen to 8 scoops of a standard polymeric formula and 1 scoop of a protein modular product mixed with 300 ml of water, taken 3 times daily. The new feeding regimen provided 1127 kcal/day and 57 g protein/day.

SECOND FOLLOW-UP (15 NOVEMBER 2024)

The patient's weight decreased from 109.1 kg to 105.7 kg over two weeks. Symptoms worsened, including vomiting, appetite loss, early satiety, lethargy and altered taste. The patient also complained of a sandy sensation when swallowing. Dietary intake primarily relied on ONS, with minimal consumption of the blended diet.

To address these challenges, the diet was shifted to primarily rely on nourishing fluids. The ONS regimen of 12 scoops of a standard polymeric formula and 1 scoop of a protein modular product, mixed with 360 ml of water, was prescribed to be taken 4 times daily. The patient was required to prepare the ONS prescription himself. However, the patient complained of being unable to take ONS four times daily due to lethargy and early satiety.

A more flexible approach was implemented by setting a minimum daily intake of 40 scoops of a standard polymeric formula and 4 scoops of protein modular product without specific timing to increase adherence to ONS and ensure adequate intake. This regimen provided 1852 kcal/day and 97 g of protein/day. Nutrition education included the preparation of standard ONS dilution, food safety and hygiene, delivered to the patient. The patient was also advised to consume small, frequent amounts to prevent vomiting and improve tolerance

THIRD FOLLOW-UP (19 NOVEMBER 2024)

The patient adhered to the ONS regimen but continued to lose weight, reaching 104.6 kg (a 6% weight loss in 1 month) due to side effects from CCRT and a hypercatabolic state. Limited oral intake of energy and protein, along with rapid weight loss prompted a recommendation for enteral nutrition via a nasogastric tube to prevent interruption of CCRT treatment.

Nutrition counseling was provided to clarify that enteral feeding aimed to reduce the burden of consuming large ONS volume and maintain weight for ongoing treatment. The patient requested time to consider the recommendation before providing consent.

DISCUSSION

The patient experienced radiation-induced mucositis and xerostomia. Oral mucositis causes pain that limits oral intake while xerostomia, a hyposalivation condition, impairs chewing, swallowing and taste, further reducing appetite. These conditions are associated to reduced nutritional intake and increased weight loss (Müller et al. 2023; Wang et al. 2021).When planning nutrition interventions for patients with xerostomia and mucositis, food texture plays a crucial role. Soft and liquid diets are better tolerated. Patients with xerostomia prefer moist, easy-to-eat foods and increased fluid intake, while avoiding dry items like bread and crackers (Müller et al. 2023; Wang et al. 2021). Decreased nutritional intake can lead to malnutrition and weight loss (Lalla et al. 2008; Müller et al. 2023; Wang et al. 2021). Head and neck cancer patients often experience significant weight loss within two weeks of starting CCRT (Wang et al. 2021). Enteral nutrition may be initiated if intake remains insufficient to meet requirements, preventing treatment disruption. Tube feeding, via a nasogastric tube (NGT) or percutaneous gastrostomy (PEG), effectively delivers high protein and energy for weight maintenance (Chien et al. 2007). However, patient acceptance of tube feeding varies. While some find it beneficial for stabilizing weight and improving well-being, others perceive it as a

TABLE 1 Summary of anthropometrics measurements during on-going CCRT..

Date	13 Oct 2024	29 Oct 2024	7 Nov 2024	15 Nov 2024	19 Nov 2024
Height (cm)	163	163	163	163	163
Weight (kg)	111.3	109.1	109.1	105.7	104.6
BMI (kg/m^2)	41.4	41.1	41.4	39.8	39.4
Percentage of weight loss (%)	-	2% of weight loss in 2 weeks	-	-	6% of weight loss in 1 month

Note. Body Mass Index (BMI)

TABLE 2 Renal profile and liver function tests results with reference range.

Parameter	Flag	Result	Unit	Reference Range
Urea		7.8	mmol/L	2.8-8.1
Sodium	L	132	mmol/L	136-145
Potassium	L	3.2	mmol/L	3.5-5.1
Chloride	L	90	mmol/L	98-107
Creatinine		93	μmol/L	59-104
Total protein		71	g/L	64-83
Albumin		35	g/L	35-52
Total Bilirubin		7	μmol/L	<22
Alkaline Phosphatase		23	U/L	<42

Note. Lower than normal range (L)

TABLE 3 Summary of PG-SGA assessment.

