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Oatmeal interventions in severe insulin resistance on the intensive care unit: A case report

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ABSTRACT

Objectives: To report on the potential effectiveness of hypocaloric, plant-based short-term dietary oatmeal interventions in the treatment of insulin resistance in critically ill patients on the intensive care unit.

Clinical features and outcome: A 67-year-old female with type 2 diabetes was admitted to our hospital with suspected pneumonia. The patient developed acute hypoxemic respiratory failure and was diagnosed with pneumogenic sepsis requiring invasive ventilation and an immediate transfer to our medical intensive care unit. Within 48 h the patient developed severe to extreme insulin resistance and required more than 200 units of insulin per day.

Based on the "Noorden diet" described in 1903, a modified hypocaloric (700 kcal) and plant-based dietary oatmeal intervention was performed to "break" insulin resistance and to improve glycaemic control. For two days, the patient received a low-fat diet that restricted carbohydrates to whole-grain oats (180 g) and included small amounts of vegetables (60 g). Enteral feeding was done via nasogastric tube. During and after the intervention, glycaemic control improved significantly. A significant reduction in total daily insulin requirements was achieved during and after the intervention.

Conclusions: Hypocaloric, plant-based short-term dietary oatmeal interventions significantly reduced mean blood glucose levels and mean required daily insulin doses in a critically ill and septic patient on the intensive care unit.

1. Introduction

Dysregulated glucose homeostasis is a common finding in critically ill patients on the intensive care unit.[1] These patients can develop acute insulin resistance – a condition manifesting as hyperinsulinemia, hyperglycaemia or a combination of both.[1,2] Patients suffering from insulin resistance may require very high ($> 2\,U\,kg^{-1}\,day^{-1}$) or extremely high ($> 3\,U\,kg^{-1}\,day^{-1}$) insulin doses.[3]

Here, we report a case of a 67-year-old septic female who acutely developed severe to extreme insulin resistance in the critical care setting. On the third day after admission, the patient required > 200 units of insulin per day. Based on the "Von Noorden Concept",[4,5] a modified dietary oatmeal intervention was performed to "break" insulin resistance, to improve glycaemic control and to reduce daily insulin requirements.

2. Case presentation

A 67-year-old woman with type 2 diabetes (T2D) and hypertension was admitted to our hospital with suspected pneumonia. The patient complained of dyspnoea, dry coughing, sore throat, fever, and malaise. She denied substernal or left-sided chest pain as well as gastrointestinal symptoms such as vomiting and diarrhoea. Vital parameters revealed tachycardia with a heart rate of 106 beats per minute, blood pressure of 125/59 mmHg, and a respiratory rate of 28 breaths per minute, with SpO2 (capillary saturation) of 98% on room air. The patient was febrile (38.7 °C). Laboratory findings revealed a normal leukocyte count of 6100 cells/μl (normal: 3500–9800 cells/μl) and an elevated C-reactive protein of 5.26 mg/dl (normal: < 0.5 mg/dl).

Auscultation revealed wheezing, but neither decreased breath sounds nor crackles. A chest x-ray did not show any signs of pneumonia. On the day of admission, the patient developed acute hypoxemic respiratory failure (with SpO2 in the low 70s on 10 L NRB). At this stage, the patient's quick sepsis-related organ failure assessment (qSOFA)

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Table 1
The modified oatmeal intervention: composition and calorie intake.

Food	Calories from fat [kcal]	Calories [kcal]
180 g of unprocessed whole-grain oatmeal cooked in water	101.3 (15%)	˜675
60 g of added vegetables (carrots)	1.3 (5.3%)	˜25
		Total: 700

score was 2 (systolic blood pressure ≤100 mmHg and respiratory rate ≥22/min). The patient required an immediate transfer to our medical intensive care unit where she initially received continuous positive airway pressure therapy. Broad-spectrum antibiotics (piperacillin and tazobactam) were administered after blood and sputum cultures were obtained. A SOFA score ≥2 points was determined and the patient was diagnosed with pneumogenic sepsis. The situation gradually worsened and the patient developed acute respiratory distress syndrome requiring invasive ventilation.

Before hospitalization, the patient's diabetes regimen included Saxogliptin 2.5 mg daily and Metformin 2000 mg daily. Her HbA1c has not been controlled within the last six months.

