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CASE REPORT

Metabolic effects of monounsaturated fatty acid–enriched diets on glycaemic control in patient with type 2 diabetes: an evidence-based case report

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Abstract

Introduction: Diabetes mellitus type 2 (T2D) is the most common type of diabetes. There is an ongoing debate as to whether nutrient quality or quantity is mainly responsible for the effects on hyperglycaemic control of patients with T2D**.** Monounsaturated fatty acid (MUFA) has a metabolic effect in reducing the risk factor for metabolic syndrome to prevent and control hyperglycaemia in patients with T2D and is recommended by professional organizations.
Methods: Literature searching was conducted by advanced searching in Pubmed, Cochrane Library, Scopus, and ProQuest database using MeSH Terms combined with Title/Abstract. After removing duplicates, the literature were screened based on the eligibility criteria. Critical appraisal and level of evidence of the selected literature were determined based on Oxford Centre for Evidence-Based Medicine.
Results: Two selected literature were relevant to answer our clinical question, both literature are systematic review/meta-analysis studies. The first literature is a study by Fumiaki et al. (2016), while the second is by Frank Qian et al. (2016). All literature provided evidence that a diet high in MUFA could improve glucose-insulin homeostasis among patients with T2D. These effects were marked by lower fasting blood glucose and haemoglobin A1c (HbA1c), and insulin level in the enriched MUFA diet group compared to PUFA.
Conclusion: Nutrient quality is mainly responsible for the effects on glycaemic control profile in patients with T2D, with a high MUFA diet consistent with favourable effects to improve fasting glucose and HbA1c.

Keywords: T2D, MUFA, glucose fasting, HbA1

Case scenario

A 55-year-old woman was treated at Sumber Waras hospital with a diagnosis of acute gastroenteritis, hyperglycaemic diabetes mellitus, acute kidney injury, grade II hypertension, electrolyte imbalance and anemia gravis. Five days before being hospitalized, she felt fatigued after she traveled out of town. During the trip, she could not control her food intake and forgot to take her regular medication for diabetes. When she arrived home, she immediately checked her blood sugar level, and the result was 280 mg/dL; after that, she took her medicine regularly. She checked her blood sugar level two days before hospital admission, showing 230 mg/dL.

The patient has had diabetes for 10 years, and her sugar level has never been below 200 mg/dL. In the hospital, the doctor analyzed her dietary

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habits and found that she liked to eat fried food, coconut milk, and bread for snacking. She was recommended to change her dietary habits by replacing the source of fat with olive oil, which is known to be able to control blood sugar levels for patients with diabetes mellitus.

Introduction

Diabetes mellitus is a global health burden with a worldwide prevalence of 9%. Type 2 diabetes (T2D) is the most common type of diabetes and accounts for approximately 90% of all cases. The prevalence of T2D has increased rapidly in both developed and developing countries over the last few decades. The number of T2D incidences has globally reached 425 million (8,8% of adults), with an additional 352 million at risk of developing T2D.[1,2] In China, the morbidity of T2D sharply increased from 2.5% in 1994 to 10.9% in 2013.[2] Based on the 2018 *Riset Kesehatan Dasar* (RIskesdas) data in Indonesia, there is also an increased prevalence of T2D to 8.5%.[3]

Risk factors for developing T2D are divided into two, unmodifiable (age and family history of diabetes) and modifiable factors (dietary habits and physical activity).[1,4] Epidemiological evidence has consistently demonstrated that diet is a key modifiable risk factor for T2D prevention.[1,2] There is an ongoing debate as to whether nutrient quality or quantity is mainly responsible for controlling hyperglycaemia in patients with T2D. Currently, energy-dense foods rich in saturated fatty acid (SFA) are considered the main culprit of the epidemic rise of obesity, T2D, fatty liver and cardiovascular diseases.[5] The fatty acid composition appears to play an important role in lipid-induced metabolic alteration, which is supported by the finding of higher liver triglyceride (TG) content and insulin resistance. International organizations and the 2015 USDA Dietary Guidelines for Americans have advocated substituting SFA with unsaturated fatty acid (MUFA AND PUFA). The recommendation is mainly based on the effect, especially MUFA, for preventing and controlling T2D. [2,6]

