# Reducing bacterial resistance with IMPACT

Interhospital Multi-disciplinary Programme on Antimicrobial ChemoTherapy

**Fifth Edition**  
*Edited by P.L. Ho & T.C. Wu*

## Quick Reference

<table>
<thead>
<tr>
<th>Part</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Antibiotic resistance - Local scenario</td>
<td>19</td>
</tr>
<tr>
<td>II</td>
<td>Antimicrobial stewardship programme</td>
<td>41</td>
</tr>
<tr>
<td>III</td>
<td>Guidelines for selected antimicrobial use</td>
<td>47</td>
</tr>
<tr>
<td>IV</td>
<td>Recommendation for the empirical therapy of common infections</td>
<td>68</td>
</tr>
<tr>
<td>V</td>
<td>Guidelines for known-pathogen therapy</td>
<td>98</td>
</tr>
<tr>
<td>VI</td>
<td>Guidelines for surgical prophylaxis</td>
<td>107</td>
</tr>
<tr>
<td>VII</td>
<td>Cost and recommended dosage of commonly-used antimicrobial agents</td>
<td>117</td>
</tr>
<tr>
<td>VIII</td>
<td>Other issues</td>
<td>128</td>
</tr>
</tbody>
</table>
Reducing bacterial resistance with IMPACT –

Interhospital Multi-disciplinary Programme on Antimicrobial Chemotherapy
Editors: Pak Leung, HO & Tak Chiu, WU

Fifth Edition 2017

Version 5.0

All rights reserved. No part of this publication may be reproduced, stored in a retrieved system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, and recording or otherwise, without the prior approval from IMPACT.

We seek to improve the quality of this document. If you have comments or suggestion on this publication, please email to plho@hkucc.hku.hk

NOTICE

This publication contains information relating to general principles of medical care, which should not be construed as specific instructions for individual patients. It is important to realise that the content cannot always account for individual variations among patients. They should not supplant clinical judgement or clinical microbiology/infectious diseases consultation when indicated. We have attempted to verify that all information is correct at the time of publication but because of ongoing research, things may change. Readers should consider our recommendation in light of their local resistance and susceptibility patterns, availability of and variations in formulations of antimicrobial agents. Manufacturers' product information, package inserts and peer-reviewed literature should be reviewed for current information, including contraindications, dosages and precautions.

This publication should be cited as:


IMPACT Editorial Board

Editors

Dr. Pak Leung, HO
Director
Carol Yu Centre for Infection
The University of Hong Kong

Dr. Tak Chiu, WU
Consultant
Division of Infectious Diseases
Department of Medicine
Queen Elizabeth Hospital

Associate Editors (in alphabetical order)

Dr. David Vai Kiong, CHAO
Vice-President
(Education and Examinations)
Hong Kong College of Family Physicians

Prof. Ivan Fan Ngai, HUNG
Clinical Professor
Department of Medicine
The University of Hong Kong

Dr. Leo, LUI
Associate Consultant
Infection Control Branch
Centre for Health Protection
Department of Health

Dr. David Christopher, LUNG
Associate Consultant
Department of Clinical Pathology
Tuen Mun Hospital

Dr. Tommy Hing Cheung, TANG
Associate Consultant
Division of Infectious Diseases
Department of Medicine
Queen Elizabeth Hospital

Dr. Alan Ka Lun, WU
Consultant
Division of Microbiology
Department of Clinical Pathology
Pamela Youde Nethersole Eastern Hospital
Members (in alphabetical order)

Dr. Kin Sang, CHAN
Consultant
Department of Medicine
Haven of Hope Hospital

Dr. Johnny Wai Man, CHAN
Chief of Service
Department of Medicine
Queen Elizabeth Hospital

Dr. Wai Ming, CHAN
Chief of Service
Adult Intensive Care Unit
Queen Mary Hospital

Dr. Eric Yuk Tat, CHAN
Head and Consultant Immunologist
Division of Clinical Immunology
Department of Pathology
Queen Mary Hospital

Dr. Kwok Chiu, CHANG
Senior Medical and Health Officer
Tuberculosis and Chest Service
Centre for Health Protection
Department of Health

Dr. Vincent Chi Chung, CHENG
Consultant Microbiologist
Queen Mary Hospital and
Infection Control Officer
Hong Kong West Cluster

Dr. James Chung Man, HO
Specialist in Respiratory Medicine
Clinical Associate Professor
Department of Medicine
The University of Hong Kong

Professor Margaret, IP
Professor
Department of Microbiology
Chinese University of Hong Kong

Dr. Wai Man, LAI
Chief of Service
Department of Microbiology
Prince of Wales Hospital

Dr. Edman Tin Keung, LAM
Senior Medical and Health Officer
Infection Control Branch
Centre for Health Protection
Department of Health

Ms. Anna, LEE
Chief Pharmacist
Hospital Authority
Dr. Chi Chiu, LEUNG  
Representative  
Hong Kong Medical Association

Dr. Albert Chau Hung, LIT  
Chief of Service  
Accident and Emergency Department  
Princess Margaret Hospital and  
North Lantau Hospital

Dr. Janice Yee Chi, LO  
Head  
Public Health Laboratory Services Branch  
Centre for Health Protection  
Department of Health

Dr. Wei Kwang, LUK  
Senior Medical Officer  
Department of Clinical Pathology  
Tseung Kwan O Hospital

Dr. Chi Wai, MAN  
Representative  
Coordinating Committee in Surgery  
Chief of Service  
Department of Surgery  
Tuen Mun Hospital and Pok Oi Hospital

Dr. Ka Ho, NG  
Representative  
Coordinating Committee in  
Orthopaedics and Traumatology  
Consultant  
Department of Orthopaedics and  
Traumatology  
Queen Mary Hospital

Dr. Tak Lun, QUE  
Consultant Microbiologist  
Department of Clinical Pathology  
Tuen Mun Hospital

Dr. Wing Kin, TO  
Consultant Microbiologist  
Department of Pathology  
Princess Margaret Hospital

Dr. Dominic Ngai Chong, TSANG  
Consultant Microbiologist  
Queen Elizabeth Hospital and  
Chief Infection Control Officer  
Hospital Authority

Dr. Andrew Tin Yau, WONG  
Head  
Infection Control Branch  
Centre for Health Protection  
Department of Health
Ms. Linda, WOO
Assistant Director (Drug)
Drug Office
Department of Health

Dr. Adrian Young Yuen, WU
Specialist in Immunology and Allergy

Dr. Wing Wa, YAN
Chairman
Coordinating Committee in
Intensive Care
Chief of Service
Intensive Care Unit
Pamela Youde Nethersole Eastern Hospital

Professor Kwok Yung, YUEN
Chair of Infectious Diseases
Department of Microbiology
The University of Hong Kong

Dr. Raymond Wai Hung, YUNG
Representative, Hong Kong Private Hospitals Association
Specialist in Clinical Microbiology and Infection
Honorary Consultant,
Hong Kong Sanatorium & Hospital

Secretary

Dr. Ka Man, AU
Senior Medical and Health Officer
Infection Control Branch
Centre for Health Protection
Department of Health
# Contents

List of tables ................................................. 10  
List of figures ............................................... 13  
Foreword ......................................................... 14  
Preface .......................................................... 17  

**Part I**  **Antibiotic resistance - Local scenario**  
1.1 Background: the problem of antimicrobial resistance (AMR) in Hong Kong (HK) ................................................. 20  
1.2 Methicillin-resistant *Staphylococcus aureus* (MRSA) ......................................................... 25  
1.3 Vancomycin-resistant enterococci (VRE) .......................................................... 28  
1.4 ESBL-producing *Enterobacteriaceae* ................................................. 30  
1.5 Carbapenem-resistant *Enterobacteriaceae* (CRE) ......................................................... 32  
1.6 Carbapenem-resistant *Acinetobacter baumannii* (CRAB) ................................................. 36  
1.7 Macrolide Resistant *Mycoplasma pneumoniae* (MRMP) ................................................. 37  

**Part II**  **Antimicrobial stewardship programme**  
2.1 Antimicrobial stewardship programme (ASP) ................................................. 42  
2.2 Tips on safe use of antibiotics in outpatient setting ................................................. 44  

**Part III**  **Guidelines for selected antimicrobial use**  
3.1 Vancomycin ................................................. 48  
3.2 Linezolid ......................................................... 51  
3.3 Daptomycin ......................................................... 52  
3.4 Tigecycline ......................................................... 53
3.5 Colistin/colomycin
3.6 Fosfomycin trometamol
3.7 Carbapenems
3.8 Once daily aminoglycosides
3.9 Ceftaroline
3.10 Antifungal agents

**Part IV**

**Recommendation for the empirical therapy of common infections**

4.1 Guidelines for empirical therapy
Musculoskeletal infections
Skin and soft tissue infections
Central nervous system infections
Intra-abdominal and gastrointestinal system infections (community-acquired)
Cardiovascular infections
Gynaecological infections
Head and neck infections
Urinary tract infections
Respiratory tract infections

4.2 Guidelines on the use and choice of antibiotics in severe acute pancreatitis (SAP)

4.3 Management of community-acquired pneumonia (CAP)

**Part V**

**Guidelines for known-pathogen therapy**

- *Acinetobacter baumannii* 99t
- *Clostridium difficile* 99t
- *Enterobacter cloacae* complex 100t
- *E. coli* (ESBL-neg) 101t
- *Haemophilus influenzae* 101t
- *Klebsiella pneumoniae* (ESBL-neg) 102t
- *E. coli/K. pneumoniae* (ESBL-pos) 102t
- *Pseudomonas aeruginosa* 103t
- Methicillin-sensitive *S. aureus* 103t
- Methicillin-resistant *S. aureus* 104t
- *Mycoplasma pneumoniae* 104t
- *Stenotrophomonas maltophilia* 105t
Streptococcus pneumoniae (for infection outside the central nervous system) 105t
Streptococcus pneumoniae (for central nervous system infection) 106t