On the first day on the intensive care unit, the patient continuously demonstrated elevated blood sugar concentrations (see Table 1). Mean blood glucose concentration on the first inpatient day was 248 mg/dl. Within the first 24 h of inpatient management, the patient received a total of 98 units of intravenous insulin, however, the patient showed continuing hyperglycaemia (see Table 1). Despite increasing doses of the intravenous insulin infusion, blood glucose levels remained persistently in the mid-200 mg/dl range. On day 3, the patient required a total of 205 units of intravenous insulin, indicating severe insulin resistance. Up until that day, the patient received "Diben" - a tube feed nutrition (1 kcal/ml; with a low glycaemic index and a balanced fat profile high in monounsaturated fatty acids) that is believed to optimize glycaemic control in patients suffering from diabetes.[6,7]

The critical care team decided to perform a modified dietary oatmeal intervention to "break" insulin resistance and to reduce daily insulin requirements. This concept termed "Hafertage" which translates to "oatmeal days" was first described in 1903 by the German diabetologist Carl von Noorden.[4] In 1903, Dr. Von Noorden prescribed a diet consisting of 250 g of oatmeal, 300 g of butter and 100 g of vegetable albumin to reduce glycosuria in polyuric patients in danger of impending ketoacidotic coma and to improve metabolic control in individuals suffering from poorly-controlled diabetes.

Our critical care team modified this diet and omitted the butter, resulting in a hypocaloric, low-fat and plant-based intervention with a duration of two days. The patient received three meals a day with a total of 180 g of oatmeal and 60 g of added vegetables (carrots, cucumber) per day (see Table 1). Enteral feeding was done via nasogastric tube. The total energy content per day was approximately 700 kcal.

During and after the intervention, glycaemic control improved significantly. Mean insulin dosage and mean glucose levels are shown in Table 2. Mean blood glucose concentrations fell to 174 mg/dl (first day of the intervention) and 164 mg/dl (second day of the intervention) respectively. After the intervention, mean blood glucose levels remained constantly between 140 and 150 mg/dl. Furthermore, we observed a significant reduction in daily insulin requirements. During the intervention, daily insulin requirement was reduced to 105 IE/d (first day of the intervention) and 45 IE/d (second day of the intervention) respectively. When the critical care team resumed a standard tube feed nutrition on day 5, the patient required a total of 101 insulin units. During the consecutive days, however, a further reduction in daily insulin requirement was noted. In short, required insulin doses and mean blood glucose concentrations were markedly reduced during and after the oatmeal intervention, when compared to the third inpatient day.

Blood and urine cultures were both negative. Moreover, urinary antigen tests for Legionella pneumophila serogroup 1 were negative as well. Finally, RT-PCR revealed Influenza A virus and therapy was adjusted correspondingly.

3. Discussion

The key finding of this case report is that two days of oatmeal intervention significantly reduced mean blood glucose levels and mean required daily insulin doses in a critically ill patient suffering from sepsis-related severe insulin resistance. This finding is consistent with the results of studies by Lammert et al. and Zerm et al.. Both authors reported on beneficial effects of a comparable intervention in patients suffering from poorly-controlled diabetes.[8–10] While this care report includes a patient in an acute setting with sepsis-related insulin resistance, the other studies included patients with longer lasting, poorly-controlled T2D.[8,10]

According to Lammert et al., a diabetes-adapted diet, followed by two days of oatmeal intervention, achieved a significant reduction of insulin dosage by 42.5% (from 145 ± 68.9 IE/d to 83 ± 34.2 IE/d; $p < 0.001$).[8] Zerm et al. reported similar results, showing a significant decrease in mean daily insulin requirement from 151.1 ± 54.05 IE to 104.3 ± 46.5 IE ($p < 0.001$) 2 days after a comparable oatmeal intervention.[10] Hereafter, a few possible explanations are discussed.

First of all, this oatmeal intervention is strictly hypocaloric (700 kcal). Dietary energy restriction has been associated with normalization of both beta cell function and hepatic insulin sensitivity in type 2 diabetes.[11] Likewise, it has been shown that fasting plasma glucose can normalize within days on a very low-calorie diet because of a rapid decrease in liver fat.[12] However, this kind of oatmeal intervention is more than simply a hypocaloric diet.

In 2018, Delgado et al. published the OatMeal And Insulin Resistance (OMA-IR) study, comparing two days of oatmeal intervention with a diabetes-adapted diet only.[13] They emphasized that a two-day oatmeal intervention allowed for a highly significant reduction of required daily insulin dose as compared to a diabetes-adapted diet only. They concluded that caloric restriction alone may not sufficiently explain the difference between both groups and emphasized on other factors, such as an increased ingestion of beta-glucan along with the oats.