Date	29 Oct 2024	19 Nov 2024
PG-SGA score	14	20
Remarks	- Decrease in weight. 2% of weight loss in 2 weeks. - Taking only liquid foods. - Nausea, mouth sore, swallowing problem, dry mouth, fatigue. - Up and about with normal activities. - No fever - No noticeable muscle and fat loss.	- Decrease in weight. 6% of weight loss in 1 month. - Only tolrate Oral Nutrition Supplement (ONS) - Nausea, mouth sore, swallowing problem, dry mouth, fatigue, altered taste, vomiting, feel full quickly. - No fever - Up and about with normal activities - No noticeable muscle and fat loss

shift from being a person to a patient, leading to rejection.

CONCLUSION

This case highlights the difficulties in treating Stage IV NPC in patients receiving CCRT. The treatment resulted in complications such as poor oral intake, significant weight loss, mucositis, xerostomia and electrolyte imbalance which negatively impacted the patient's nutritional status. Nutritional interventions, including texture-modified diets and ONS, were implemented to address these issues. Despite efforts and compliance, patient's nutritional intake remain insufficient, thus enteral nutrition was taken into consideration to maintain treatment continuity and prevent further weight loss

LEARNING POINTS

- This case underscores the importance of communication in multidisciplinary care when addressing both clinical and nutritional complications arising from CCRT treatment.

- Choosing an appropriate dosing weight for managing cancer patients with obesity can be challenging, as there are few to no established guidelines for weight maintenance in obese patients that benefit ongoing CCRT. The determination to dose weight relies primarily on the dietitian's judgement based on patient's condition.

- Negative perceptions towards the initiation of tube feeding are common. This causes the patient to be hesitant in giving consent and in many cases leads to rejection. Therefore, extensive nutrition counselling is essential to educate patients and shift their perception of tube feeding to emphasize its benefits for treatment.

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Laporan Kes /*Case Report*

A Case Report on Combined Overweight and Stunting in Adolescent with Underlying Dyslipidaemia

Laporan Kes: Kombinasi Berat Badan Berlebihan dan Bantut dalam Kalangan Remaja dengan Dislipidemia

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ABSTRACT

The complex combination of stunting and overweight have been overlooked as a significant form of malnutrition. Childhood stunting not only impairs growth and development but also increases the risk of overweight and obesity later in adulthood (Keino. et al. 2014). This case study discusses the nutritional management of a 12-year-old boy with dyslipidaemia, overweight, and stunted growth. Interventions included reducing sugary drinks, optimising protein intake, and increasing physical activity. This case emphasizes the importance of a balanced approach that combines tailored dietary strategies, growth-promoting activities, and regular monitoring. This case also highlighted the inclusive approach between healthcare provider and parents. Early, targeted interventions are critical not only for improving immediate health outcomes but also for preventing long-term complications such as metabolic syndrome, cardiovascular diseases, and reduced adult height. Continued efforts in addressing stunting alongside overweight are vital to combat this dual burden form of malnutrition effectively.

Keywords: overweight, stunting, dyslipidaemia, childhood

ABSTRAK

Gabungan masalah bantut dan berat badan berlebihan sering dipandang remeh sebagai satu isu malpemakanan yang serius. Bantut sejak kecil bukan sahaja menjejaskan pertumbuhan dan perkembangan kanak-kanak, tetapi juga boleh meningkatkan risiko menjadi berlebihan berat badan dan obes semasa dewasa (Keinoet al. 2014). Kajian kes ini membincangkan pengurusan pemakanan seorang kanak-kanak lelaki berusia 12 tahun dengan bacaan kolesterol tinggi, berat badan berlebihan, dan pertumbuhan terbantut. Antara langkah yang diambil termasuk mengurangkan minuman manis, memastikan pengambilan protein mencukupi, dan meningkatkan aktiviti fizikal. Kes ini menunjukkan betapa pentingnya pendekatan seimbang yang menggabungkan pemakanan yang sesuai, aktiviti untuk merangsang pertumbuhan, serta pemantauan berkala. Selain itu, ia juga menekankan kepentingan kerjasama antara doktor, pakar pemakanan, dan ibu bapa dalam memastikan kanak-kanak mendapat penjagaan yang terbaik. Intervensi awal bukan sahaja membantu memperbaiki kesihatan kanak-kanak dalam jangka masa pendek, tetapi juga dapat mengurangkan risiko masalah kesihatan jangka panjang seperti masalah metabolik, penyakit jantung, dan masalah bantut. Oleh itu, usaha berterusan untuk menangani masalah bantut dan berat badan berlebihan perlu diperkukuhkan bagi mengatasi masalah malpemakanan dengan lebih berkesan.

