PREFACE

The thesis investigates the flow dynamics of oesophageal swallowing. Swallowing is affected by the pathological states of the oesophagus, types of ingested foods and kinds of wave generated in the wall of the oesophagus. The outcomes of the investigation have potential application to the physiology of oesophageal swallowing. The thesis consists of seven chapters.

Chapter 1 begins with a brief discussion on peristalsis which is the prime cause of flows in the oesophagus. It further discusses the physiological systems associated with peristalsis and some important pathological states of oesophagus in view of the research problems taken up in the thesis. Light is also thrown on the physical categorization of fluids and also the various models that resemble physiological fluids.

Chapter 2: A brief review of the relevant previous investigations concerning peristalsis has been presented by giving adequate details of the long expedition. This includes the theoretical as well as the experimental investigations that laid the foundation stone for further explorations. Objective of research is also contained in this segment.

The objective of **Chapter 3** is to mathematically model the flow of Herschel-Bulkley fluid induced by peristaltic waves with progressively dilating amplitude. This model investigates the impact of swallowing of particularly single food bolus such as raisin paste, minced fish paste transported in oesophagus. This type of food stuff behaves as Herschel-Bulkley fluid model. Emphasis is given on the study of spatial and temporal dependence of local pressure with increasing wave amplitude and flow behavior index. As an application it is concluded that feeding of pseudo plastic fluids are preferable to the patients suffering from achalasia.

The presented formulation in **Chapter 4** is an intended act to model the swallowing of various types of chewed foods in oesophagus which suffers from hiatus hernia. The fluid for investigation has been considered as Herschel-Bulkley fluid which on account of its formulation contains a plug flow region. Pseudo-plastic and dilatant fluids are special cases. These features of Herschel-Bulkley fluid makes it a versatile model. Moreover, 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, is examined. The method of solution involves low Reynolds number and long wavelength approximations. Effects of dilating amplitude, the flow behaviour index etc. are also investigated. The main observation of this chapter is that the pressure requirement to deliver the bolus in the stomach is smaller in a diverging oesophagus than that in a uniform oesophagus. This is the reason that the patients suffering from sliding hiatus hernia do not feel swallowing difficult. Another interesting observation is that even if the tube diverges only towards the end, its impact is experienced on the pressure distribution right from the beginning of the oesophagus.

The model in **Chapter 5** characterizes the flow behaviour of suspended particles in swallowing through oesophagus. Transport of particle-fluid mixture induced by dilating peristaltic waves on a circular cylindrical tube has been considered for investigation. Unsteady closed form solutions for pressure gradient, velocity and stream function are obtained by applying regular perturbation technique up to the first order of wave number (the ratio of the tube radius to the wavelength). The effect of volume fraction of suspended particulate matter on pressure gradient and velocity is examined. The outcome of this investigation endorses the doctors' advice to the patients suffering from achalasia, oesophageal stricture and oesophageal tumors to take liquid or food items with lesser solid contents.

In **Chapter 6**, we investigate swallowing through oesophagus when the elastic wall is constrained to a prescribed external forcing which consists of a forward travelling wave. The mechanics of flow is closely related to that in the oesophageal tube. The mechanics of the tube is characterized by a relationship between transmural pressure difference and radial variation of the tube. The dimensionless radial variation of the tube has been assumed to be small and perturbation techniques have been used to solve the radial variation as part of the solution. The results demonstrate that the elastic tube plays a significant role in fluid flow. We conclude that the elasticity of oesophageal tube favours swallowing of a food bolus.

Several oesophageal diseases (e.g. oesophageal cancer, oesophageal motility disorders, Barrett's oesophagus) put the human health in danger in the modern society. The oesophageal heat transfer device is used for temperature management of adult survivors of cardiac arrest. Oesophageal cancer is one of the most lethal cancers which may be cured by cryosurgery. Cryosurgery is a type of surgery that involves the use of extreme cold liquid to destroy cancerous cells. Therefore, **Chapter 7** is an attempt to construct a mathematical model for the study of heat transfer in swallowing of food bolus through the oesophagus. The main observation is that pressure drops along the oesophageal axis when either of the Grashof number and the heat source/sink parameter increases. Therefore it may be inferred that smaller is the requirement of pressure to swallow when heat propagates in the oesophagus.

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