ABSTRACT

The dynamics of swallowing within oesophagus has been investigated in the thesis. Chapter 1 discusses the role mathematical modelling plays in the field of applied mathematics, particular how it helps draw useful inferences after formulating a real word phenomenon mathematically. Then it describes the anatomy and physiology of oesophagus. The various types of peristalsis observed in the nature has also been described. Then is briefly described how a man-made peristaltic pump works.

A review of the literature that revolves round the topic of the thesis has been very carefully presented in Chapter 2, which contains theoretical and experimental investigations both in the chronological order. With its growth, research in peristalsis produced several off-shoots and branches.

In Chapter 3, we analytically investigate axi-symmetric flow of a micro-polar fluid induced by peristaltic waves with progressively dilating amplitude. By means of mathematical formulation we examine its impact on swallowing of single food bolus through oesophagus. The study suggests that achalasia patients should avoid the consumption of micro-polar fluids. It is also concluded that reflux action weakens with dilation of wave amplitude for micro-polar flows.

The model in Chapter 4 characterises the flow behaviour of suspended particles swallowing through oesophagus. Transport of particle-fluid mixture due to dilating peristaltic waves on a circular cylindrical tube has been investigated. It is observed that the fluid axial velocity exceeds the solid particle velocity almost everywhere. However, at the wall the axial velocity of the fluid is zero due to the no-slip condition imposed on it; but the suspended particulate material has non-zero positive axial velocity. It is further observed that the axial velocity is negative in the regions near maximum occlusions paving way to instantaneous backward flow.

In Chapter 5, we present a mathematical formulation that deals with the flow of micro-polar fluid in a circular cylindrical tube of non-uniform cross-sectional area induced by peristaltic waves of increasing amplitude. This is an intended act to model swallowing of various types of foods in a herniated oesophagus. Due to sliding hiatus hernia, the cross section of the lower oesophagus does not remain uniform. The impact of bulging, which is formed by various combinations of divergence and convergence, has been examined.

Chapter 6 models a peristaltically driven flow when the cross section of the tube changes exponentially. This may resemble the shape of the oesophagus when it suffers from sliding hiatus hernia, that is, when the abdomen protrudes through the hiatus. The fluid transported is considered micro-polar while the peristaltic waves propagating along wall too dilate exponentially. It is observed whether the tube diverges entirely or partly, pressure required for carrying the fluid is less, hence facilitating easier swallowing, which causes sliding hiatus hernia to go unnoticed.

Chapter 7 presents the analysis of the transport of a Newtonian fluid with suspended solid particles in a tube which diverges exponentially under the influence of peristaltic waves whose amplitude too increases progressively. Besides engineering applications, this models the state of hiatus hernia of an oesophagus swallowing a mixture of fluid and solid particles.

The thesis concludes with overall conclusions and further scope of study.