The association of MUFA consumption with the risk of T2D development remains limited and controversial. Moreover, nutrition recommendations still differ.[2,7] The current recommendation by the American Diabetes Association emphasizes the inclusion of MUFA and PUFA in the diet of individuals with T2D over intake of SFA. However, the evidence for the quantity of total fat intake is inconclusive. Meta-analyses of randomized controlled trials demonstrated that high MUFA diets were effective in reducing glycaemic control, lipid serum, and blood pressure compared to a high carbohydrate diet. In contrast, most of the previous cohort studies in European/American countries reported non-significant associations.[2,8]

The effect of MUFA on glycaemic control in patients with T2D is still inconclusive, and there is no consideration for a specific daily amount of MUFA; therefore, the author wanted to explore this topic through an *Evidence-Based Case Report* (EBCR).

Clinical question

The population target of this study is adult patients with T2D. The discussion of this study is high MUFA diet, compared to PUFA, as diet factors can control glycemic index in patients with T2D. The clinical question is, “In a patient with T2D, could a high MUFA diet effectively control blood glucose levels?”

P : Adult with T2D
I : High MUFA diet consumption
C : High PUFA diet consumption
O : level of HbA1c, fasting glucose and plasma insulin.

Methods

Literature searching was conducted by advanced searching using a combination of both Mesh Terms and Title/Abstract in four databases: Pubmed, Cochrane Library, Scopus, and ProQuest. Keywords that were used include “type 2 diabetes” or “type II diabetes” or “non-insulin diabetes,” “monounsaturated fatty acid” or “MUFA,” and “glycemic” or “glucose” or “HbA1c”, and ”systematic review” or “randomized” or “trial.” Authors used Oxford Centre for Evidence-Based

Medicine as a guide to critically appraise the literature and determine the level of evidence.

Eligibility criteria

Inclusion criteria
1. Aged ≥ 18 years old
2. Subject with T2D diagnosis.
3. Subject with an intervention of enriched MUFA diet ≥ 12% total daily calories
4. An intervention of enriched MUFA diet ≥ 2 weeks
5. Study design: Systematic review-meta analysis or RCT
6. Article published up to the last ten years.
7. Articles published in English.

Exclusion criteria
1. Subject with insulin therapy
2. Study not in the human subject.
3. Study results did not include HbA1c, fasting glucose and plasma insulin levels.

Results

The author found 19 literature from Pubmed database, 6 from Cochrane Library, and 6 from ProQuest (Table 1). Duplicate removal was done using the Covidence application. Lastly, literature were assessed for eligibility based on PICO and eligibility criteria (Figure 1). We selected two articles from Fumiaki et al.[9] and Frank Qian et al.[8]

Table 1 Literature searching strategy

Database	*Search Strategy*	*Hits*
Pubmed	#1: (((((type 2 diabetes mellitus[MeSH Terms]) OR (diabetes mellitus, non insulin dependent[MeSH Terms])) AND (acids, monounsaturated fatty[MeSH Terms])) OR (fatty acids, monounsaturated[MeSH Terms])) OR (monounsaturated fatty acids[MeSH Terms])) OR (polyunsaturated fatty acids[MeSH Terms])) AND (hb a1[MeSH Terms]) #2: (((((type 2 diabetes mellitus[MeSH Terms]) OR (diabetes mellitus, non insulin dependent[MeSH Terms])) AND (acids, monounsaturated fatty[MeSH Terms])) OR (fatty acids, monounsaturated[MeSH Terms])) OR (monounsaturated fatty acids[MeSH Terms])) OR (polyunsaturated fatty acids[MeSH Terms])) AND (hb a1[MeSH Terms]) #1 AND #2	19
Cochrane Library	#1 ("type 2 diabetes mellitus"):ti,ab,kw OR ("non insulin dependent diabetic"):ti,ab,kw AND ("monounsaturated fatty acid"):ti,ab,kw AND ("polyunsaturated fatty acid"):ti,ab,kw AND ("glucose control"):ti,ab,kw AND ("systematic review"):ti,ab,kw #2 ("type 2 diabetes mellitus"):ti,ab,kw OR ("non insulin dependent diabetic"):ti,ab,kw AND ("monounsaturated fatty acid"):ti,ab,kw AND ("polyunsaturated fatty acid"):ti,ab,kw AND ("glucose control"):ti,ab,kw AND ("randomized clinical trial"):ti,ab,kw #1 AND #2	6
Scopus	Type 2 diabetes OR type II diabetes OR non insulin diabetes AND monounsaturated fatty acid OR MUFA AND glycemic OR glucose OR hbA1c AND systemic review OR randomized OR trial AND Limit (PUBYEAR 2013) TO (pubyear 2022) AND (medical) AND exclude (animal) OR exclude (child) OR exclude (depression) OR exclude (diabetes Mellitus Type 1)	0
ProQuest	ti(Type 2 Diabetes Mellitus) AND ti(monounsaturated fatty acids) AND ti(polyunsaturated fatty acids) AND ti(blood glucose control) OR ti(glycemic) OR ti(hba1c) AND ti(a systematic review) OR ti(a randomized trial)	6