Kata kunci : berat badan berlebihan, bantut, dislipidemia, kanak-kanak

INTRODUCTION

The coexistence of overweight and stunting in adolescent represents a critical aspect of the global

"dual burden" of malnutrition, often overlooked as malnutrition is perceived as a condition that impacted only the underweight. This dual burden, which overnutrition and undernutrition happens within an individual or populations has rose as a health concerns particularly in developing country with rapid nutrition transitions. Globally, the prevalence of stunting and overweight among children and adolescents aged 5 to 19 years reveals important health trends. As of 2023, around 14.3% of children in this age group were stunted, while 18% were overweight. However, the exact overlap between stunting and overweight in this age group remains less frequently quantified in global data, though it has been noted as a rising concern in regions undergoing rapid nutrition transitions, such as Southeast Asia and parts of Africa (UNICEF, 2023; WHO, 2023). Findings from the National Health and Morbidity Survey (NHMS) 2019 also reported that 15% of Malaysian children aged 5 to 17 years old were overweight while 14.8% were obese. These indicate nearly one in three children in Malaysia have excess weight.

Childhood overweight is defined as excess body weight relative to height or body mass index (BMI) falls at or above 95th percentile for children of same age and gender (Dietz & Robinson 2005). It is a result from an imbalance between energy intake and expenditure (Hill et al. 2013). In contrast, stunting reflects chronic undernutrition during critical growth periods which may indicate child being too short for their age (WHO 2014). These conditions, though contradictory to each other, might coexist due to shared underlying factors such as poor-quality diets, food insecurity, and inadequate maternal and child healthcare.

Dyslipidaemia, characterized by abnormal lipid profiles, including elevated levels of total cholesterol, low-density lipoprotein (LDL), or triglycerides, and reduced high-density lipoprotein (HDL), is increasingly recognized in paediatric populations. In children with overweight, dyslipidaemia is a significant concern, as it increases the long-term risk of cardiovascular diseases such as coronary artery disease and stroke (Kopin & Lowenstein, 2017). Managing dyslipidaemia in children requires early intervention to modify dietary habits and lifestyle factors, preventing the progression of metabolic syndrome.

In cases of combined overweight and stunting, dietary management must carefully balance calorie restriction to address excess weight while ensuring adequate nutrient intake to support linear growth. The presence of dyslipidaemia also weighs up and need further dietary modification to improve lipid profiles, emphasizing the types and quantity of fats and carbohydrates consumed.

This case study emphasizes the dual burden of malnutrition by exploring the application of medical nutrition therapy (MNT) in managing an adolescent presented with the rare combination of overweight, stunting, and underlying dyslipidaemia. By addressing the multifaceted nutritional needs and integrating evidence-based strategies, this report aimed to provide insights into optimizing growth and metabolic health in similar cases

CASE STUDY

PATIENT PROFILE

A 12-year-old Malay boy, accompanied by his father, presented at the dietetic clinic after being referred by paediatricians for obesity and dietary management. He was diagnosed with dyslipidaemia in early 2024 and has a body mass index (BMI) of 25 kg/m². Additionally, he has well-controlled bronchiolitis asthma and partially controlled allergic rhinitis, both managed with medication. He lives with his family as the eldest of four siblings. His father works as a prison warden, and his mother is an office worker. His maternal family has a history of hypertension. The patient started attending boarding school in April 2024. His lifestyle has changed significantly since the dyslipidaemia diagnosis, influenced by his parents' supervision and his transition to boarding school. His father appeared motivated to support his son's condition.

NUTRITION ASSESSMENT

During the appointment, patient weighed 48.2 kg. According to the CDC weight-for-age chart, this places him between 50th and 75th percentiles, indicating a normal weight for his age. He has been experiencing significant weight gain with a gain of 2.2 kg over the past two months and 1.1 kg per month. The patient's height was 138.5 cm, charted between 5th and 10th percentiles on the CDC height-for-age chart, indicating patient was stunted.

Although his weight was within the normal range, his short stature contributes to a BMI of 25.12 kg/m², which is above the 95th percentile on the CDC BMI-for-age chart, classifying him as overweight. His waist circumference was 84.4 cm, slightly above the 90th percentile, according to Poh et al. (2011) this suggests risk of abdominal obesity for 12 years old. The ideal body weight at 50th percentile for his age was 45 kg, while ideal height for his age is 148 cm. Ideal CDC BMI for age was suggested as 21 kg/m² at 50th percentile.

The patient appeared cheerful and communicated well throughout the session. He was reported to be in the pre-pubertal Tanner stage. He claimed to have consistent appetite even though he has experienced weight gain since starting school.

