Higher serum levels of short-chain fatty acids are associated with non-progression to arthritis in individuals at increased risk of RA

Transition from the autoimmune to the clinical phase of rheumatoid arthritis (RA) is a critical step that is yet insufficiently understood. Identification of factors that facilitate the progression from this prodromal RA at-risk state to clinical RA may open new possibilities for preventive interventions. In this context, nutritional factors may be critical. Short-chain fatty acids (SCFAs) are intestinal microbial metabolites that result from nutritional fibre digestion and exert immune regulatory properties. SCFAs have shown to effectively inhibit the onset of experimental arthritis. Furthermore, serum butyrate levels decrease shortly before the onset of arthritis. Whether SCFA levels may play a role in the transition from the autoimmune to the clinical phase of RA in humans, however, has not been studied to date.

To address this concept, we measured serum SCFA levels in a prospective cohort of 82 individuals with an increased risk to develop RA. At inclusion, these individuals were positive for anti-citrullinated protein antibodies (ACPA) and had musculoskeletal pain but no clinical signs of arthritis (joint swelling). Baseline characteristics are shown in online supplemental table 1. Following a median follow-up of 72 months, 39 patients (48%) had developed clinical arthritis after a median of 6 months. Baseline serum samples were analysed for SCFA concentrations as previously described. At-risk individuals not progressing to arthritis had significantly higher mean baseline serum levels of total SCFA (ie, the sum of acetate, butyrate, propionate or pentanoate), butyrate and acetate as compared by t-test to individuals who progressed to arthritis (figure 1). In contrast, levels of propionate and pentanoate did not significantly differ (figure 1). Univariable Cox regression analyses revealed significant association between lower total SCFA levels and progression to arthritis (p=0.029), while for the individual SCFA, we found significant associations concerning butyrate (p=0.038) and acetate (p=0.039) levels, but not regarding pentanoate or propionate (online supplemental table 2). Statistical significance remained after adjusting for age, sex, symptom duration, rheumatoid factor status, ACPA levels and CRP levels (total SCFA p=0.030; butyrate p=0.009 and acetate p=0.045, online supplemental table 2).

Butyrate levels inversely correlated with serum IgA-ACPA levels (r=−0.23, p=0.039), but not with IgG-ACPA or IgM-ACPA. No other SCFAs were significantly correlated with any ACPA subtype.

These data suggest that SCFA, in particular butyrate and acetate, influences the risk for the transition from the autoimmune to the clinical phase of RA. Although most p values would not remain significant after correction for multiple testing, the data are in line with previous findings in animal models and thus confirm our prespecified hypothesis. As SCFAs are produced by intestinal microbiota on fermentation of dietary fibres, our findings strengthen the concept that nutritional factors could influence the onset of RA. SCFAs are critical for the barrier function...
of the intestinal epithelium and thereby influences the migration of cells from the gut to the joints. Increasing SCFA levels by direct supplementation, fiber-rich diet or faecal transplantation to restore early dysbiosis thus represent potential strategies to inhibit the onset of arthritis. In this context, high-fibre diet has already shown to increase SCFA levels and decrease inflammatory burden in patients with established RA but has not been applied in a preventive setting. These data suggest that a state of high SCFA concentrations, which can be reached by dietary supplementation, fiber diet or faecal transplantation, can inhibit the onset of arthritis. In this context, high-SCFA concentrations, which can be reached by dietary interventions such as high-fibre diet, may go along with a lower risk to progress to clinical arthritis in individuals with a high risk to develop RA.

Figure 1 Baseline serum samples from rheumatoid arthritis at-risk individuals (ACPA+; musculoskeletal pain+) progressing (n=39) or not progressing (n=43) to arthritis in a prospective observational cohort study were analysed for (A) acetate, (B) butyrate, (C) pentanoate and (D) propionate levels. Bars represent means and error bars represent SD. ACPA, anti-citrullinated protein antibodies.

Contributors All authors had access to the data and a role in writing the manuscript. KMKM, MMZ, GS and AK contributed to the study conception and design. AK was responsible for patient recruitment and characterisation. Sample preparation was done by KD. Data was collected by KD and MMZ. Statistical analyses were performed by KMKM. MMZ and AK wrote the first manuscript draft and all authors commented on posterior versions and approved the final manuscript.

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Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval We declare that this study was approved by Swedish Ethical Review Authority (2020-06162) and was conducted in accordance with the ethical standards set forth in the Declaration of Helsinki and its subsequent amendments. All study subjects provided written informed consent before inclusion in the TIRx cohort.

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REFERENCES

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in proteasome—was suspected given that a genetic digenism is usually frequent gene, a second underlying pathogenic variant PSMB8 lipodystrophy and elevated temperature syndrome (CANDLE—is analogous to a chronic atypical neutrophilic dermatosis with whom the first NGS panel’s results hypothesised a diagnosis that child with prominent inflammatory and cutaneous phenotype, in patients with unexpected phenotype. We describe the case of a patient with CANDLE—novo mutation in the gene of arthritis: a case report. Clin Case Rep 2021;9:906–9.


The prototypical CANDLE syndrome is linked to recessive mutations in the immunoproteasome subunits genes, that is, subunit beta type 8 (PSMB8), affecting the clearance of damaged cytosolic proteins and promoting immune alterations. The constellation of criteria that mainly include cutaneous, ocular, neurological and immunological features, along with dysmorphic and growth aspects, reflects a restricted genetic basis. Despite the fact that the patient had prominent inflammatory and cutaneous phenotype, the examination of her skin by an experienced dermatologist did not show any signs of lipodystrophy. Then, other factors were considered. Ataxia—syndrome was excluded due to the absence of clinical ataxia and cytopenia as well as the mild interferon signature. Genetic investigations through NGS of a 55 auto—gene panel did not detect any pathogenic variant, mostly genes associated autoinflammatory disease (SAMD9L—SAAD). So far, at 7 years old, she does not have evidence of arthritis, thrombocytopenia, or other systemic disease. However, follow-up is necessary to detect any potential late-onset phenotypic features.

Cytokines and components of the pattern recognition receptors (PRRs) and the NLRP3 inflammasome are involved in the inflammatory responses and cutaneous manifestations. However, not all patients have the typical clinical and laboratory features of CANDLE syndrome. In this case, the patient developed unexplained recurrent fever (2—per month) with no ganglia basa calcifications. Moreover, the pulmonary function test and pulmonary CT scan did not suspect interstitial lung disease (ILD). Our patient (and seemingly the other one carrying the c.2626del/p.(Ile876Leufs*15) mutation4) had a milder phenotype and de—resolved mechanisms, promoting barrier breakdown by Porphyromonas gingivalis. JCI Insight 2019;4:e125191.
