

Review

Next-Generation TB Vaccines: Progress, Challenges, and Prospects

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Abstract: Tuberculosis (TB), caused by *Mycobacterium tuberculosis* (MTB), is a prevalent global infectious disease and a leading cause of mortality worldwide. Currently, the only available vaccine for TB prevention is Bacillus Calmette–Guérin (BCG). However, BCG demonstrates limited efficacy, particularly in adults. Efforts to develop effective TB vaccines have been ongoing for nearly a century. In this review, we have examined the current obstacles in TB vaccine research and emphasized the significance of understanding the interaction mechanism between MTB and hosts in order to provide new avenues for research and establish a solid foundation for the development of novel vaccines. We have also assessed various TB vaccine candidates, including inactivated vaccines, attenuated live vaccines, subunit vaccines, viral vector vaccines, DNA vaccines, and the emerging mRNA vaccines as well as virus-like particle (VLP)-based vaccines, which are currently in preclinical stages or clinical trials. Furthermore, we have discussed the challenges and opportunities associated with developing different types of TB vaccines and outlined future directions for TB vaccine research, aiming to expedite the development of effective vaccines. This comprehensive review offers a summary of the progress made in the field of novel TB vaccines.

Keywords: tuberculosis (TB); *Mycobacterium tuberculosis* (MTB); vaccines; clinical trials; deep learning



Citation: Zhuang, L.; Ye, Z.; Li, L.; Yang, L.; Gong, W. Next-Generation TB Vaccines: Progress, Challenges, and Prospects. *Vaccines* **2023**, *11*, 1304. <https://doi.org/10.3390/v11081304>

Academic Editor: Ralph A. Tripp

Received: 1 July 2023

Revised: 28 July 2023

Accepted: 28 July 2023

Published: 31 July 2023



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1. Introduction

Tuberculosis (TB) is an ancient disease widely distributed across the world and is the leading cause of death from bacterial infections [1]. In 17–18th century Europe, TB was known as the “white plague”, with almost 100% of Europeans infected and 25% of them dying from the disease [2]. In 1882, Robert Koch, a German microbiologist, deciphered *Mycobacterium tuberculosis* (MTB) as the etiological factor responsible for TB, thereby opening a new chapter in the prevention, diagnosis, and treatment of TB [3]. With the continuous development of anti-TB drugs and improvements in sanitation and living conditions, the incidence and mortality of TB decreased significantly. However, since the 1990s, the global TB epidemic has worsened due to factors such as the emergence of drug-resistant strains of MTB, the use of immunosuppressive agents, drug addiction, poverty, and population movements [4]. TB has become a leading re-emerging infectious disease and a serious global health problem, especially in developing countries.

Despite the effectiveness of anti-TB drugs, eradicating TB still faces many challenges. On 27 October 2022, the World Health Organization (WHO) Global TB Report showed that approximately one-quarter of the world’s population is infected with MTB [4]. In 2021, the estimated global number of new TB cases was 10.6 million, a 4.5% increase from 2020, and the number of deaths from TB was 1.6 million, a 6.7% increase from 2020 [5]. China is one of the countries with a high burden of TB, with an estimated number of TB cases only second to India and Indonesia, accounting for 7.4% of the global TB incidence [5]. In 2015, the WHO introduced the “End TB Strategy”, a comprehensive plan that outlines ambitious targets for the period of 2020–2035. These objectives include a significant reduction of 90% in the