Available biochemical data included fasting blood sugar (FBS), fasting serum lipids (FSL), and liver function tests (LFT). The patient's triglycerides (TG) and high-density lipoprotein cholesterol

(HDL-C) levels were within normal ranges. However, total cholesterol (TC) and low-density lipoprotein cholesterol (LDL-C) levels were elevated, reflecting current condition of dyslipidaemia. Additionally, the alkaline phosphatase (ALP) level was high, raising concerns about potential fatty liver. Table 1 summarizes the laboratory results.

The estimated daily calorie intake of the patient was 2000–2400 kcal/day (40–50 kcal/kg body weight), while the estimated protein intake was 50–60 g/day (1–1.2 g/kg body weight). The patient is allergic to seafood and avoids prawns and squid, as these trigger rashes and worsen his asthma. Since attending boarding school, he receives five meals daily at the dining hall, including breakfast, morning tea, lunch, afternoon tea, and dinner. He usually only skipped breakfast or supper. Additionally, he purchases food from the school canteen.

The patient has several notable dietary patterns. Firstly, he does not finish protein-rich foods such as chicken, meat, or fish during main meals. His father mentioned that this habit began before he started school. The patient explained that he feels bored and sick of eating these foods. However, he enjoys vegetables and often finishes an entire tray, as other children tend to leave them.

Secondly, before his diagnosis, the patient frequently consumed heavy meals before bedtime, such as fried rice, nasi lemak, or other fried foods as the school canteen operates even after their night class. However, he claimed that he has stopped buying supper meals and only eats biscuits. His parents have also reduced his pocket money and controlled his spending using the school's cashless card system. This system has aid them in monitoring his purchases.

Thirdly, the patient consumes excessive sugary snacks and beverages. He drinks sugary beverages 4–5 times daily, either from the dining hall or purchased at the canteen or vending machine. For snacks, he usually eats biscuits provided by his parents. His father also reported that the patient often joins his peers for "hangout sessions" at a table filled with snacks, making it difficult to accurately quantify his snacking habits.

The patient was physically active, as indicated by his HDL-C levels and his participation in activities like badminton and jogging. However, he only occasionally plays badminton on the court, often playing indoors or in his dormitory with friends.

NUTRITION DIAGNOSIS

Excessive calorie intake related to food preferences as evidenced by high intake of carbohydrates and fibers than protein and reported frequent consumption of sugary drink and sweet biscuits snacking.

NUTRITION INTERVENTION

The primary goals for the patient was to lower his BMI to within the normal range (24.9 kg/m²) by the next appointment and to optimize his protein intake. According to the RNI 2017, the estimated nutritional needs for boys aged 13–15 years is 1900–2300 kcal/day for calories and approximately 45 g/day for protein.

The importance of protein in growth and development was explained to the patient, including sources of high biological value (HBV) and low biological value (LBV) protein (RNI 2017). He was encouraged to finish the protein portion of his meals. Other essential nutrients that could promote growth and height includes a combination of vitamins and minerals. Thus, daily intake of milk that is high in calcium was recommended. Milk also contains protein that work synergistically to support healthy growth patterns. Zinc and magnesium also support one growth and development, with zinc being particularly important for cell growth and division. High sources of magnesium and zinc food are often found in oysters, red meat, poultry, fish, bananas and leafy greens.

Although it is good that he consumes a high amount of fibre, this preference for vegetables may lead to satiety (Hakim et al. 2018), reducing his protein intake. Therefore, proper portioning of fibre was recommended around 3 servings of vegetables (MDG for Children and Adolescents 2023).

As he is still in the pre-pubertal phase, he has the potential for height growth. Exercises that promote growth, such as stretching, badminton, skipping, and pull-ups, were recommended to help increase his height.

The patient was advised to limit sugary snacks and beverages to no more than twice daily. Sugary snacks like biscuits and beverages are often low in nutrients but high in calorie which also affect weight gain (Olsen &Heitmann 2009).

NUTRITION MONITORING AND EVALUATION

Parameters to monitor include weight, height, lipid profile, waist circumference, and compliance with dietary recommendations. Monthly weight and height measurements were recommended, but the lack of measurement tools at school may pose a challenge. Waist circumference was suggested as an alternative, with the 90th percentile cutoff for a 12-year-old being 75 cm, based on study done by Poh et al. (2011) on cut-off points for adolescent's waist circumference.