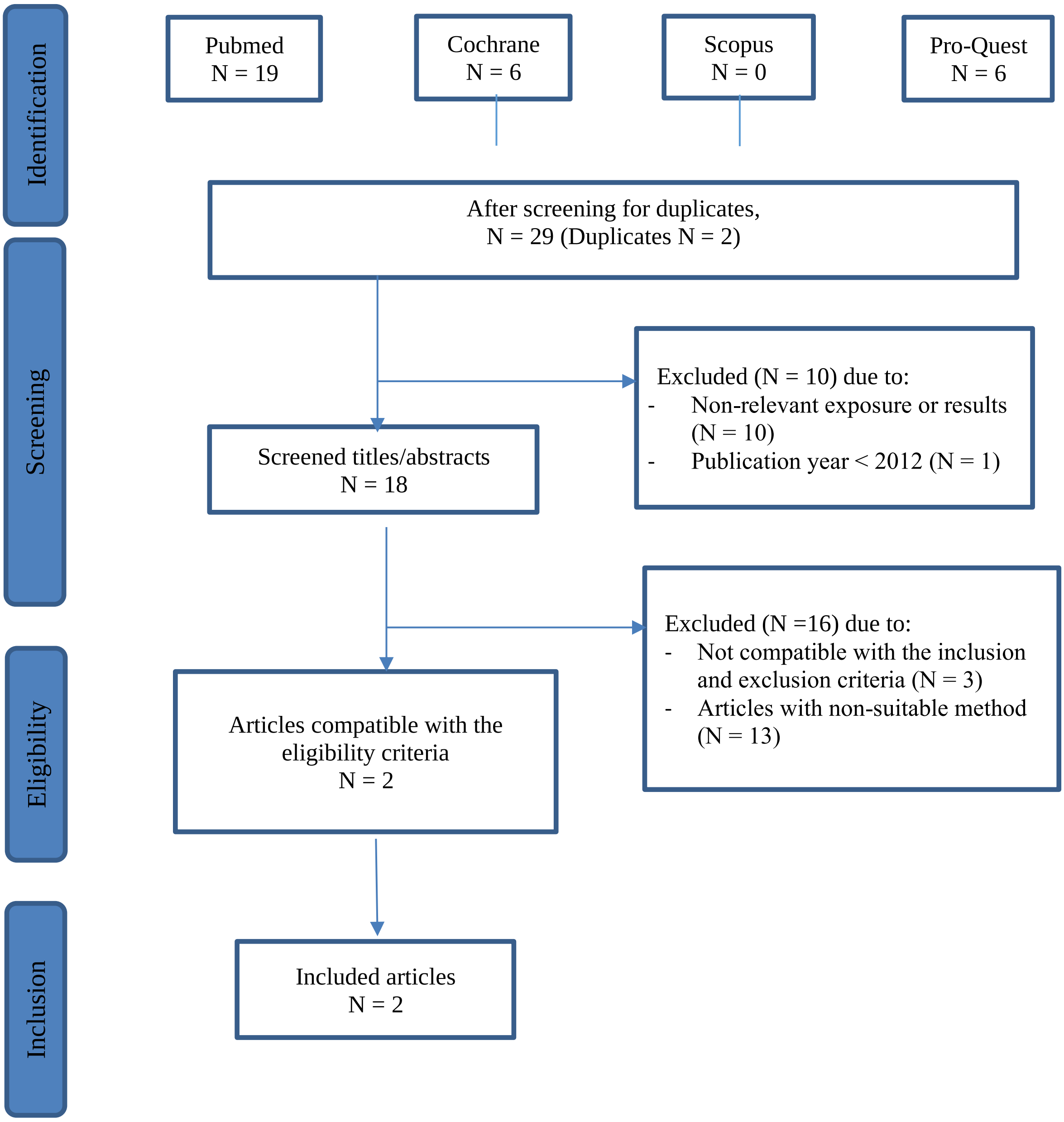

Diagram 1 Prisma's flow chart

Table 2 The Characteristics of the Literature

Articles	Study design	Population	Outcome
Fumiaki et al. (2016)	Systematic review and Meta-analysis of Randomized Controlled feeding trials	4220 subjects (45% men). 11 trials evaluated the two-hour post-prandial glucose test or insulin, 13 trial tests of intravenous infusion to evaluate the sensitivity of insulin. 10 trial tests of intravenous infusion to evaluate the capacity to secrete insulin.	Reduced HbA1c levels, 2-hour insulin post-challenge (HOMA IR), fasting insulin levels and improved insulin secretion capacity. Reduced HbA1c levels, 2-hour insulin post-challenge (HOMA IR), fasting insulin levels and improved insulin secretion capacity. Replacement of 5% dietary energy from carbohydrate or SFA to MUFA lowered HbA1c. Replacement of SFA with PUFA decreased fasting glucose levels.
Frank Qian et al. (2016)	Systematic review and Meta-analysis of Randomized Controlled Trials	Full-text screening was conducted and resulted in 53 studies, 28 studies were included with 24 studies for MUFA vs carbohydrate diet with a total participant of 1460 and 4 studies for MUFA vs. PUFA diets with a total of 44 participants.	Enriched MUFA diet significantly reduced fasting glucose plasma levels, triglyceride, weight and systolic blood pressure, also with a significantly increased HDL.

Table 3 Validity criteria

Article	Common point	Follow up	Outcome	Adjustment	Outcome over time	Precision	Applicability	Clinically important	Result
Fumiaki et al.[9]	+	+	+	+	+	+	+	+	A
Frank Qian et al.[8]	+	+	+	+	+	+	+	+	B

Table 4 The Similarity of Articles with PICO

	Similarity Population	*Similarity Determinant*	*Similarity Outcome*
Fumiaki Imamura *et al.*[9]	+	+	+
Frank Qian *et al.*[8]	+	+	+