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Clinical Tuberculosis Peter D. O. Davies, Stephen B Gordon, Geriant Davies, 2014-04-30 Completely updated and revised Clinical Tuberculosis continues to provide the TB practitioner whether in public health laboratory science or clinical practice with a synoptic and definitive account of the latest methods of diagnosis treatment and control of this challenging and debilitating disease New in the Fifth Edition Gamma interferon based *Clinical Tuberculosis* Peter Barnes, Peter D. O. Davies, Stephen B Gordon, 2008-04-25 Over three previous editions Clinical Tuberculosis has established itself as an indispensable guide to all aspects of tuberculosis diagnosis and treatment This fully revised and updated fourth edition provides practical guidance to healthcare professionals involved in any aspect of patient management or disease control chapters are included on epidemiology pathology immunology disease presentation diagnosis treatment and management options The problem of TB associated with HIV infection is given special emphasis as are the increasing problems of multi drug resistant strains and environmentally opportunistic mycobacteria Chapter authors have been hand picked to represent the most up to date thinking in their particular subject areas making Clinical Tuberculosis the essential reference work for the bookshelves of respiratory physicians infectious disease specialists public health workers and other individuals involved in the management and control of tuberculosis worldwide **Tuberculosis** Mario C. Raviglione, 2016-04-19 Every second a new person is exposed to tuberculosis TB Each untreated TB infected person will infect 10 15 people every year Following the success of its predecessor this new edition of Tuberculosis The Essentials scrutinizes the new discoveries and observations of the key aspects of the disease Recognized world experts provide a concise state of the art review of the 15 essential elements of TB supply an international current view of the epidemiology pathophysiology diagnosis and treatment methods discuss the emerging threat of XDR TB and the HIV AIDS factor assess advances in TB research such as new drugs and vaccines reflect on the progress of the Stop TB strategy Tuberculosis Control Saurabh Shrivastava, 2014-10-26 Recent global estimates suggest tuberculosis to be the second leading cause of death attributed to any infectious disease India has the largest share of tuberculosis cases across the world and it presents as one of the biggest challenges to the public health system To counter this menace Government of India has initiated Revised National Tuberculosis Control Program This book has been written to cover the different aspects of the national program especially Directly Observed Treatment and Short Course Strategy Drug resistant tuberculosis airborne infection control in hospital settings and recent developments in the diagnostic therapeutic aspects of tuberculosis in India In addition a section has been added to provide practical insights about the infamous outbreak of total drug resistant TB in Mumbai **Target product profile for tuberculosis screening tests** World Health Organization, 2025-08-05 This document summarizes the latest WHO Target Product Profiles TPPs to guide the development of new tests or tools for screening for tuberculosis disease as well as the process that was followed to arrive at the updated TPPs Innovation, Communication and Engineering Teen-Hang Meen, Stephen Prior, Art de Donald

Kin-Tak Lam,2013-10-08 This volume represents the proceedings of the 2013 International Conference on Innovation Communication and Engineering ICICE 2013 This conference was organized by the China University of Petroleum Huadong East China and the Taiwanese Institute of Knowledge Innovation and was held in Qingdao Shandong P R China October 26 November 1 2013 The conference received 653 submitted papers from 10 countries of which 214 papers were selected by the committees to be presented at ICICE 2013 The conference provided a unified communication platform for researchers in a wide range of fields from information technology communication science and applied mathematics to computer science advanced material science design and engineering This volume enables interdisciplinary collaboration between science and engineering technologists in academia and industry as well as networking internationally Consists of a book of abstracts 260 pp and a USB flash card with full papers 912 pp *Tuberculosis E-Book* H. Simon Schaaf,Alimuddin Zumla,2009-03-24 This book provides all the vital information you need to know about tuberculosis especially in the face of drug resistant strains of the disease Coverage includes which patient populations face an elevated risk of infection as well as which therapies are appropriate and how to correctly monitor ongoing treatment so that patients are cured Properly administer screening tests interpret their results and identify manifestations of the disease with authoritative guidance from expert clinicians from around the world Discusses screening tests for tuberculosis so you can interpret their results and identify not only common manifestations of the disease but also those that are comparatively rare such as tuberculosis in pregnant women Covers all clinical aspects of tuberculosis in children including current practices on managing those infected with HIV Provides details on how best to interact with the public health system in both industrialized and developing countries Addresses the social aspects of tuberculosis and presents the latest advances on new and potential vaccines against tuberculosis Offers the expertise of internationally recognized tuberculosis clinicians to provide you with well rounded global coverage Features numerous illustrations to provide clear and detailed depictions of rare manifestations of tuberculosis Essential Tuberculosis Giovanni Battista Migliori,Mario C. Raviglione,2021-07-26 This textbook covers the full spectrum of tuberculosis related topics in a comprehensive yet easy to follow readily accessible format Filling a significant gap in tuberculosis literature it addresses tuberculosis sensu latu mirroring the content of the London Queen Mary University tuberculosis Diploma Covering all aspects related to this condition from prevention diagnosis and treatment to public and global health the book provides a broad overview of tuberculosis management Further it includes a wealth of case studies and exercises making it an essential guide for all staff involved in tuberculosis management Written by an international and interdisciplinary panel of experts the book appeals to a broad readership including students postdoctoral fellows clinicians researchers and nurses as well as public health officers working in tuberculosis control programs **Emerging Infectious Diseases** ,2016 Tuberculosis Bassam Mahboub,Mayank Vats,2013-03-20 Data are rapidly accumulating from all over the world regarding the efficacy of standardized treatment regimens for drug sensitive drug resistant TB and latent TB infection

