

Foot-and-mouth Disease Virus

Current Research and Emerging Trends

Edited by

Francisco Sobrino and Esteban Domingo

Centro de Biología Molecular 'Severo Ochoa' (CSIC-UAM)

Madrid

Spain



Copyright © 2017

Caister Academic Press
Norfolk, UK

www.caister.com

British Library Cataloguing-in-Publication Data
A catalogue record for this book is available from the British Library

ISBN: 978-1-910190-51-7 (paperback)

ISBN: 978-1-910190-52-4 (ebook)

Description or mention of instrumentation, software, or other products in this book does not imply endorsement by the author or publisher. The author and publisher do not assume responsibility for the validity of any products or procedures mentioned or described in this book or for the consequences of their use.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior permission of the publisher. No claim to original U.S. Government works.

Cover design adapted from Figures 4.1(a) and 9.1.

Ebooks

Ebooks supplied to individuals are single-user only and must not be reproduced, copied, stored in a retrieval system, or distributed by any means, electronic, mechanical, photocopying, email, internet or otherwise.

Ebooks supplied to academic libraries, corporations, government organizations, public libraries, and school libraries are subject to the terms and conditions specified by the supplier.

Contents

	Contributors	v
	Preface	xi
1	Introduction: Foot-and-mouth Disease – Much Progress But Still a Lot to Learn	1
	David J. Rowlands	
2	Genome Organization, Translation and Replication of Foot-and-mouth Disease Virus RNA	13
	Encarnación Martínez-Salas and Graham J. Belsham	
3	Foot-and-mouth Disease Virus Proteinases and Polyprotein Processing	43
	Fiona Tulloch, Garry A. Luke and Martin D. Ryan	
4	The Foot-and-mouth Disease Virion: Structure and Function	61
	Mauricio G. Mateu	
5	Foot-and-mouth Disease Virus Receptors: Multiple Gateways to Initiate Infection	107
	Paul Lawrence and Elizabeth Rieder	
6	The RNA-dependent RNA Polymerase 3D: Structure and Fidelity	137
	Cristina Ferrer-Orta and Nuria Verdaguer	
7	Quasispecies Dynamics Taught by Natural and Experimental Evolution of Foot-and-mouth Disease Virus	147
	Esteban Domingo, Ignacio de la Higuera, Elena Moreno, Ana I. de Ávila, Rubén Agudo, Armando Arias and Celia Perales	
8	Clinical Signs and Pathology of Foot-and-mouth Disease	171
	Charles Nfon, Oliver Lung, Carissa Embury-Hyatt and Soren Alexandersen	
9	Natural Habitats in which Foot-and-mouth Disease Viruses are Maintained	179
	Wilna Vosloo and Gavin R. Thomson	
10	Innate to Adaptive: Immune Defence Handling of Foot-and-mouth Disease Virus	211
	Kenneth C. McCullough, Margarita Sáiz and Artur Summerfield	

11	Laboratory Diagnostic Methods to Support the Surveillance and Control of Foot-and-mouth Disease	275
	Anna Ludi, Valerie Mioulet, Nick J. Knowles and Donald P. King	
12	Quality Attributes of Current Inactivated Foot-and-mouth Disease Vaccines and their Effects on the Success of Vaccination Programmes	287
	Eliana N. Smitsaart and Ingrid E. Bergmann	
13	Peptide Vaccines Against Foot-and-mouth Disease	317
	Esther Blanco, David Andreu and Francisco Sobrino	
14	Control of Foot-and-mouth Disease by Using Replication-defective Human Adenoviruses to Deliver Vaccines and Biotherapeutics	333
	Fayna Diaz-San Segundo, Gisselle N. Medina, Marvin J. Grubman and Teresa de los Santos	
15	Antiviral Therapies for Foot-and-mouth Disease	357
	Annebel R. De Vleeschauwer, David J. Lefebvre and Kris De Clercq	
16	Mathematical Models of the Epidemiology and Control of Foot-and-mouth Disease	385
	Michael J. Tildesley, William J.M. Probert and Mark E.J. Woolhouse	
17	The Role of International Organizations in the Control of Foot-and-mouth Disease	409
	Bernard Vallat, Joseph Domenech and Alejandro A. Schudel	
18	Overview of Foot-and-mouth Disease and its Impact as a Re-emergent Viral Infection	417
	Brian W.J. Mahy and Graham J. Belsham	
	Index	427

Preface

Foot-and-mouth disease virus (FMDV) maintains a continuing fascination not only because of its worldwide implications for economic development, but also because it makes us relive the events of an outbreak of disease upon unsuspecting areas of our planet. On top of this, many fundamental questions about its replication, transmission, detection, spread and persistence do not yet have an answer, since the virus displays unique features even when compared with its closest picornavirus relatives. As with other small viruses, FMDV is endowed with complex biological behaviour for an apparently simple pathogen.

An invitation to produce a book similar in content to the 2004 book is a clear sign that not only the first edition was well received by the scientific community, but also that many problems and questions remain, and that the unsolved issues have a very relevant scientific and economic impact in our increasingly global world. Unanswered questions are, for example, the limited knowledge about host range determinants, or the lack of cost-effective vaccines, as alternatives to the chemically inactivated conventional vaccines. The limited amount of funding devoted to FMDV research in the EU is surprising considering the potential economic impact of a disease outbreak within the EU or in neighbouring countries.

A very important change regarding the social perception of the disease has taken place since 2004. Perhaps as a result of the terrible images of mass animal slaughtering during the 2001 European epidemic, witnessed on television by the public at large, there is a growing trend to consider alternative means to deal with the disease. In particular, the non-vaccination policy and the possibility of new types of antiviral interventions are gaining

impetus, and gradually diminishing the traditional support for a slaughter-based control strategy. This is reflected in renewed effort on vaccine designs and the consideration of antiviral agents to control or prevent the infection, either by administering the agents alone or as a complement to vaccination or other immunization-based interventions. This book reflects this trend by including a chapter on antiviral therapies that was not even considered in the 2004 version where small molecule inhibitors or RNA interference or silencing (to name just two points) were not even mentioned.

In planning the new volume, we have done our best as authors to invite those experts that in our view have contributed either recently or historically to construct the body of current knowledge on FMDV. Of course, they are not the only ones in this endeavour, and we apologize for any omissions of experts that could have been invited as authors. Many names are listed in a remarkable number of references that should serve as further reading to complement the core information gained by reading the 18 chapters. This book is not a reprint or even an updated version of the 2004 book. While many topics have been retained, each chapter has been written afresh, so as to include recent progress as evidenced by the large number of references to publications of the last decade. It is our hope that the present book will provide an updated overview of several interconnected aspects of FMDV and its disease, including the structure of the viral particle and encoded proteins, expression of the genetic material, natural habitats of the virus, diagnostic procedures, epidemiological spread, and control measures. As in the 2004 book, great attention has been paid to what is known, and what is not, regarding the

innate and acquired immune responses elicited by the virus and their implications for classical vaccines improvement and the development of new immunization strategies.

We thank all authors for their timely contributions, and for reflecting recent developments as well

as historical developments by many devoted scientists some of whom, unfortunately, are no longer among us. Finally, our appreciation goes also to Caister Academic Press, and in particular to Hugh Griffin, for his friendly and constructive work in the planning and production of this book.

Francisco Sobrino and Esteban Domingo
Centro de Biología Molecular 'Severo Ochoa'
Cantoblanco