A : This result showed that replacing 5% of energy with MUFA could reduce HbA1c levels (-0.09%; -0.12,-0.05: n=23), 2-hour challenge insulin level (-20.3 pmol/L; -32.2, -8.4; n= 11) and the homeostasis of insulin resistance (HOMA-IR) (-2.4%; -4.6,-0.3; n=30).
B : This result showed that enriched MUFA diet consumption could improve the metabolic risk factors in patients with type 2 diabetes mellitus compared to enriched PUFA diet, with a significant result in reducing fasting blood glucose -0.87 (-1.67,-0.07) WMD (95% CI)

Discussion

Optimizing the control of glycemic parameters in patients with type 2 DM is an essential procedure to reduce long-term complications. The United Kingdom Prevention study showed that hyperglycemia is the biggest factor for coronary heart disease.[7] Many observational studies have reported improved glycemic control and insulin resistance in subjects who consumed enriched MUFA diets.[8] MUFA is classified as a fatty acid with one double bond, with a higher melting point than PUFA (two double bonds or more).[10]

Qian et al.[8] conducted a systematic review and meta-analysis that compared the effect of an enriched MUFA diet to an enriched carbohydrate diet in glycemic control, lipid serum, and systolic blood pressure in patients with type 2 diabetes mellitus. The study showed improved glycemic control in patients who consumed MUFA, particularly when the enriched MUFA diet was used as a replacement for a carbohydrate diet. This is in line with a study by Scwingshackl et al.[8] who reported a significantly reduced HbA1c level when comparing an enriched MUFA diet with an enriched carbohydrate diet. Most outcomes in this study showed a statistically significant reduced fasting blood glucose (WMD −0.44 mmol/L (95% CI −0.74, −0.14)). This indicated that food composition has its own metabolic effect.[8]