While we are facing the menace of multi drug resistant TB MDR TB extensively drug resistant tuberculosis XDR TB has emerged threatening to undermine global efforts at TB control Hence we have included chapters to cover all aspects of the diagnosis and management of MDR TB This book will cover all these developments in great detail With the widespread availability of internet globally various standard web resources available on TB have also been included so that the readers may get the comprehensive and updated guidelines from these resources The changing clinical presentation of TB advances in laboratory imaging diagnostic modalities therapeutic measures and emergence of MDR TB all suggest a pressing need to have a updated book on TB Furthermore while all physicians encounter the TB disease in their clinical practice there have been a lot of controversies and misconceptions over various issues for the diagnosis and management of TB Paucity of a well referenced updated standard book of TB has prompted us to undertake this venture sharing the clinical experience of global experts of TB Our book contains chapters on epidemiology immune pathology diagnosis treatment and latest advances for TB highlighting the global perspective of tuberculosis World wide resurgence of MDR TB indicates that the battle against this foe of mankind will continue in the coming years TB still remains to be a research priority of paramount importance from medical social and financial aspects and we have attempted to highlight all the aspects for the treatment of TB We believe that this book will serve as a practical guide for the diagnosis and management of TB for practicing physicians especially pulmonologists and internists and all those who are involved in the management of TB

Clinical Tuberculosis Lloyd N. Friedman, Martin Dedicoat, Peter D. O. Davies, 2020-08-26 Entirely updated and revised the 6th edition of Clinical Tuberculosis continues to provide the TB physician with a definitive and erudite account of the latest techniques in diagnosis treatment and control of TB including an overview of the latest guidelines from the CDC and WHO With an increased emphasis on the clinical aspects and treatment this book will be an invaluable resource to the TB practitioner in public health or clinical practice and an ideal reference to laboratory staff Key Features Completely updated and reorganized Includes brand new chapters on radiology and an overview of the latest WHO ATS CDC IDSA ERS NICE CTS and IUATLD guidelines Clinically focused to provide up to date guidance on diagnosis treatment and control Edited by three renowned experts in the field of tuberculosis

Proceedings of the International Conference on Medical Science and Health (ICOMESH 2024) Dyah Wulan Sumekar Rengganis Wardani, Sutopo Hadi, 2024-12-18 This is an open access book Continuing the success of the previous ICOMESH this year's conference will be held again in Bandar Lampung Sumatra Island Indonesia hosted by University of Lampung The 2024 conference continuing the tradition and the goals of ICOMESH consists of plenary presentations by leading researchers in health and experts from regulatory institutions as well as research paper presentations The theme of the 2024 conference is Life Sciences

Closure Strategies for Turbulent and Transitional Flows Brian Edward Launder, N. D. Sandham, 2002-02-21 Publisher Description

ERS Handbook of Respiratory Medicine Paolo Palange, Gernot Rohde, 2019-09-01 The European Respiratory Society ERS Handbook of Respiratory Medicine now in

its third edition is a concise compact and easy to read guide to each of the key areas in respiratory medicine Its 20 sections written by clinicians and researchers at the forefront of the field explain the structure and function of the respiratory system its disorders and how to treat them The Handbook is a must have for anyone who intends to remain up to date in the field and to have within arm s reach a reference that covers everything from the basics to the latest developments in respiratory medicine This book was replaced by a newer edition in July 2025

