A 3D Polymer Model for Future Nutrition Design Novel Nutrition Approach for Cystic Fibrosis, Ulcerative Colitis and Crohn’s Disease

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Abstract

Background: Inflammatory diseases such as; crohn’s disease and ulcerative colitis are responsible for the malfunction of the patients. These patients due to structural damage within the gastrointestinal tract do not absorb nutrients. Cystic fibrosis is a hereditary disease where the viscosity of mucus induces organ deficiency and nutrition malnutrition.

Materials and Methods: A novel polymer tube was constructed in order to evaluate the rheology of different types of nutrients. Results: The current 3D model simulates both light and severe disease with the different types of “traps” that have been constructed within it.

Conclusion: Modification of the different nutrients will elicit the proper future modifications that the industry should make for the patients with these underlying diseases.

Keywords: Crohn’s disease; Ulcerative colitis; Cystic fibrosis; 3D model; Bioengineering; Bioscience

Background

Crohn’s disease and Ulcerative Colitis are two chronic bowel inflammatory diseases that affect the gastrointestinal tract. Crohn’s disease might affect any part of the gastrointestinal (GI) tract from mouth to anus and it has a variety of symptoms such as; vomiting, weight loss, abdominal pain and diarrhea. Moreover; other symptoms outside the GI tract are; eye inflammation, anemia, arthritis and skin rash [1]. The manifestation of this disease depends on the interaction of the immune system, environmental factors and bacteria. The body’s immune system attacks the GI tract, however; Crohn’s diseases it does not appear to be an autoimmune disease and research is still being conducted to identify the factors that interact with the genetic substrate and induce the disease manifestations [2-4]. Treatment consists of anti-inflammatory agents, immune system suppressors, antibiotics, surgery and treatment for symptom relief and nutrition (Anti-diarrheals, Laxatives, Pain relievers, Iron supplements, Nutrition, Vitamin B-12 shots, Calcium and vitamin D supplements) [5]. Patients receiving immunosuppressant therapy are under cancer surveillance since tumorigenesis has been observed such as; lymphoma. Ulcerative colitis causes constant diarrhea mixed with blood. It usually attacks the large intestine and it has exacerbation periods and disease free periods [6]. It is treated as an autoimmune disease, although symptoms might diminish on their own. Environmental factors are responsible for symptom manifestation and symptom exacerbation. They interact with the genome substrate of the individual, although the genetic component has not been identified yet. Nutrition modification certainly improves the patients’ state. Treatment consists of anti-inflammatory agents, immune system suppressors, antibiotics, surgery and treatment for symptom relief and nutrition (Anti-diarrheals, Laxatives and Pain relievers. Pregnancy is possible between symptom free periods. Cancer surveillance is again an issue that should be observed with caution [7-11]. Patients treatment consists of Cystic fibrosis is an autosomal recessive genetic disorder that affects the lungs, liver, intestine and pancreas. In cystic fibrotic patients there is abnormal transport of chloride and sodium across an epithelium which leads to thick and viscous secretions. In the pancreas fibrotic tissue and cysts are observed. Moreover; during the progression of the disease we have frequent sinus infections and infections of the lower respiratory tract. Poor growth and infertility are also observed, however; the progressive dyspnea is the main symptom. Increased PCO2 and respiratory oxidosisis is observed in advanced disease. Cystic fibrosis is caused due to a mutation in the gene for the protein cystic fibrosis transmembrane conductance regulator (CFTR). The CFTR is responsible for the transportation of chloride and sodium ions across epithelial membranes. Cystic fibrosis can be diagnosed before birth and lung transplantation is often required as disease progresses [12]. Treatment of cystic fibrosis...
consists of bronchodilators, corticosteroids, antibiotics, enzyme replacement, insulin, bisphosphonates and vaccination during influenza exacerbation, and physiotherapy. In cystic fibrotic patients mucus builds up and blocks the small channels that carry digestive juices and enzymes. Especially the pancreas is damaged from this process. Lung transplantation is eligible for final stage disease [13-17].

Materials and Methods

We pursued the concept of designing and engineering a 3D model of tract simulating a patients diseased GI tract with ulcerative colitis and cystic fibrosis. In order to do that we used the Altech® breathing circuit LOT: 6259.1503.12, 120 cm limb Y connector with ports 2lt latex free. We acquired pipettes with two different diameters 5 mm and 7 mm. We cut out most of the suction tube leaving only 5 mm in length. Afterwards we punctured 10 holes in different parts of the circuit and glued the pipettes head and neck in between the beginning and end (Figure 1). We glued the neck of the pipettes with Pattex® silicone that was melted again with Pattex® Henkel KGaA melting apparatus (Nr: 10172786 Dueseldorf) (Figure 2). It is well known that inflammatory bowel diseases induce crypts within the GI tract of different formations. These crypts have different sizes with different entrances. The result is that the nutritional material enters the entrance of these formations, however, does not escapes easily. Therefore we chose to use two different pipettes with different ‘`necks’` in order to simulate two different types of crypts, we named the 7 mm diameter grade I and the 5 mm diameter grade II (Figure 3). Grade II being the worse, based on the fact that a crypt with a smaller entrance releases the nutritional material more difficult. We designed three different groups of nutritional material: a) Proteins b) Carbohydrates and c) Fat. For each group we designed additionally six subgroups with different pH and viscosity. Viscosity is the most important factor influencing the rheology and deposition of nutrition within the GI tract. We have to comment at this point that all pipettes had the same volume. We are currently designing and engineering a pump simulating the GI tract movement, so that more information can be gathered regarding function of the GI tract and administered nutrition.

Conclusion

In all three previously described diseases, nutrition plays a key role since malnutrition is a factor influencing the immune system of the host. The GI tract is malfunctioning in a different way and length in all three diseases. Moreover, the defense mechanisms and absorption is modulated [18,19]. Sufficient nutrition enhances the defense of the immune system and identifying key parameters of the composition of nutrition for each disease is crucial. There are already in the market several compounds that can be used by the patients additionally to their treatment. We should experiment with the different types of nutritional elements and different viscosity in order to identify the optional combination. Optimal nutrition rheology could be the next adjuvant treatment for these patients. 3D models are excellent for initial experimentation, and thereafter we can easily proceed to an in vitro or in vivo experimentation [20]. Polyflow could be also used for this kind of simulation; however, in any case clinical application is irreplaceable. Further experimentation with different nutritional compounds will further assist the health of these patients.

Conflict of Interest

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