An enriched MUFA diet is a proper choice for nutritional management in patients with glucose and lipid metabolism issues. MUFA can affect the function and composition of cellular membrane's fatty acid, including membrane fluidity, ion permeability, and insulin membrane receptor's affinity, thus, accelerating glucose intake into the cells. MUFA stimulates the improvement of insulin sensitivity; this mechanism is associated with the insulin signaling process involving IRS-1/PI3K. This pathway is associated with the influence of inflammatory mediators such as C-reactive protein (CRP), tumor necrosis factor (TNF-α), and interleukin, which have a central role in increasing insulin resistance. An enriched MUFA diet is expected to reduce CRP and/or TNF-α levels.[11]

Another systematic review and meta-analysis by Fumiaki Imamura et al.[9] were conducted by replacing a 5% carbohydrate diet with SFA, MUFA, and PUFA, followed by an evaluation of metabolic components such as glucose, 2-hour glucose plasma, HbA1c, and insulin levels. By replacing the 5% carbohydrate diet with MUFA, an improved HbA1c level of 0.1% and a reduced complication incidence of type 2 DM of 0.1% by 22% were found (95% CI = 15.9, 28.4%).[9] The physiological mechanism that provides metabolic effects by replacing carbohydrate diet with MUFA is reduced glycemic load, leading to reduced insulin needs and increased insulin sensitivity.[8]

A study from KANWU (Kuopio, Aarhus, Naples, Wollongong and Uppsala) in 162 healthy subjects reported a reduced insulin sensitivity with an enriched SFA diet for 3 months; they conducted a comparison by replacing SFA with an enriched MUFA diet, which showed improved insulin sensitivity. This result was obtained with a total fat consumption of <37% of the total energy, with a high-MUFA fat type. The recommended daily intake of fatty acids in the United States is MUFA 13-14% of the total energy, SFA 11-12%, and PUFA ≤7% of the total energy. The total fat consumption in the Mediterranean diet should be

33-40% of the total energy with a total MUFA of 16-29%, with olive oil as the main source of fat.[10] Based on PERKENI in Indonesia for patients with type 2 DM, the recommended total fat intake is 20-25% of the total caloric requirement and should not exceed 30%, with a composition of SFA <7% of the caloric requirement, PUFA <10%, and MUFA 12-15% of caloric requirement. The recommendation for saturated fat : monounsaturated fat : polyunsaturated fat = 0.8 : 1.2 : 1, and the recommended caloric consumption is <200 mg/day.[3]

MUFA can be obtained from oils derived from plants such as olive oil, canola oil, hazelnut oil, and sunflower oil. Several fruits also contain high MUFA, such as avocado. Nuts and seeds can also be sources for MUFA, including macadamia nuts, hazelnuts, and pecans. As for animal-based protein, it is still in debate whether this source of protein can be consumed in high amounts although containing MUFA; for example, 100g of meat contains 5.7g MUFA; however, it also contains a high SFA level of 16.3 g. Therefore, it is recommended to consume plant-derived MUFA.[10]

In conclusion these literature, provides novel quantitative evidence for effects of major dietary fats on glucose-insulin homeostasis. The results support guidelines to increase MUFA intake to improve glycaemia and insulin resistance, with possibly stronger effect among patients with type 2 diabetes. These findings help inform public health and clinical dietary guidelines to improve metabolic health. Most of the trial in these literature review were conducted among Western population, which may limit the generalizability of our findings to other population. Hence we cannot completely rule out the possibility that the metabolic differences were attributable to some unmeasured dietary component. Our result and available evidence support the importance of future experimental studies with large number of research subject population.

Conclusion

Based on the critical review of both literature, there is a significant association between enriched MUFA-typed fatty acid consumption with glycemic control, especially in reducing fasting blood glucose and HbA1c level. This finding could be a base to educate and answer clinical questions from patients, which is an association between an enriched MUFA diet with glucose control in patients with type 2 DM. Patient is advised to replace 5% of their carbohydrate intake with foods high in MUFAs such as canola oil, avocados, nuts such as Brazil nuts, sunflower seeds, hazelnuts, macadamia nuts, or walnuts, reduce intake of SFA and simple carbohydrates such as deep fried foods, flour, biscuits, or cakes.

Conflict of Interest

Authors declared no conflict of interest regarding this article.

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