Part VI Guidelines for surgical prophylaxis 107
Part VII Cost and recommended dosage of commonly-used antimicrobial agents 117
Part VIII Other issues 128
  8.1 Management of penicillin allergy 129
  8.2 Tips on laboratory diagnostic tests 137
  8.3 Tuberculosis (TB) 141

Abbreviations 144
References 146
Index 186
# List of tables

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 1.1</td>
<td>Top eight organisms isolated from different clinical specimens in 2016. Data from a regional hospital in HK</td>
<td>21</td>
</tr>
<tr>
<td>Table 1.2</td>
<td>Intrinsic and associated resistance to antimicrobial agents among five nosocomial pathogens</td>
<td>22</td>
</tr>
<tr>
<td>Table 1.3</td>
<td>Resistance of common bacterial isolates from all specimens in four regional hospitals (Kowloon, Hong Kong Island and the New Territories) in 2015</td>
<td>23</td>
</tr>
<tr>
<td>Table 1.4</td>
<td>Estimates of microorganisms significantly associated with AMR, HK, 2013–2016</td>
<td>24</td>
</tr>
<tr>
<td>Table 1.5</td>
<td>Interpretation of vancomycin susceptibility for staphylococci</td>
<td>26</td>
</tr>
<tr>
<td>Table 1.6</td>
<td>Characteristics of vancomycin-resistant <em>E. faecium</em> CC17</td>
<td>29</td>
</tr>
<tr>
<td>Table 1.7</td>
<td>Characteristics of ESBL and AmpC ß-lactamases</td>
<td>32</td>
</tr>
<tr>
<td>Table 1.8</td>
<td>Different classes of carbapenemase</td>
<td>35</td>
</tr>
<tr>
<td>Table 2.1</td>
<td>Methods to implement ASP in hospital setting</td>
<td>43</td>
</tr>
<tr>
<td>Table 2.2</td>
<td>Core elements of outpatient ASP</td>
<td>46</td>
</tr>
<tr>
<td>Table 3.1</td>
<td>Dosage table for vancomycin using creatinine clearance</td>
<td>50</td>
</tr>
<tr>
<td>Table 3.2</td>
<td>Mechanisms of antifungal action</td>
<td>60</td>
</tr>
<tr>
<td>Table 3.3</td>
<td>General patterns of antifungal susceptibility</td>
<td>61</td>
</tr>
<tr>
<td>Table 3.4</td>
<td>Comparison of selected pharmacokinetic parameters for the azoles and caspofungin</td>
<td>62</td>
</tr>
<tr>
<td>Table 3.5</td>
<td>A suggested scheme for systemic antifungal agents</td>
<td>64</td>
</tr>
<tr>
<td>Table 3.6</td>
<td>Selected clinical trials conducted on licensed antifungals</td>
<td>65</td>
</tr>
</tbody>
</table>
Table 4.1 Guidelines for empirical therapy

Table 4.2 Severity grading of acute pancreatitis according to revised Atlanta criteria (2012)

Table 4.3 Interpretation of penicillin susceptibility for S. pneumoniae

Table 4.4 Comparative activities of commonly used β-lactams against S. pneumoniae with different levels of penicillin susceptibility

Table 5.1 Guidelines for known-pathogen therapy

Table 6.1 Suggested initial dose and time to re-dose for selected antimicrobial agents used for surgical prophylaxis

Table 6.2 Antimicrobial prophylaxis in clean operations

Table 6.3 Antimicrobial prophylaxis in clean-contaminated operations

Table 6.4 Antimicrobial prophylaxis in contaminated-infected operations

Table 7.1 Preparation and recommended dosing regimens for antibiotics

Table 7.2 Cost comparison of selected I.V. and P.O. antibiotics

Table 7.3 Cost comparison of systemic antifungal agents

Table 7.4 Dosage of antimicrobial agents for central nervous system infections

Table 7.5 Intra-peritoneal antibiotic dosing recommendations for patients with continuous ambulatory peritoneal dialysis peritonitis

Table 8.1 Oral β-lactam desensitisation protocol

Table 8.2 Cross-reacting side chains between β-lactam antibiotics

Table 8.3 Risk of cross-reactivity between different β-lactams
| Table 8.4 | Key points in the use of UAT | 138 |
| Table 8.5 | TTP of blood culture of different organisms | 139 |
| Table 8.6 | Diagnosing CABS by differential time to positivity | 140 |
List of figures

Figure 1.1 Number of CA-MRSA reported to the CHP from 2007–2016. 28
Figure 1.2 Burden for ESBL-producing E. coli bacteraemia in a regional hospital in HK. 31
Figure 1.3 Number of carbapenemase-producing Enterobacteriaceae confirmed at the Public Health Laboratory Services Branch, CHP, 2009 to 2016. 34
Figure 1.4 Changes in the multidrug-resistant rate of Acinetobacter baumannii according to three different definitions, 1997–2008 39
Figure 1.5 Prevalence of Mycoplasma pneumoniae in respiratory specimens according to patient age groups, all HA hospitals, 2015–2016. 40
Figure 2.1 Cue card for patient education 45
Figure 3.1 Distribution by species for 595 episodes of fungaemia in HA, 2015–2016 67
Figure 4.1 Management of pancreatic necrosis when infection is suspected 91
Figure 4.2 Susceptibility of 775 invasive pneumococcal isolates to penicillin and cefotaxime according to patient age groups, 2012–2016, HK 96
Figure 8.1 Flow chart on assessment of β-lactam allergy 135
Figure 8.2 β-lactam skin testing 136
Foreword

I am most delighted to write the foreword for the fifth edition of the IMPACT guideline.

I wish to express my appreciation to the Chairman of the IMPACT Editorial Board, Professor HO Pak-Leung (PL) for his decades-long commitment and contribution to science in antimicrobial resistance, and for his invaluable advice to improving our public health policy on infectious diseases. PL is a clinician scientist with a strong passion on containment of antimicrobial resistance. I still remember vividly our many discussions on policy issues related to multidrug-resistant bacteria – notification, public disclosure, and investment in public health intervention and vaccinations. The IMPACT guideline is an initiative he pioneered in 1999. It was initially launched in one hospital but has since then extended to become territory-wide. I also thank the many people and organizations that have contributed to the continuous improvement of this project including its dissemination in App and eBook platforms.

Antimicrobial resistance is a worldwide problem with serious health and economic consequences. At the Sixty-eighth World Health Assembly in May 2015, the Global Action Plan on Antimicrobial Resistance was adopted. In 2016, the Chief Executive in his policy address has announced the setting up of High Level Steering Committee and Expert Committee on antimicrobial resistance and the Hong Kong Strategy and Action Plan on Antimicrobial Resistance was subsequently launched in 2017. As set out in the Hong Kong Action Plan, one of the six key areas is to optimise the use of antimicrobial agents. The launch of the fifth edition of IMPACT is most timely. With the focus on local epidemiology and insights from experts in the editorial board, I am confident that the fifth edition of IMPACT will continue to be an important reference for empowering our medical practitioners in meeting this objective.

Dr. Ko Wing-man, BBS, JP
Secretary for Food and Health
The Government of the Hong Kong Special Administrative Region
June 2017
Foreword

It gives me great pleasure to congratulate the Interhospital Multi-disciplinary Programme on Antimicrobial ChemoTherapy (IMPACT) Editorial Board for its publication of the fifth edition of IMPACT. Antimicrobial resistance (AMR) is a global threat that has received greater international attention in recent years. Locally, formidable challenge of AMR is obvious given the increasing infections caused by multi-drug resistant organisms, which often result in major morbidity and even mortality. The IMPACT first released in 1999 is a pioneer on this front, and it is most timely to have a new edition.

In this fifth edition, with updated local and overseas information, the IMPACT continues to focus on promoting the use of the right antimicrobials in the right way for hospital infections. There are coverage on antibiotic-resistant organisms, various antimicrobials, as well as specific clinical conditions and settings. A part on tuberculosis has been added to address the rising concern on drug resistance. I am sure local readers and beyond will find the IMPACT a comprehensive and useful reference.

I would like to take the opportunity to thank all people who have contributed to this new IMPACT, in particular the Editors and Members of the Editorial Board. A few colleagues of the Centre for Health Protection (CHP) are honoured to serve the Board. Furthermore, the CHP’s Infection Control Branch provides secretariat and technical support to the production of IMPACT, including a new website this time. Optimising the use of antimicrobials is crucial not just for individual health but also public health. The CHP is committed to protect health of the community through continual work in partnership.

Dr. WONG Ka Hing
Controller
Centre for Health Protection
Department of Health
June 2017
Foreword

It is a great honor for me to write a brief foreword to the fifth edition of Interhospital Multi-disciplinary Programme on Antimicrobial ChemoTherapy (IMPACT). Antimicrobial resistance (AMR) is a major global public health crisis. Inappropriate use of antimicrobials as well as frequent use of broad-spectrum ones accelerates the emergence of newer resistant strains of microorganisms. Antibiotic stewardship programme (ASP) across the healthcare systems could decrease the prevalence of AMR. Evidence-based clinical guidelines is an essential component of ASP to ensure that patients receive the right antibiotic, at right dose, at the right time, and for the right duration that leads to the best clinical outcome for the treatment or prevention of infection while producing the fewest possible side effects and the low risk for subsequent resistance. IMPACT definitely served this purpose as an invaluable reference tool for medical and health professionals to achieve rational use of antimicrobials.