Tuberculosis Control in Migrating Population

Wei-ye Yu,Pu-Xuan Lu,Wei-guo Tan,2019-11-25 With the rapid development of economy and international communication world population mobility increase significantly As migrating population is one of vulnerable populations to infectious diseases strengthening monitoring system and intervention approaches will be a key factor in controlling the spread of infectious diseases This book is intended to provide valuable information on creating effective prevention and intervention strategies of tuberculosis taking Shenzhen one of typical immigrant cities as an example Followed by overview of tuberculosis the control strategy diagnosis and treatment of tuberculosis drug resistant tuberculosis and HIV associated tuberculosis in migrating population is introduced In addition application of innovative technologies for example internet molecular biology and artificial intelligence in tuberculosis control is presented It will be a useful reference for practitioners in centers for infectious disease control and prevention hospitals academic institutions as well as staff in government agencies and non government organizations with interests in tuberculosis prevention and control

AJRCCM,2008

Global Tuberculosis Control World Health Organization,2009 This report is WHO s thirteenth annual report on global tuberculosis TB control in a series that started in 1997 It presents WHO s latest assessment of the epidemiological burden of TB numbers of cases and deaths as well as progress towards the 2015 targets for global TB control that have been established within the context of the Millennium Development Goals MDGs It also includes a thorough analysis of implementation and financing of the WHO s Stop TB Strategy and the Stop TB Partnership s Global Plan to Stop TB since in combination these have set out how TB control needs to be implemented and funded to achieve the 2015 targets The report gives particular attention to the period 2006 2009 but selected epidemiological implementation and financial data are presented for previous years as well This includes epidemiological data back to 1990 and financial data back to 2002 Bringing together data reported by 196 out of 212 countries and territories in 2008 as well as data collected from these countries and territories in previous years Global Tuberculosis Control 2009 is the definitive source of information about the national and international response to the worldwide TB epidemic

The Challenge of Tuberculosis in the 21st

Century Alberto L. García-Basteiro,Füsun Öner Eyüboğlu,Molebogeng X. Rangaka,2023-09-01 Recent years have witnessed key developments in the diagnosis and treatment of tuberculosis Alongside this and running in direct opposition to this progress was the COVID 19 pandemic which had an unprecedented detrimental effect on tuberculosis control and the achievement of targets set by the End TB Strategy This timely and important Monograph provides a crucial update on recent

changes developments and setbacks in the field and calls for a re commitment to the achievement of the End TB Strategy and Sustainable Development Goals Written by authors from across the world the Monograph covers diagnosis advances in treatment prevention and tuberculosis control challenges in different populations and contexts *World health statistics 2021* ,2021-07-13 **Campbell's Operative Orthopaedics, E-Book** Frederick M. Azar,S. Terry Canale,James H. Beaty,2020-12-23 Still the most widely used comprehensive resource in orthopaedic surgery Campbell s Operative Orthopaedics is an essential reference for trainees a trusted clinical tool for practitioners and the gold standard for worldwide orthopaedic practice Unparalleled in scope and depth this 14th Edition contains updated diagnostic images practical guidance on when and how to perform every procedure and rapid access to data in preparation for surgical cases or patient evaluation Drs Frederick M Azar and James H Beaty along with other expert contributors from the world renowned Campbell Clinic have collaborated diligently to ensure that this 4 volume text remains a valuable resource in your practice helping you achieve optimal outcomes with every patient Features evidence based surgical coverage throughout to aid in making informed clinical choices for each patient Covers multiple procedures for all body regions to provide comprehensive coverage Keeps you up to date with even more high quality procedural videos a new chapter on biologics in orthopaedics and expanded and updated content on hip arthroscopy patellofemoral arthritis and more Follows a standard template for every chapter that features highlighted procedural steps high quality illustrations for clear visual guidance and bulleted text Enhanced eBook version included with purchase Your enhanced eBook allows you to access all of the text figures and references from the book on a variety of devices

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