In fact, β-glucan, a soluble and fermentable fiber readily found in oats, has been associated with an improved glycaemic control in patients suffering from type 2 diabetes.[14] According to Hou et al., a single-oatmeal can significantly reduce acute postprandial glucose or the insulin response.[15] β-glucan has been reported to increase the viscosity of the alimentary bolus within the upper gastrointestinal tract.[16] This delays gastric emptying and reduces mixing of digestive enzymes with the food, which, in turn, may retard glucose absorption.[16]

Furthermore, this intervention has a favourable macronutrient profile with a low fat content: 100 g of whole-grain oats contain only about 7 g of fat.[9] Animal fat is strictly excluded and several studies in the past suggested that a low-fat, plant-based diet could improve beta-cell function, insulin resistance and glycaemic control in type 2 diabetes.[17–19]

In short, there are multiple possible explanations for the beneficial effects of hypocaloric, plant-based short-term dietary oatmeal interventions in patients suffering from insulin resistance and poorly-controlled diabetes. While it is beyond the scope of this paper to discuss this in detail, we emphasized on the beneficial effects of such an

Table 2
Glucose control and daily insulin requirement – before, during and after the intervention. OD = Oatmeal Day. SD = standard deviation.

	Day I	Day II	Day III	OD I	OD II	Day VI	Day VII	Day VIII
Insulin (IU)								
Insulin glargine	0	36	36	0	0	0	0	0
Insulin i.v.	98	85	169	105	45	101	89	42
Total insulin	98	121	205	105	45	101	89	42
Blood sugar (mg/dl)								
#1	249	139	246	229	161	135	135	104
#2	252	112	185	222	146	129	103	145
#3	248	157	217	186	156	139	78	179
#4	294	256	227	128	208	146	174	188
#5	307	307	228	145	188	157	206	166
#6	253	246	233	161	174	167	195	94
#7	139	267	224	165	147	181	158	
#8		277	207	161	135	148	123	
#9		267	229			162	104	
#10		246				135		
Mean blood glucose ± SD (mg/dl)	248.86 ± 50.02	227.40 ± 62.87	221.78 ± 16.43	174.63 ± 33.25	164.38 ± 22.74	149.90 ± 15.73	141.78 ± 41.71	146 ± 35.87

intervention in terms of glycaemic control and a substantial reduction in daily required insulin doses.

As mentioned earlier, we performed the oatmeal intervention in an acute care setting in a critically ill patient with pneumogenic sepsis. Several authors suggested that persistent hyperglycaemia during critical illness is associated with poor outcome.[1,2,20] Moreover, hyperglycaemia was identified as an independent predictor of hospital mortality.[20] The intervention described in this case report was performed in accordance with the German S2k guideline "Clinical Nutrition in Intensive Medicine".[21] According to this consensus-based guideline of the German Society for Nutritional Medicine, calorie intake should be reduced in the presence of clear signs of metabolic intolerance, such as increased blood glucose levels > 180 mg/dl despite insulin delivery > 4 IE/h. Findings from a recently published review by Ingels et al. support this decision.[20] The authors emphasized on the benefits of accepting low macronutrient intake early during the course of critical illness. In fact, several large and well-designed prospective randomized clinical trials found superior outcomes in patients randomized to lower vs. higher nutrient intakes in the first ˜7 days of an ICU stay.[22] Outcomes included lower mortality rates,[23] fewer ICU infections and greater likelihood of discharge alive from the ICU in patients receiving minimal feedings.[22,24]

To the best of our knowledge, this is the first case report in the literature of such an intervention where enteral feeding was done via nasogastric tube on the intensive care unit. We successfully replaced a sip feed nutrition product with an unprocessed intact whole-grain food and vegetables, demonstrating adequate glucose control.

Of note, this case report has several limitations. First of all, we were unable to show beneficial effects on HbA1c-levels due to a missing pre-interventional value. In addition to that, the exact body weight could not be determined due to the severely impaired general condition of the patient. Finally, the intervals of blood glucose measurements are not exactly matched between days. Measurements were performed before and after each meal and additionally in view of the previous blood glucose value, the administered insulin dosage and available nursing care.

Altogether, we demonstrated that hypocaloric, plant-based short-term dietary oatmeal interventions might be a useful tool to “break” insulin resistance in critically-ill patients in the intensive care unit. This kind of dietary intervention might be of high value in the intensive care setting, however, further clinical trials including more patients and a randomized control group will be necessary to confirm the results described in this case report.

Author disclosures

The authors received no specific funding for this work. We hereby confirm, that the manuscript has not been accepted elsewhere for publication. The authors declare that there is no conflict of interest. The authors report no proprietary or commercial interest in any product mentioned or concept discussed in this article.

Consent

Informed consent was obtained from the patient described in this case report. A copy of the written consent for publication of this case report was uploaded along with the manuscript file.

CARE guidelines

The CARE guidelines were followed for this case report.[25]

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