AMR leads to prolonged illness and hospital stays, the use of more aggressive treatment, increased deaths, loss of productivity, and increased healthcare and social costs. Smart and rational use of antimicrobials is very important to contain AMR. Concerted effort from all stakeholders in the community is the key to success. The Hospital Authority (HA) works in partnership with the government to contain AMR under the “one health” framework. HA had established ASP since 2005 to optimize antimicrobials usage in public hospitals. With the launching of Hong Kong Strategy and Action Plan on Antimicrobial Resistance early this year, efforts from inter-departmental and various sectors of the society could join hands together to fight against this AMR battle.

The IMPACT Editorial Board, comprising members of academics and professionals of high standing from all major medical disciplines especially in the field of antimicrobial use, offered invaluable expert advice to the new revision. I would like to express my heartfelt thanks and congratulations to the successful launching of the fifth edition of IMPACT. Their great contribution has safeguarded the health of Hong Kong citizens.

Dr. P Y Leung
Chief Executive
Hospital Authority
June 2017
Preface

Antimicrobial agents are unique in that their activities vary inversely with time. Today, the efficacy of antimicrobial agents is seriously threatened by an alarming increase in microbial resistance. In 2016, the United Nations General Assembly adopted a political declaration giving full attention to antimicrobial resistance, following a call for global action by the World Health Organization. In Hong Kong, owing to the high population density and lack of hospital space for implementation of infection control measures, it has long been recognized that rates of antibiotic resistance among bacteria are higher than in many other regions. It is for this reason that our medical profession has taken many actions and strategies ahead of time. A web-based platform has been established by the Hospital Authority for surveillance of multidrug-resistant bacteria and audit of big gun antibiotic usage. MRSA infection has been made a key performance indicator for the organization. There is a pledge that the first dose of life-saving antibiotic should be administered within one hour of the patient’s arrival. Protocols for hospital admission screening of carbapenemase-producing Enterobacteriaceae (CPE), vancomycin-resistant enterococcus (VRE) and methicillin-resistant Staphylococcus aureus (MRSA) are now widely implemented in both public and private hospitals. Among the frontline doctors, there is now a broad consensus that proper use of antibiotics should be given high priority and that unfounded patient requests for antibiotics should be resisted.

IMPACT is a coordinated and multifaceted effort that aims to support prudent use of antimicrobial agents. The content has been extensively reviewed and recommendations carefully considered after a review of the evidence base. The focus is on clinical situations in which the local epidemiology is unique; highlighting the antimicrobial agents with a strong link to development of multidrug-resistant organisms or situations where dosing is complicated. Where appropriate, comments are provided to indicate the situations where the advice of a specialist should be sought. This edition of IMPACT involved and is supported by the Hospital Authority, Centre for Health Protection, University of Hong Kong, Chinese University of Hong Kong, Hong Kong Medical Association, and Hong Kong Private Hospital Association. The publication is freely available at the homepages of the partner organizations and made accessible as an app (Android and iOS) and website for mobile PC and phones. Features that are only available in the app version include medical calculators and up-to-date antibiograms from the Hospital Authority, private hospitals and Department of Health.
I am grateful to the members of the Editorial Board for their contributions. We thank the Centre for Health Protection for providing secretarial support and resources for printing and production of the app and website; as well as the Hospital Authority for granting access to the data and figures.

PL Ho, JP
Chairman, IMPACT Editorial Board
August 2017
Part I: Antibiotic resistance  - Local scenario
1.1 Background: the problem of antimicrobial resistance (AMR) in Hong Kong (HK)

1. The emergence of AMR has threatened the successful treatment of patient with infections (1–5).

2. AMR increases drug costs and length of hospital stay, and adversely affects patient’s outcome (6).

3. Resistance to all classes of antibiotics has developed to various extents among common and important nosocomial pathogens (Tables 1.1–1.3).

4. In HK, methicillin-resistant *Staphylococcus aureus* (MRSA) and extended-spectrum β-lactamase (ESBL)-producing *E. coli* are the two most important multidrug-resistant organisms (Table 1.4). Increase in the annual number of vancomycin-resistant *Enterococcus faecium* (VREfm) in 2013 and 2014 was attributed to a major interhospital outbreak which was eventually controlled. Carbapenem-resistant *Acinetobacter* and carbapenemase-producing *Enterobacteriaceae* (CPE) are on the rise (Figure 1.3).

5. Factors contributing to the rapid rising and high prevalence of AMR in HK (7):
   - **Hospital**: overcrowding, manpower shortage, lapse in infection control measures, inappropriate use of antibiotics, environmental contamination, lack of transparency of surveillance data and lack of incentive in healthcare setting at administrative level.
   - **Community**: antimicrobial misuse including in animal husbandry, lack of awareness, and inadequate food and personal hygiene.
### Table 1.1 Top eight organisms isolated from different clinical specimens in 2016. Data from a regional hospital in HK

<table>
<thead>
<tr>
<th>Blood</th>
<th>Respiratory specimens</th>
<th>Urine</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organism</strong></td>
<td><strong>Non-ICU/HDU rank</strong></td>
<td><strong>ICU/HDU rank</strong></td>
</tr>
<tr>
<td><em>E. coli</em></td>
<td>1 (31%)</td>
<td>2 (9%)</td>
</tr>
<tr>
<td>Klebsiella spp.</td>
<td>2 (12%)</td>
<td>6 (6%)</td>
</tr>
<tr>
<td>CoNS¹</td>
<td>3 (9%)</td>
<td>1 (28%)</td>
</tr>
<tr>
<td><em>S. aureus</em></td>
<td>4 (7%)</td>
<td>4 (8%)</td>
</tr>
<tr>
<td>Enterococcus spp.</td>
<td>5 (4%)</td>
<td>3 (8%)</td>
</tr>
<tr>
<td><em>P. aeruginosa</em></td>
<td>6 (2%)</td>
<td>7 (4%)</td>
</tr>
<tr>
<td>Bacillus spp.¹</td>
<td>7 (2%)</td>
<td>-</td>
</tr>
<tr>
<td><em>P. mirabilis</em></td>
<td>8 (2%)</td>
<td>-</td>
</tr>
</tbody>
</table>

Note:
1 Some of these could be contaminants
CoNS, coagulase-negative staphylococci; ICU, intensive care unit; HDU, high dependency unit
## Table 1.2 Intrinsic and associated resistance to antimicrobial agents among five nosocomial pathogens

<table>
<thead>
<tr>
<th>Bacteria</th>
<th>Intrinsic resistance</th>
<th>Associated resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRSA</td>
<td>All ß-lactams¹, ß-lactam/ß-lactamase inhibitor combinations</td>
<td>Common: erythromycin, clindamycin, aminoglycosides, cotrimoxazole, fluoroquinolones</td>
</tr>
<tr>
<td>VREfm</td>
<td>Glycopeptides, cotrimoxazole, clindamycin, aminoglycosides</td>
<td>Common: ampicillin, carbapenems, fluoroquinolones, high level aminoglycoside resistance</td>
</tr>
<tr>
<td>ESBL-producing Enterobacteriaceae (CTX-M, SHV-, TEM-derived)</td>
<td>All cephalosporins including third generation cephalosporins, (variable activity against fourth-generation cephalosporins), all penicillins and monobactams</td>
<td>Common: fluoroquinolones, aminoglycosides, cotrimoxazole</td>
</tr>
<tr>
<td>Carbapenem-resistant Enterobacteriaceae (CRE)</td>
<td>All ß-lactams including carbapenem (except monobactam)</td>
<td>Common: fluoroquinolones, aminoglycosides, cotrimoxazole</td>
</tr>
<tr>
<td>Carbapenem-resistant A. baumannii (CRAB)</td>
<td>Cross-resistance to other ß-lactams are common</td>
<td>Common: fluoroquinolones, aminoglycosides, cotrimoxazole</td>
</tr>
</tbody>
</table>

**Note:**

¹ Except anti-MRSA cephalosporins such as ceftaroline
### Table 1.3 Resistance of common bacterial isolates from all specimens in four regional hospitals (Kowloon, Hong Kong Island and the New Territories) in 2015

<table>
<thead>
<tr>
<th>Organisms (No. of isolates)</th>
<th>Ampicillin</th>
<th>Ampicillin + sulbactam</th>
<th>Amoxicillin + clavulanate</th>
<th>Piperacillin</th>
<th>Ticarcillin + clavulanate</th>
<th>Piperacillin + tazobactam</th>
<th>Cefoperazone + sulbactam</th>
<th>Cefuroxime (parenteral)</th>
<th>Ceftriaxone</th>
<th>Cefotaxime</th>
<th>Cefepime</th>
<th>Gentamicin</th>
<th>Amikacin</th>
<th>Ciprofloxacin</th>
<th>Cotrimoxazole</th>
<th>Imipenem</th>
<th>Nitrofurantoin</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Escherichia coli (26,943)</strong></td>
<td>76</td>
<td>26</td>
<td>5</td>
<td>4.9</td>
<td>33</td>
<td>36</td>
<td>20</td>
<td>19</td>
<td>30</td>
<td>2</td>
<td>40</td>
<td>50</td>
<td>&lt;1</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Klebsiella spp. (8,958)</strong></td>
<td>100</td>
<td>27</td>
<td>29</td>
<td>8</td>
<td>6</td>
<td>27</td>
<td>20</td>
<td>18</td>
<td>10</td>
<td>8</td>
<td>1</td>
<td>15</td>
<td>29</td>
<td>&lt;1</td>
<td>45</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Enterobacter spp. (2,094)</strong></td>
<td>95</td>
<td>96</td>
<td>34</td>
<td>22</td>
<td>13</td>
<td>40</td>
<td>24</td>
<td>5</td>
<td>3</td>
<td>&lt;1</td>
<td>5</td>
<td>11</td>
<td>2</td>
<td>27</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Acinetobacter spp. (2,461)</strong></td>
<td>50</td>
<td>56</td>
<td>56</td>
<td>48</td>
<td>34</td>
<td>53</td>
<td>31</td>
<td>26</td>
<td>56</td>
<td>30</td>
<td>55</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pseudomonas aeruginosa (8,151)</strong></td>
<td>9</td>
<td>43</td>
<td>4</td>
<td>11</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>&lt;1</td>
<td>10</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Stenotrophomonas maltophilia (1,088)</strong></td>
<td>40</td>
<td>44</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note:
The results were interpreted according to the Clinical Laboratory Standards Institute (CLSI), M100–S20. Most ceftriaxone-non-susceptible isolates were ESBL-producers.
### Table 1.4 Estimates of microorganisms significantly associated with AMR, HK, 2013–2016

