J Eng Math (2009) 64:317–318
DOI 10.1007/s10665-009-9290-2

Preface

Published online: 12 April 2009

This special issue contains a selection of papers contributed by authors working in the general area of modelling the cardiovasculature using mathematics, engineering and related methodologies. The selection of papers is intended as a refreshing interdisciplinary collection bringing together researchers to present and critically review the recent and latest studies made, and discuss the latest advances in key areas of clinical concern. The papers include such fascinating facets as cerebral autoregulation, flow in the cerebrovasculature, aneurysms, the role of the Circle of Willis, arterial pulse waveforms and wave reflection, arterial stiffness, branching networks of vessels, diastolic decay, the dicrotic notch and wall shear stress. The research also brings data from particle imaging velocimetry and magnetic resonance imaging together with modelling via differential equations, geometric multiscales, domain splitting, matching conditions, one-dimensional modelling, wave tracking algorithms, spectral elements, vortex identification and lumped parameter models, along with relevant theory, computation and applications.

Medical modelling of problems in health and medicine and allied techniques have seen quite an upsurge of interest especially in recent years. There is great intrinsic concern in the various real applications themselves which are primarily driven by clinical need. Moreover there is much fundamental interest in developing the required modelling and/or science that is required. The present issue and review is to an extent an update of a successful review issue of the Journal of Engineering Mathematics that appeared approximately 6 years ago (vol. 47, nos. 3–4 Dec 2003) on mathematical modelling of the cardiovascular system. The present issue also covers a wide range of subjects, reflecting both the breadth and the inherently interdisciplinary nature of the area as well as hinting at a still wider range. There are indeed many adjunct topics such as angiogenesis, targeted drug delivery and atherosclerotic plaque rupture that are generating significant interest at present.

The first four papers focus on unsteady and complex haemodynamics in the cerebrovasculature. The subject of the paper by Passerini, de Luca, Formaggia, Quarteroni and Veneziani considers a geometrical model of cerebral vasculature, highlighting in particular a coupling between a one-dimensional model of the Circle of Willis and a three-dimensional model of a carotid artery. Alastruey, Parker, Peiro and Sherwin then discuss the pattern of pulse waves in arterial networks based on a time-domain one-dimensional study aimed at the parameters and pathways that most affect pulse waveforms. The concern of Green, Smith and Ovenden is with wall-compliance effects on flow through multi-branching vessels, motivated by the application to cerebral arteriovenous malformations and particularly the physical scales involved. The article by Cebral, Putman, Alley, Hope, Bammer and Calamante concerns comparisons between magnetic resonance techniques and image based computational fluid dynamics predictions for normal cerebral arteries, partly to help identify areas of disagreement and guide interpretation of data for the blood flow patterns.

Two papers look at the complex flow through aneurysms. The interest of Sheard's paper lies in flow through a fusiform aneurysm (as in abdominal aortic cases) and its wall shear stress properties with special emphasis on peak instantaneous values and comparisons with particle image velocimetry experiments. Mulder, Bogaerds, Rongen and van de Vosse present work on flow patterns in cerebral aneurysms, using three-dimensional vortex identification and with reference to in vitro models and to the risk of rupture in clinical practice.

The final two papers present research on the relationship between arterial pressure and flow and its control. David, Alzaidi and Farr examine coupled autoregulation models in the cerebrovasculature where the matter of finding the dominant mechanism for such autoregulation is addressed. Vermeersch, Rietzschel, De Buyzere, Van Bortel, Gillebert, Verdonck and Segers address a windkessel model with application to a particular population study, making use of a reservoir pressure concept in a hybrid model for carotid pressure waveforms and considering the increase of pulse pressure with age.

The issue provides a timely and exciting opportunity to assess recent progress in modelling the cerebrovasculature and to look again at outstanding problems highlighted in the separate articles themselves including in particular the matters listed at the end of the first paragraph above and for example unsteady three-dimensional flows and advanced computational techniques. The issue has active researchers contributing extended discussion and debate. What emerges is that, despite the maturity attained in certain aspects there are fundamental problems in all or most of the many subjects discussed in detail here that remain unresolved. Moreover, there are many new and developing areas (such as are studied in all the present articles) where novel approaches have an important role to play. It seems also abundantly clear that engineering/mathematics approaches could benefit from being more closely aligned with direct medical or health applications and *vice versa*, to correctly capture the important scales and interactions arising in many relevant fluid flows and solid mechanics for instance.

Frank T. Smith, Nicholas C. Ovenden
University College London