The patient's next appointment was in five months, during which a repeat blood test will be conducted by the paediatrician. The lipid profile will be reassessed, and the goal was for the LDL-C level to be within the normal range (<3.33 mmol/L) or

TABLE 1 shows the full laboratory results

	Day 1	Unit	Reference range
FBS	4.6	mmol/L	3.3-5.6
FST			
Total	6.9*	mmol/L	<5.2
Cholesterol			
Triglyceride	0.78	mmol/L	<1.70
HDL-C	1.80	mmol/L	>1.55
LDL-C	4.7*	mmol/L	<3.33
LFT			
Total	80.4	(g/L)	57-80
Protein			
Albumin	45.3	(g/L)	35-52
ALP	252.8*	(U/L)	43-115
AST	48.62	(U/L)	3-50
Bilirubin	35.22	(U/L)	<50
total			

*Higher than normal range

show a reducing trend. Further assessment and management will be based on the results of the next blood test.

FOLLOW-UP

A recent follow-up via phone call indicated that the patient has been adhering well to the recommended dietary and lifestyle changes. He reported successfully limiting his sugary drink intake to three times daily and making a great effort to finish his protein sources during meals. Additionally, he has joined his school's cricket team, further supporting his physical activity levels.

During a recent medical check-up, the patient was measured at 47 kg and 138 cm in height. This reflects a 1 kg weight loss over the past month, which was a notable progress toward his weight management goals. However, there has been no significant change in his height during this period. The patient's adherence to the previous recommendation of milk consumption was not clearly documented. Thus, it is uncertain whether this influenced the lack of height change. This outcome shows the importance of ongoing monitoring and sustained interventions to support both weight and height improvements.

DISCUSSION

The patient was presented with dyslipidaemia where the probable cause was most likely due to his excessive intake of sugary beverages and snacks, concurrent with his imbalance in macronutrient intake. Despite his weight being in the normal range for age, his short stature placed him in the overweight BMI category. These shows the connection between dietary intake, growth and metabolic condition.

Self-monitoring of weight and height monthly might be a challenge for this patient due to the limited access of measurement tools at school. His parents were also unable to evaluate his adherence to the dietary advice given. Additionally, the school environment, which facilitates access to sugary snacks and beverages, and peer influence encouraging snacking habits might further complicates patient's adherence to the dietary advice.

Because the patient is still in the pre-pubertal stage, there is still room for significant growth if appropriate nutritional habits and interventions are implemented. The pre-pubertal stage is critical for height gain as it sets the foundation for growth spurts that occur during puberty. During this phase, factors such as nutrition, physical activity, and hormonal regulation play a pivotal role in maximizing growth potential (Soliman et al. 2014, Chen 2022). Thus, by achieving height gain it will indirectly improve his BMI classification as his current stunted stature disproportionately raises his BMI despite a normal weight-for-age percentile.

Adequate protein intake is vital for bone growth and height, especially during critical growth periods like pre-puberty. Protein provides essential amino acids necessary for bone matrix development and muscle growth (Antonio et al. 2020). Studies indicate that dietary protein, particularly high-quality sources, can significantly impact linear growth by supporting both skeletal and muscle development, especially when combined with

adequate calcium, vitamin D, and other nutrients critical for bone health (Xiong et al. 2023).

Exercise that involves stretching and resistance, such as badminton, skipping, and pull-ups, has been shown to promote growth potential. Physical activity stimulates growth hormone secretion and strengthens the musculoskeletal system, enhancing the potential for linear growth during pre-pubertal and pubertal stages (Antonio et al. 2020).

In the long term, if dyslipidaemia and overweight status remain untreated, the patient may face an increased risk of metabolic diseases during the transition to adulthood. Atherosclerotic cardiovascular disease (ASCVD), a leading cause of death globally, often emerges in children presented with overweight and dyslipidaemia (Schefelker & Peterson 2022). Additionally, Mainieri (2023), highlights that childhood obesity frequently correlates with a higher prevalence of dyslipidaemia, emphasizing the need for early management. Early dietary and lifestyle modifications can significantly lower these risks and improve overall health outcomes.

CONCLUSION

This case highlights the critical importance of early intervention in managing paediatric dyslipidaemia, overweight and stunted growth. The patient's pre-pubertal phase presents a window of opportunity for targeted nutritional and physical activity strategies to optimize growth and metabolic health. Key challenges, such as the school environment and monitoring limitations, highlight the need for a collaborative approach involving the family, school, and dietitians or also other healthcare providers. Addressing these issues can not only improve the patient's immediate health but also reduce the risk of long-term complications like cardiovascular disease and obesity. By fostering a supportive environment and empowering the patient and his family with knowledge and tools, this case demonstrates the potential for meaningful improvements in growth and overall well-being.

CONSENT

Verbal consent has been obtained from the patient.

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DECLARATION OF CONFLICT OF INTERESTS

The authors declared no potential conflicts of interest concerning the preparation and publication of this article.

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