<table>
<thead>
<tr>
<th>Antibiotic-resistant microorganism</th>
<th>Included in estimates</th>
<th>Number of cases by year&lt;sup&gt;4&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRSA</td>
<td>Blood only</td>
<td>2013</td>
</tr>
<tr>
<td>ESBL-producing <em>E. coli</em></td>
<td>Blood only</td>
<td>1,319</td>
</tr>
<tr>
<td>ESBL-producing <em>Klebsiella</em> spp.</td>
<td>Blood only</td>
<td>186</td>
</tr>
<tr>
<td>Carbapenem-resistant <em>Acinetobacter</em></td>
<td>Blood only</td>
<td>93</td>
</tr>
<tr>
<td>MRSA</td>
<td>All clinical specimens</td>
<td>12,462</td>
</tr>
<tr>
<td>ESBL-producing <em>E. coli</em></td>
<td>All clinical specimens</td>
<td>10,778</td>
</tr>
<tr>
<td>ESBL-producing <em>Klebsiella</em> spp.</td>
<td>All clinical specimens</td>
<td>2,502</td>
</tr>
<tr>
<td>Carbapenem-resistant <em>Acinetobacter</em> spp.</td>
<td>All clinical specimens</td>
<td>2,684</td>
</tr>
<tr>
<td>Multidrug-resistant <em>Acinetobacter</em> spp.&lt;sup&gt;1&lt;/sup&gt;</td>
<td>All clinical specimens</td>
<td>1,161</td>
</tr>
<tr>
<td>Ceftazidime-resistant <em>Pseudomonas aeruginosa</em></td>
<td>All clinical specimens</td>
<td>850</td>
</tr>
<tr>
<td>Vancomycin-resistant <em>Enterococcus</em> spp.&lt;sup&gt;2&lt;/sup&gt;</td>
<td>All clinical specimens</td>
<td>1,810</td>
</tr>
<tr>
<td>Erythromycin-resistant <em>Streptococcus pyogenes</em>&lt;sup&gt;3&lt;/sup&gt;</td>
<td>All clinical specimens</td>
<td>556</td>
</tr>
<tr>
<td>Multidrug-resistant <em>Pseudomonas aeruginosa</em>&lt;sup&gt;1&lt;/sup&gt;</td>
<td>All clinical specimens</td>
<td>18</td>
</tr>
<tr>
<td><em>Clostridium difficile</em></td>
<td>Stool only</td>
<td>2,077</td>
</tr>
</tbody>
</table>

**Note:**

1. Per surveillance definitions used by the Hospital Authority (HA).
2. Mostly vancomycin-resistant *Enterococcus faecium*.
3. Erythromycin-resistant strains are also resistant to other macrolides such as clarithromycin and azithromycin.
4. Annual number of cases was estimated by using microbiological results collected from all HA laboratories. Each patient was only counted once in the estimation.
1.2 Methicillin-resistant *Staphylococcus aureus* (MRSA)

Due to the alteration of penicillin binding protein, MRSA are resistant to penicillins (including oxacillin, cloxacinil and flucloxacillin), β-lactam/β-lactamase inhibitor combinations, cephalosporins, and carbapenems. Only the new anti-MRSA β-lactams (e.g. ceftaroline) retain activity against MRSA. However, in vitro and in vivo reduced susceptibility to ceftaroline has recently been reported (8–9).

MRSA has been categorised into healthcare-associated (HA-MRSA) and community-associated (CA-MRSA). The Centers for Disease Control and Prevention (CDC) classification, which is the most widely accepted, classified HA-MRSA and CA-MRSA epidemiologically (10). However the border between the two is becoming blurred and surveillance using epidemiological criteria alone has become insufficient.

1.2.1 Healthcare-associated methicillin-resistant *Staphylococcus aureus* (HA-MRSA)

1. For *S. aureus* that are susceptible to methicillin, vancomycin is inferior to anti-staphylococcal β-lactam (11). However, vancomycin remains the treatment of choice for infection caused by MRSA. The efficacy of vancomycin may be limited by inadequate potency of generic drug, suboptimal dosing, poor tissue penetration, slow bactericidal activity and strains with reduced susceptibility to the drug (11–12).

2. In the recent years, a silent and gradual increase in the vancomycin minimal inhibitory concentration (MIC) has been observed. This phenomenon is known as ‘vancomycin creep’ (13–14). Since the increment is small and the MIC still falls within the ‘sensitive’ range, it usually goes unnoticed. This phenomenon has also been observed in HK (15). In HK, there has been a gradual increase in the number of strains with vancomycin MIC = 1 μg/mL from 1997 to 2008. The elevated MIC paralleled an increase in consumption of vancomycin (15).

3. The vancomycin creep has been observed in some, but not all hospitals. This is probably due to difference in the susceptibility testing methods, clonal dissemination of more resistant strains and the intensity of vancomycin usage (15).

4. Unfortunately, there is no international consensus on the appropriate breakpoint for interpretation of vancomycin MIC results for staphylococci (Table 1.5). Vancomycin MIC ≥ 2 μg/mL has been associated with vancomycin treatment failure (16–18). Therefore, guidelines have recommended isolates with vancomycin MIC ≥ 2 μg/mL be treated with an alternative antibiotic instead of vancomycin (11).
Table 1.5 Interpretation of vancomycin susceptibility for staphylococci

<table>
<thead>
<tr>
<th></th>
<th>Vancomycin MIC (µg/mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Susceptible</td>
</tr>
<tr>
<td><strong>Staphylococcus aureus</strong></td>
<td></td>
</tr>
<tr>
<td>EUCAST 2017</td>
<td>≤2</td>
</tr>
<tr>
<td>CLSI 2017</td>
<td>≤2</td>
</tr>
<tr>
<td><strong>Coagulase-negative staphylococci</strong></td>
<td></td>
</tr>
<tr>
<td>EUCAST 2017</td>
<td>≤4</td>
</tr>
<tr>
<td>CLSI 2017</td>
<td>≤4</td>
</tr>
</tbody>
</table>

CLSI, Clinical Laboratory Standards Institute; EUCAST, European Committee on Antimicrobial Susceptibility Testing

5. The susceptibility profile cannot be used as a differentiating feature of HA-MRSA and CA-MRSA. In a recent local report, it demonstrated an increase in prevalence of multi-susceptible MRSA (MS-MRSA) over the past few years in the hospital setting. The increase in multi-susceptible strains actually represents a rise in HA-MRSA, which was associated with the spread of the clone ST45/t1081 possessing SCCmec type IV or V. About 75% of these isolates were recovered from elderly living in residential care homes. This suggests that these strains may be more transmissible among the elderly in residential care home and convalescent care settings, serving as a reservoir (19).

6. In 2011, a local study on MRSA carriage at admission to 15 acute medical units showed that the overall carriage rate was 14.3%. Risk factors include MRSA history within the past 12 months, old age home residence, bed-bound state. Molecular typing revealed that ST45/t1081 is a major clone circulating among the patients (20).
1.2.2 Community-associated methicillin-resistant *Staphylococcus aureus* (CA-MRSA)

1. CA-MRSA was first reported in HK in 2001, and is rapidly emerging over the past 10 years (21–22). Reporting to the Department of Health (DH) has been made mandatory since January 2007. It is responsible for 10.4% of purulent cellulitis and 5% of cutaneous abscess in the Accident & Emergency setting (23).

2. In 2007, a total of 173 cases of CA-MRSA infection were notified to the Centre for Health Protection (CHP). The number increased by more than 6 times to 1,148 in 2016. Among the reported cases, about two-thirds of the cases required hospitalisation, while the remaining cases were managed in outpatient settings. The absolute increase in the total number of cases reflects the increasing burden of CA-MRSA in HK (24–25).

3. A total of 3,650 cases of CA-MRSA were recorded between January 2012 and October 2015. Majority of the CA-MRSA presented with uncomplicated skin and soft tissue infections (98%) and 74% of these cases required surgical management. Fifty-three (2%) of the cases presented with invasive CA-MRSA infections, where 14 cases were admitted to the ICU for treatment. Four (0.1%) cases died from sepsis (n=2), pneumonia (n=1) and necrotising fasciitis (n=1) (24).

4. Patients infected with CA-MRSA do not have the usual risk factors associated with HA-MRSA. Locally, case control studies revealed that ethnic minority and sharing of personal items with other persons were risk factors for CA-MRSA while frequent hand washing was protective against CA-MRSA infection (21,26).

5. Panton-Valentine leukocidin (PVL) toxin is a pore forming cytotoxin that is capable of destroying human monocytes and neutrophils. PVL toxin has been associated with virulence and transmissibility of CA-MRSA. While presence of PVL toxin in MRSA is used as a criterion for reporting of CA-MRSA in HK, it has been showed that some of the CA-MRSA causing skin and soft tissue infection were PVL negative (21).

6. Other than skin and soft tissue infections, PVL toxin is also associated with necrotising pneumonia, necrotising fasciitis and meningitis. CA-MRSA has also been reported to co-infect with influenza resulting in fulminant pneumonia (27–29).
1.3 Vancomycin-resistant enterococci (VRE)

1. VRE were first reported in Europe in 1986. Since then, this resistant organism has spread throughout the world and has become a major nosocomial pathogen. Currently, Enterococcus faecium is the most important vancomycin-resistant species. In the United States and some European countries, VREfm has disseminated widely in the hospitals and old age homes (30).

2. In HK, the first case of VREfm was identified in 1997 in a patient returning from the United States. During 1997–2008, the occurrence of VRE was sporadic which on several occasions have led to small clusters (<5 to 10 cases) of nosocomial transmission. There had been no continued transmission in our healthcare system. In the mid-2000s, two ad hoc studies demonstrated that VRE was carried by <0.1% of patients in high risk areas (31–32).

3. In our public hospitals, a protracted outbreak of VREfm occurred since 2011. With the implementation of directly observed patient hand hygiene and other infection control measures, the outbreak was finally contained in 2015. In this outbreak, a total of 4,060 VREfm new cases were reported in local public hospitals from 2011–2015 (33).
4. Vancomycin resistance in enterococci is plasmid-mediated. The \textit{vanA} gene is encoded in a transposon Tn\textit{1546} and \textit{vanB} encoded in Tn\textit{1547}. The transposons are mobile and able to disseminate the resistant gene to other more virulent organisms, e.g. \textit{Staphylococcus aureus}. Therefore, despite the low pathogenicity of VRE, they can act as a reservoir of mobile resistance gene (34).

5. Hospital outbreaks caused by VRE have been increasingly reported worldwide. Molecular epidemiology study by multilocus sequence typing revealed that this rise is attributed to the spread of a genetic lineage of \textit{Enterococcus faecium} clonal complex 17 (CC17), Table 1.6 (34–35). CC17 is currently the predominant clone seen in hospital outbreaks worldwide (36–40). The protracted outbreak of VREfm in HK’s public hospitals from 2011–2015 also involved strains that belonged to CC17 (33).

6. Most of the \textit{E. faecium} CC17 isolates remained susceptible to linezolid. However in a Germany survey, selection of linezolid-resistance in epidemic-virulent CC17 strains occurred during linezolid therapy (36). It is due to the accumulation of mutations in position 2,576 of the 23S rRNA gene for at least one of the gene copies, necessary for acquisition of phenotypic linezolid resistance in \textit{E. faecium}.

7. Molecular epidemiological study has shown that CC17 has been circulating in hospitals in the United States since early 1980s (34).

\textbf{Table 1.6 Characteristics of vancomycin-resistant \textit{E. faecium} CC17}

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Multidrug-resistant, including resistance to:</td>
</tr>
<tr>
<td>a.</td>
<td>Ampicillin</td>
</tr>
<tr>
<td>b.</td>
<td>Fluoroquinolones</td>
</tr>
<tr>
<td>2.</td>
<td>Contains a putative pathogenicity island and the \textit{esp} gene which encodes for a protein involved in colonisation and biofilm formation</td>
</tr>
<tr>
<td>3.</td>
<td>An association with hospital outbreaks</td>
</tr>
</tbody>
</table>
1.4 ESBL-producing Enterobacteriaceae

1. ESBLs are enzymes capable of hydrolysing penicillin, first-, second- and third-generation (extended-spectrum) cephalosporins and aztreonam (except the cephemycins and carbapenems). Most ESBLs can be inhibited by ß-lactamase inhibitors such as clavulanic acid and tazobactam (41) (Table 1.7). TEM, SHV and CTX-M are the three most common families of ESBLs seen worldwide.

2. In HK (Figure 1.2), >90% of strains with an ESBL phenotype produced CTX-M type enzymes (42–43). There is a high rate of resistance towards non-ß-lactam antibiotics, particularly fluoroquinolones, cotrimoxazole and aminoglycosides (42–43). The high rate of resistance to non-ß-lactam antibiotics therefore limits the choice for management of patients in outpatient setting.

3. ESBL-producing Enterobacteriaceae has been considered to be a hospital pathogen in the past. However, community-onset infection has been described in different countries including HK in the recent years. Most of the patients presented with lower urinary tract infection, other presentations includes bacteraemia and intra-abdominal infection (44–47).

4. Rectal colonisation with ESBL-producing Enterobacteriaceae has been increasingly seen in healthy individuals (48), and this has been postulated to be a risk factor for community-onset ESBL-producing Enterobacteriaceae infection. Food animals are a major reservoir of ESBL-producing E. coli (49–50).

5. In HK, the burden of ESBL is highest among the elderly population, especially those aged 75 years and above (51).

6. For two decades, ESBL-producing Enterobacteriaceae were considered to be clinically resistant to all cephalosporins. Accordingly, all laboratories are advised to edit the results for ceftazidime, ceftriaxone and cefepime to resistant, irrespective of the in vitro inhibition zone diameters or MIC values.

7. Recently, the laboratory testing advisory bodies in the United States and Europe have revised their advice and argued that with the lowered cephalosporin breakpoints that both organisations now adopted, it is unnecessary to edit susceptibility categories if an ESBL is found (52–53). A group of international experts in this field considered such advice is misguided (54). Therefore it is prudent to continue to test for the presence of ESBLs directly and to avoid cephalosporins as treatment.
8. In HK, if we apply the new ceftazidime breakpoint, three-quarters of the ESBL-producing isolates would be re-classified from resistant to susceptible to ceftazidime (55). Caution with this approach is necessary whilst clinical data are limited (54).

Figure 1.2 Burden for ESBL-producing *E. coli* bacteraemia in a regional hospital in HK. Incidence density, number of episodes per 100,000 patient days was used as an indicator (51). R square for fitted line = 0.89 (p<0.001)
### Table 1.7 Characteristics of ESBL and AmpC β-lactamases

<table>
<thead>
<tr>
<th></th>
<th>ESBL</th>
<th>AmpC β-lactamase</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bush-Jacoby-Medeiro functional class</strong></td>
<td>2be</td>
<td>1</td>
</tr>
<tr>
<td><strong>Ambler molecular classification</strong></td>
<td>A</td>
<td>C</td>
</tr>
<tr>
<td><strong>Plasmid mediated</strong></td>
<td>Almost always (responsible for the spread)</td>
<td>Most are chromosomal Plasmid increasingly reported</td>
</tr>
<tr>
<td><strong>β-lactamase inhibitor</strong></td>
<td>Inhibited</td>
<td>Not inhibited</td>
</tr>
<tr>
<td>Cephemycins</td>
<td>Not hydrolysed</td>
<td>Hydrolysed</td>
</tr>
<tr>
<td>- cefoxitin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- cefmetazole</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oxyimino-β-lactams</td>
<td>Hydrolysed</td>
<td>Hydrolysed</td>
</tr>
<tr>
<td>- cefotaxime</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- ceftriaxone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- ceftazidime</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cefepime</td>
<td>Variable</td>
<td>Not hydrolysed</td>
</tr>
<tr>
<td>Carbapenem</td>
<td>Not hydrolysed</td>
<td>Not hydrolysed</td>
</tr>
<tr>
<td><strong>Examples</strong></td>
<td>TEM, SHV and CTX-M</td>
<td>Enterobacter, Citrobacter and Serratia possess inducible AmpC β-lactamase encoded in their chromosomes</td>
</tr>
</tbody>
</table>

#### 1.5 Carbapenem-resistant Enterobacteriaceae (CRE)

*Enterobacteriaceae* can acquire resistance to carbapenem through production of carbapenemase (Table 1.8), modification of outer membrane permeability and efflux pump (56).

1. Carbapenemase, KPC-producing *Klebsiella pneumoniae* was first discovered from a clinical isolate through the Intensive Care Antimicrobial Resistance Epidemiology (ICARE) surveillance in North Carolina in 1996 (57–58) and followed by a substantial spread in New York (59), Israel (60) and Greece (61). *Enterobacteriaceae* producing KPC has also been described in South America (Colombia, Brazil and Argentina) (62–64) and China (65–66). Other than *K. pneumoniae*, the KPC-enzyme has also been described in many other *Enterobacteriaceae* species (58). Infection caused by carbapenem-resistant organisms increases the risk of complications and mortality (67).
2. New Delhi metallo-ß-lactamase 1 (NDM-1) was first described in 2009 in a Swedish patient of Indian origin. He was hospitalised in India and acquired urinary tract infection caused by a carbapenem-resistant *K. pneumoniae* (68). Like other metallo-ß-lactamases, the enzyme NDM-1 can hydrolyse all ß-lactams except aztreonam. Resistance to aztreonam is usually due to the coexisting ESBL or AmpC ß–lactamase. Majority of the NDM-1 producing organisms harbour other resistance mechanisms, rendering them resistant to almost all classes of antibiotics with the possible exception of colistin (69–70).

3. NDM-1 producing *Enterobacteriaceae* has spread across Europe. In a recent survey conducted in 29 European countries, cases were reported in 13 countries (69). Majority of the cases had a history of travel to the Indian subcontinent. Many countries have developed their own national guidelines to deal with the problem of NDM-1 (69).

4. The first NDM-1 producing *E. coli* in HK was isolated in October 2009 from a patient with urinary tract infection with travel history to India (71). Several cases of IMP-4 were found in hospitalised patients since mid-2009 in HK (Figure 1.3) (72). The first KPC-2 producing *K. pneumoniae* was described in February 2011 (73).

5. The spread of NDM-1 is probably due to the huge selection pressure created by widespread non-prescription use of antibiotics in India (74) and involvement of promiscuous mobile elements in the gene’s dissemination (75).

6. A local review of the NDM detected from 2009–2014 was performed by the CHP. From 2009–2013, there was a gradual rise of NDM cases detected, ranging from 1 to 19 patients, but there were no local cases of NDM detected during this period. Twelve local cases of NDM was first detected in 2014, where four patients had signs of infection. Majority of the imported NDM cases were from China, followed by India and other South East Asian countries (76).

7. A local study in 2016 investigated the clonality and mechanism of resistance of 92 strains of CRE isolated between 2010 and 2012. Only 10% were genotypic carbapenemase-producing *Enterobacteriaceae* (CPE) confirmed by polymerase chain reaction (PCR). Porin loss combined with AmpC and/or CTX-M type ESBL was the major mechanism of resistance of the CRE isolated (77).

8. Plasmid-mediated colistin resistance by *mcr*-1, a gene that can be transferred horizontally among bacteria has been first described in China in both food animals and human (78). HK has also detected CPE with *mcr*-1 recently (79). The coexistence of *mcr*-1 with carbapenemase (e.g. NDM, KPC) has been described in China (80–82), South America (83), Singapore (84), Germany (85).
Figure 1.3 Number of carbapenemase-producing *Enterobacteriaceae* confirmed at the Public Health Laboratory Services Branch, CHP, 2009 to 2016. A HK wide surveillance was implemented since the last quarter of 2010.
Table 1.8 Different classes of carbapenemase

<table>
<thead>
<tr>
<th></th>
<th>Class A</th>
<th>Metallo-β-lactamase</th>
<th>OXA carbapenemase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Molecular class</td>
<td>Class A</td>
<td>Class B</td>
<td>Class D</td>
</tr>
<tr>
<td>Functional class</td>
<td>2f</td>
<td>3</td>
<td>2d</td>
</tr>
<tr>
<td>Gene location</td>
<td>Usually transposon</td>
<td>Usually plasmid</td>
<td>Usually plasmid</td>
</tr>
<tr>
<td>Examples</td>
<td>KPC&lt;sup&gt;1&lt;/sup&gt;</td>
<td>IMP&lt;sup&gt;1&lt;/sup&gt;</td>
<td>OXA-23, 24, 51, 58</td>
</tr>
<tr>
<td></td>
<td>GES</td>
<td>VIM&lt;sup&gt;1&lt;/sup&gt;</td>
<td>(types in Acinetobacter spp.)&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>SME</td>
<td>NDM&lt;sup&gt;1&lt;/sup&gt;</td>
<td>OXA-48, 181, 232</td>
</tr>
<tr>
<td></td>
<td>IMI/NMC&lt;sup&gt;1&lt;/sup&gt;</td>
<td></td>
<td>(types in Enterobacteriaceae)&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>Found in</td>
<td>Enterobacteriaceae</td>
<td>Non-fermenters and Enterobacteriaceae</td>
<td>Non-fermenters and Enterobacteriaceae</td>
</tr>
<tr>
<td>Inhibited by</td>
<td>Clavulanate and tazobactam</td>
<td>EDTA</td>
<td>No effective inhibitor</td>
</tr>
<tr>
<td>Active site</td>
<td>Serine</td>
<td>Zinc ion</td>
<td>Serine</td>
</tr>
<tr>
<td>Carbapenem</td>
<td>Hydrolysed</td>
<td>Hydrolysed</td>
<td>Hydrolysed</td>
</tr>
<tr>
<td>Aztreonam</td>
<td>Hydrolysed</td>
<td>Not hydrolysed</td>
<td>Not hydrolysed</td>
</tr>
<tr>
<td>Early β-lactam</td>
<td>Hydrolysed</td>
<td>Hydrolysed</td>
<td>Hydrolysed</td>
</tr>
<tr>
<td>Extended spectrum cephalosporin</td>
<td>Hydrolysed (except SME)</td>
<td>Hydrolysed</td>
<td>Hydrolysed poorly</td>
</tr>
</tbody>
</table>

Note:
<sup>1</sup> Seen in HK
<sup>2</sup> Common in HK
Multidrug-resistant *Acinetobacter baumannii* (MRAB) is a widely used, and yet ill-defined and non-specific term (Figure 1.4). There is no internationally agreed definition for MRAB. Carbapenem is a critically important class of antimicrobial in the treatment of infection caused by *Acinetobacter baumannii* (86–87). Therefore, resistance to the carbapenems have been defined as a sentinel event (88–90). Using the term CRAB allows better communication and surveillance data could be comparable between different centres (Figure 1.4). Moreover, the recent rise in resistant strains of *A. baumannii* seen worldwide is mainly due to the dissemination of strains possessing the Class D OXA type ß-lactamase (91–94). Therefore, for surveillance purpose, the term CRAB reflects the current situation more accurately than MRAB. In February 2017, the World Health Organization published a list of antibiotic-resistant priority pathogen for which new antibiotics are urgently needed; the term CRAB is used.

1. Resistance to carbapenem can be due to enzymatic degradation and efflux pump. However the recent spread in resistant strains of *A. baumannii* is mainly due to strains producing the class D OXA type ß-lactamase (95–96). OXA-23, OXA-24 and OXA-58 are the most common type of carbapenemase produced by *A. baumannii*. They contribute to carbapenem resistance in *A. baumannii* globally (96).

2. The metallo-ß-lactamases are class B ß-lactamases which contain at least one zinc ion at their active sites (Table 1.8). They are more potent carbapenemases and can hydrolyse all ß-lactamase except the monobactam, aztreonam (96). However, metallo-ß-lactams is less commonly seen in *A. baumannii*. Due to the simultaneous presence of resistance determinants often carried on integrons, CRAB has concomitant resistance to other classes of antibiotics (19).

3. In a local survey of CRAB in 2010, majority of the strains belonged to HKU1 and HKU2 clones (89). OXA-23 was found in all HKU1 isolates and correlated with high level of resistance to carbapenems. OXA-51 was found in both HKU1 and HKU2 clones. Chronic wounds were found to be associated with MRAB colonisation or infection, which acts as a potential reservoir for MRAB. This study demonstrated the spread of CRAB is due to the dissemination of two novel clones (91).
4. Imipenem resistance was found to have a significant impact on the mortality of *Acinetobacter* bacteraemia (97), which is mainly accounted by the higher rate of discordant antimicrobial therapy. *Acinetobacter* resistant to imipenem was also found to have a higher rate of resistance to other classes of antimicrobial agents.

5. There is an increasing endemicity of CRAB ST457 in HK, the incidence of CRAB bacteraemia was 0.27/100,000 patient-days in 2009. A rapid increase of incidence to 1.86/100,000 patient-days occurred in 2013. The increase in the absolute number of CRAB bacteraemia better reflects the true burden to the healthcare system caused by CRAB. Risk factors include resident of elderly home, use of carbapenem and ß-lactam/ß-lactamase inhibitor combinations 90 days before admission (98).

6. A recent local study screened 17,760 faecal specimens for CRAB and MRAB from 9,469 patients over a 7-month study period in a 3,200-bed healthcare network. Screening result showed that 2.6% (244/9,469) patients were CRAB carriers, where 0.57% (54/9,469) were MRAB carriers. Quantitative bacterial counts in various body sites were performed in 33 of the 54 MRAB carriers. Use of fluoroquinolones 6 months before admission was the only significant factor associated with high bacterial load in nasal and rectal swabs (99).

### 1.7 Macrolide Resistant *Mycoplasma pneumoniae* (MRMP)

1. Respiratory tract infections caused by *Mycoplasma pneumoniae* is primarily a disease of school-age children and adolescents (Figure 1.5). Infections are often self-limiting even without specific antibiotic treatment.

2. MRMP was first reported in Japan in 2001 (100). Since then, there has been reports in China (101–104), Taiwan (105–106), Korea (107), the United States of America (108–109) and various European countries, including Scotland (110), Spain (111) and Germany (112).

3. In China, the prevalence of MRMP is exceptionally high constituting over 90% of all *Mycoplasma pneumoniae* isolates (102). The first imported case of MRMP in HK was reported in an adult returning from Xi’an in 2009 (113). The first locally acquired case of MRMP in HK has been reported in 2010 (114).
4. Two local studies have described the rate of MRMP among patients requiring hospital admission. The first study evaluated different molecular methods to detect genotypic resistance in *M. pneumoniae* in both adult and paediatric subjects (115). Pyrosequencing identified mutation at the position A2063G in 79% of the *M. pneumoniae* PCR positive cases, where Sanger sequencing and melting curve analysis only identified the genotypic mutation in less than 40% of the PCR positive cases. The difference is mainly due to the ability of pyrosequencing to identify low-frequency MRMP quasispecies. Another local study evaluated the antibiotics treatment efficacy against MRMP in the paediatric age group only (116). Among the paediatric community-acquired pneumonia (CAP) cases with a positive *Mycoplasma* PCR, 70% were MRMP. A recent study has demonstrated a high rate of *M. pneumoniae*-associated pneumonia in younger children, where 18% were infants of age group 0–1 years and 30% were between 2–11 years.

5. According to the CHP laboratory surveillance statistics from January to September 2016, 35% of the *M. pneumoniae* detected in respiratory specimens harboured a macrolide-resistant mutation (117).
Figure 1.4 Changes in the multidrug-resistant rate of *Acinetobacter baumannii* according to three different definitions, 1997–2008

Definition 1: resistance to carbapenem class (imipenem, meropenem)

Definition 2: resistance to representative agents from at least three antibiotic classes, including aminoglycosides (gentamicin, amikacin), antipseudomonal penicillins (ticarcillin/clavulanic acid, piperacillin/tazobactam), carbapenems (imipenem, meropenem), cephalosporins (ceftazidime) and fluoroquinolones (ciprofloxacin)

Definition 3: resistance to all agents or with the exception of amikacin
Figure 1.5  Prevalence of *Mycoplasma pneumoniae* in respiratory specimens according to patient age groups, all HA hospitals, 2015–2016. During the period, over 20,000 respiratory specimens were tested by PCR assays. In HK, annual *M. pneumoniae*-positive rate in respiratory specimens have been reported to vary widely, ranging from 9.8% to 27.2% (118).
Part II: Antimicrobial stewardship programme
2.1 Antimicrobial stewardship programme (ASP)

1. ASP is defined as the optimal selection, dosage, route of administration and duration of antibiotic treatment (119–120).

2. Benefits of ASP include improved patient outcomes (121–122), reduced adverse reactions, reduced *Clostridium difficile* infection rate (121,123), minimal impact on subsequent antibiotic resistance (124–125) and optimisation of resource utilisation (125–126).

3. ASP is one of the core components of infection control which is one of the mandatory criteria in the Australian Council on Healthcare Standards Evaluation and Quality Improvement Program Hong Kong Guide (127).

4. It involves a multidisciplinary, programmatic, prospective, interventional approach to optimising the use of antimicrobial agents.

5. ASP team comprises clinical microbiologists, infectious disease physicians, infection control nurses, and infectious disease pharmacists.
<table>
<thead>
<tr>
<th>Table 2.1 Methods to implement ASP in hospital setting</th>
</tr>
</thead>
</table>
| **Preauthorisation** | • Restricted use of certain antibiotics  
| | • Prior approval by an ASP team  
| | • Reduces initiation of unnecessary/inappropriate antibiotics |
| **Prospective audit and feedback** | • Use of antibiotic order form  
| | • Provides educational benefit to clinicians  
| | • Can increase visibility of ASP and build collegial relationships |
| **Administrative control** | • Restriction of hospital drug formulary through the Drug and Therapeutics Committee  
| | • Use of antibiotic order form  
| | • Selective or cascade reporting of antibiotic susceptibility test results |
| **Guidelines, education & consultation** | • Written hospital guidelines for common infectious diseases syndromes  
| | • Educational efforts aimed at changing prescribing practices of clinicians  
| | • Providing consultation from clinical microbiologist or infectious disease physician |
| **Review and surveillance** | • On-going monitoring and analysis of antibiotics usage  
| | • On-going surveillance of antibiotic susceptibility  
| | • On-going monitoring of *Clostridium difficile* infection rate |
2.2 Tips on safe use of antibiotics in outpatient setting

1. Understand the local prevalence of pathogens and associated antibiotic susceptibility profiles. Information on surveillance of AMR at community outpatient setting is available at the CHP webpage (128).

2. Management of patients with respiratory tract infections should be personalised. A careful clinical evaluation (e.g. patient’s age, underlying comorbidity, duration and severity of symptoms, physical findings) is essential in making decision to use or to avoid antibiotics. Upper respiratory tract infections are often viral in origin. In a study, antibiotics were prescribed in 68% of visits for symptoms of acute respiratory tract infections; among those, 80% were unnecessary according to CDC guidelines (129). Clinical discrimination is required in using clinic-based, point-of-care testing (e.g. flu A and B, C-reactive protein, white blood cell (WBC), urinalysis).

3. It is a good clinical practice to explain to the patient the reasons for giving or not giving antibiotics (130) and to provide information on the average total length of the illness (131) as below:
   a). Acute otitis media: 4 days
   b). Acute sore throat/acute pharyngitis/acute tonsillitis: 1 week
   c). Common cold: up to 10 days
   d). Acute rhinosinusitis: 2 to 3 weeks
   e). Acute bronchitis: 3 weeks

4. Whenever appropriate, prescribe the simplest regimen and shortest duration of treatment (132).

5. Take an ‘antibiotic timeout’ if possible, e.g. reassessing need of antibiotics after 48–72 hours.

6. Advise patients to observe the following precautions while on antibiotics (Figure 2.1):
   a). Practice frequent hand hygiene;
   b). Eat or drink only thoroughly cooked or boiled items;
   c). Disinfect and cover all wounds;
   d). Wear mask if he/she has respiratory symptoms;
   e). Young children with symptoms of infection should minimise contact with other children.
7. Take the opportunity to educate patients on proper use of antibiotics:
   a). Only take antibiotics prescribed for him/her;
   b). Do not share or use leftover antibiotics;
   c). Do not save antibiotics for the next illness;
   d). Do not ask for antibiotics when your doctor thinks you do not need them. In a study of paediatric care, doctors prescribe antibiotics 62% of the time if they perceive pressure from parents and 7% of the time if they feel parents do not expect them (133).

**Figure 2.1  Cue card for patient education**

- **While taking antibiotic which is necessary to cure your infection, the antibiotic also kills the normal bacteria in your body and predisposes you to acquire more resistant bacteria.**
- Therefore, you should enhance your personal hygiene to protect the health of you and your family:
  1. Practise frequent hand hygiene
  2. Eat or drink only thoroughly cooked and boiled items
  3. Disinfect and cover all wounds
  4. Wear mask if you have respiratory infection symptoms
  5. Young children with symptoms of infection should minimize contact with other children

- **使用抗生素可治疗细菌感染, 但同时亦会杀死身体内之正常细菌, 及增加感染抗药性细菌的风险。**
- **保持您与家人的健康，请注意个人卫生：**
  1. 时刻保持手部卫生
  2. 食水和食物必须彻底煮沸及煮熟
  3. 消毒及覆盖伤口
  4. 当有呼吸道感染徵状时，请戴上口罩
  5. 有传染病徵状的幼童，应尽可能减少接触其他儿童
### Table 2.2 Core elements of outpatient ASP (134)

| Commitment | • Identify a single leader to direct antibiotic stewardship activities  
|            | • Include antibiotic stewardship-related duties in position description or job evaluation criteria  
|            | • Communicate with all clinic staff members to set patient expectations  
| Action for policy and practice | • Use evidence-based diagnostic criteria and treatment recommendations  
|                              | • Use delayed prescribing practices or watchful waiting when appropriate  
|                              | • Require explicit written justification in the medical record for nonrecommended antibiotic prescribing  
|                              | • Provide support for clinical decisions  
| Tracking and reporting | • Provide audit and feedback at the individual clinician level or at the facility level  
|                              | • Comparison of clinicians’ performance with that of their peers  
|                              | • Identify high-priority conditions as opportunities to improve clinician adherence to guidelines for antibiotic prescribing  
| Education and expertise | • Use effective communications strategies to educate patients about when antibiotics are and are not needed  
|                            | • Provide patient education materials  
|                            | • Provide continuing education activities for clinicians  |
Part III: Guidelines for selected antimicrobial use
3.1 Vancomycin

3.1.1 Situations in which the use of vancomycin is appropriate

1. Treatment of serious infections caused by β-lactam resistant Gram-positive bacteria (e.g. MRSA, coagulase-negative staphylococci) (135–136).

2. Treatment of CA-MRSA in severe and extensive skin and soft tissue infection (multiple sites), rapid progression of cellulitis, immunosuppression, extremes of age, site of infection difficult to drain (11).

3. Treatment of infections caused by Gram-positive bacteria in patients who have serious allergies to β-lactam antibiotics (e.g. anaphylactic reaction, Stevens-Johnson syndrome).

4. When *Clostridium difficile* colitis fails to respond to metronidazole therapy or is severe and life-threatening (137–138).

5. As prophylaxis for endocarditis before dental procedures that involve manipulation of either gingival tissue or the periapical region of teeth, or perforation of the oral mucosa in inpatients at high risk for endocarditis; according to recommendation from the American Heart Association (139–140).

6. As prophylaxis for major surgical procedures involving the implantation of prosthetic material or devices in known carriers of MRSA in addition to the routine regimen. For elective procedures, daily washing of skin and hair with a suitable antiseptic soap (e.g. 4% chlorhexidine liquid soap) and topical treatment of the anterior nares with nasal mupirocin ointment (for 3 to 5 days) are recommended before the procedures. Vancomycin may be less effective in preventing surgical wound infection due to methicillin-sensitive staphylococci (141).

3.1.2 Situations in which the use of vancomycin is not advised

1. Treatment of MRSA nasal carriage or colonisation at other sites such as the isolation of MRSA from:
   a). Surface swab of superficial wounds
   b). Surface swab of chronic ulcers
   c). Surface swab of pressure ulcers

2. Routine surgical prophylaxis other than in a patient who has serious allergy to β-lactam antibiotics.
3. Vancomycin is not a standard part of empirical antibiotic therapy for neutropenic fever, except in known MRSA carriers, haemodynamically unstable neutropenic patients or in presence of severe oral mucositis (142).

4. Treatment in response to a single blood culture positive for coagulase-negative staphylococci, if other blood cultures taken during the same time frame are negative.

5. Continued empirical use for presumed infections in patients whose cultures (blood, joint fluid, peritoneal fluid, pus, etc.) are negative for ß-lactam-resistant Gram-positive bacteria (e.g. MRSA).

6. Systemic or local (e.g. antibiotic lock) prophylaxis against infection (or colonisation) of indwelling (central or peripheral) intravascular catheters.

7. As routine prophylaxis, before insertion of Hickman/Broviac catheter or Tenckhoff catheter.

8. Primary treatment of Clostridium difficile colitis, except when it is severe and life-threatening.

9. Routine prophylaxis for patients on continuous ambulatory peritoneal dialysis or haemodialysis.

10. Treatment (e.g. chosen for dosing convenience) of infection caused by ß-lactam-sensitive Gram-positive bacteria in patients who have renal failure.

11. Use of vancomycin solution for topical application (e.g. to burn wound, ulcers) or irrigation (e.g. of T-tube, drains).

### 3.1.3 Vancomycin dosing

1. In adults, the standard recommended dose of vancomycin is 30 mg/kg/day (I.V. 1 g q12h or I.V. 0.5 g q6h in a normal 70 kg person).

2. In seriously ill patients with suspected MRSA infection, a loading dose of 25–30 mg/kg of actual body weight may be considered.

3. For individual doses over 1g, infuse over 1.5–2 hours (143).

### 3.1.4 Dosing in patients with impaired renal function

1. For daily dosing based on creatinine clearance when it can be accurately measured or estimated, see Table 3.1 (this table is not suitable for functionally anephric patients).

2. An initial single dose of 15mg/kg should be given.

3. For anuric patient, 1g every 7–10 days.
Table 3.1 Dosage table for vancomycin using creatinine clearance (144)

<table>
<thead>
<tr>
<th>Creatinine clearance</th>
<th>Dosing</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;50 mL/min</td>
<td>500 mg I.V. every 6–12 hours</td>
</tr>
<tr>
<td>10–50 mL/min</td>
<td>500 mg I.V. every 24–48 hours</td>
</tr>
<tr>
<td>&lt;10 mL/min</td>
<td>500 mg I.V. every 48–96 hours</td>
</tr>
</tbody>
</table>

3.1.5 Therapeutic drug monitoring

- Usage of vancomycin therapeutic drug monitoring as a guide to treat MRSA infections is controversial (145–147).
- Vancomycin therapeutic drug monitoring can be considered in patients with impaired renal function (147), in order to avoid vancomycin-related nephrotoxicity.
3.2 Linezolid

1. Indications
   
   a). Suspected or confirmed infection caused by antibiotic-resistant Gram-positive bacteria such as MRSA with vancomycin MIC ≥2 μg/mL, VRE and some mycobacteria.
   
   b). Infections by MRSA in the case of vancomycin failure (e.g. unexplained breakthrough bacteraemia) or serious vancomycin allergy. In these complicated circumstances, the opinion of a clinical microbiologist or infectious disease physician should be sought.

2. Not active against Gram-negative bacteria (e.g. *Haemophilus influenzae*, *Moraxella catarrhalis*).

3. Most VRE identified in HK so far are susceptible to linezolid (both *E. faecalis* and *E. faecium*) at ≤4 μg/mL and quinupristin/dalfopristin (*E. faecium* only, at ≤1 μg/mL) (148). However, multidrug resistant strains including linezolid-resistant clinical isolates of *Enterococcus faecalis*, *Enterococcus faecium*, *Staphylococcus aureus*, coagulase-negative staphylococci, *Mycobacterium tuberculosis*, which develop during therapy with linezolid have been reported.

4. Dosage: P.O. or I.V. 600 mg q12h.

5. Side effects include myelosuppression; thrombocytopenia, anaemia and neutropenia reported especially for treatment >2 weeks (149); lactic acidosis, peripheral neuropathy, optic neuropathy due to inhibition of intramitochondrial protein synthesis (150); serotonin syndrome (fever, tremor, agitation and mental state changes), risk with concomitant selective serotonin reuptake inhibitor (151).

6. Please consult clinical microbiologist or infectious disease physician for the use of linezolid.
3.3 Daptomycin

1. Daptomycin belongs to the antibiotic group lipopeptide. It possesses in vitro activities against a range of Gram-positive bacteria such as methicillin-sensitive *Staphylococcus aureus* (MSSA), MRSA, VRE, *Staphylococcus epidermidis* (including methicillin resistant), *Streptococcus pyogenes* and other streptococci.

2. Indications
   a). Bacteraemia associated with intravascular catheter
   b). *S. aureus* bacteraemia, including right-sided infective endocarditis
   c). Complicated skin and soft tissue infection

3. Not indicated for pneumonia because of drug inactivation by pulmonary surfactant.

4. Dosage: 4–6 mg/kg I.V. once daily.

5. Side effects
   a). Myopathy and rhabdomyolysis especially in patients taking statins.
   b). Eosinophilic pneumonia related to the use of daptomycin has been reported (152).

6. Please consult clinical microbiologist or infectious disease physician for the use of daptomycin.
3.4 Tigecycline

1. Prototype drug of antibiotic class glycyclcyclines derived from minocycline (153).

2. Indications: MRSA, VRE and other multidrug-resistant organism with in vitro activity, when standard treatment has failed or is contraindicated (e.g. allergy).

3. As for tetracyclines, this drug is not licensed for use in children.

4. Poorly active or inactive against the non-fermenters, such as *Stenotrophomonas maltophilia*, *Pseudomonas* spp. and CRAB.

5. Limitation of use
   a). Food and Drug Administration (FDA) warnings: Reports showed an increased mortality in patients treated for nosocomial pneumonia, especially ventilator-associated pneumonia, and also complicated skin and skin structure infections, complicated intra-abdominal infections and diabetic foot infections (154).
   b). An updated FDA warning has showed a higher mortality risk among patients who received tigecycline compared to other antibacterial drugs. The deaths resulted from worsening infections, complications of infection, or other underlying medical conditions (155).

6. Dosage:
   a). I.V. loading dose of 100 mg, then 50 mg q12h.
   b). Given as slow I.V. infusion (30–60 minutes).
   c). Reduce maintenance dose (25 mg q12h) for patients with severe liver disease (Child Pugh C).

7. Side effects similar to tetracycline.

8. Please consult clinical microbiologist or infectious disease physician for the use of tigecycline.
3.5 Colistin/colomycin

1. Colistin belongs to the polypeptide antibiotic class polymyxin.
2. Mainly used in infections caused by multidrug-resistant Gram-negative bacteria like CRE, pandrug-resistant *Acinetobacter baumannii*, and *Pseudomonas aeruginosa*.
3. All Gram-positive bacteria, *Moraxella catarrhalis*, *Morganella morganii*, *Proteus* spp., *Providencia* spp. and *Serratia marcescens* are intrinsically resistant to colistin.
4. Poor lung penetration after intravenous administration. For pneumonia cases, use high I.V. dose with possible addition of nebulised colistin (156).
5. Dosing and administration
   a). Despite being available for more than 50 years, colistin use is still not optimised. This is due to confusion in dosing due to different conventions, outdated and diverse product information and uncertainties about susceptibility testing and breakpoints (157).
   b). Colistin strength is expressed in colistin base activity (mg CBA), milligrams (mg) or international units (IU) in different parts of the world.
   c). Consider 30 mg CBA approximately equal to 1 million IU colistin (158).
6. Please consult clinical microbiologist or infectious disease physician for the use of colistin.
3.6 Fosfomycin trometamol

1. Indications
   a). Indicated for treatment of complicated or uncomplicated urinary tract infections caused by ESBL-producing *Enterobacteriaceae*.
   
   b). Systematic review showed 96.8% of ESBL-producing *E. coli* isolates and 81.3% of ESBL-producing *Klebsiella pneumoniae* isolates were susceptible to fosfomycin (159).

2. Also active against enterococci and MRSA. (160–161)

3. Dosage:
   a). Uncomplicated urinary tract infection: 3 g sachet P.O. for 1 dose with/without food.

   b). Complicated urinary tract infection: 3 g sachet P.O. every 2–3 days (up to 21 days) on an empty stomach.

4. Please consult clinical microbiologist or infectious disease physician for the use of fosfomycin disodium in treatment of infections other than uncomplicated cystitis.
3.7 Carbapenems

3.7.1 Indications for using imipenem/meropenem/ertapenem

1. Therapy of infections attributed to ESBL-producing bacteria (such as *E. coli* or *Klebsiella* spp.) such as:
   a). Bacteraemia with isolation of ESBL-producing bacteria from blood culture.
   b). Deep-seated infection with isolation of ESBL-producing bacteria from normally sterile body site or fluid (cerebrospinal fluid, peritoneal fluid, pleural fluid, joint fluid, tissue, pus, etc.).
   c). Nosocomial pneumonia, as defined by CDC guidelines, with isolation of ESBL-producing bacteria in a significant quantity, from a suitably obtained, good quality respiratory tract specimens.

2. Empirical therapy of neutropenic fever in high-risk patients. (As ertapenem has no anti-pseudomonal activity, it should not be used as empirical therapy of neutropenic fever patients or patients with non-fermenters infection such as *Pseudomonas aeruginosa* and *Acinetobacter* spp.)

Footnotes

Colonisation of the respiratory tract by ESBL-producing bacteria, especially in mechanically ventilated patients is common. Antimicrobial therapy of colonisation is not indicated. Isolation of ESBL-producing bacteria at the indicated quantity and specimen type is suggestive of infection rather than colonisation (in descending order of clinical significance):

1. $10^2$–$10^3$ CFU/mL or moderate/heavy growth for protected specimen brush.
2. $10^3$–$10^4$ CFU/mL or moderate/heavy growth for bronchoalveolar lavage.
3. Moderate/heavy growth for tracheal/endotracheal aspirate specimens with ++ to +++ white cells and absent/scanty epithelial cells.
4. Expectorated sputum (as defined by the American Society for Microbiology) with >25 WBC/low power field and <10 epithelial cells/low power field.
3.7.2 Situations/conditions in which imipenem/meropenem/ertapenem is not advised

1. Treatment of colonisation by ESBL-producing bacteria such as the isolation of these organisms from:
   a). Surface swab of superficial wounds
   b). Surface swab of chronic ulcers
   c). Surface swab of pressure ulcers

2. Empirical therapy of most community-acquired infections including pneumonia, appendicitis, cholecystitis, cholangitis, primary peritonitis, peritonitis secondary to perforation of stomach, duodenum or colon, skin and soft tissue infections, etc.

3. As known-pathogen therapy for infections caused by organisms susceptible to other β-lactams.
3.8 Once daily aminoglycosides

1. Once daily aminoglycoside is an effective, well-established method to achieve therapeutic efficacy while limiting the risk of toxicity and simplifying the processes of dosing and monitoring (162–163).

2. The addition of an aminoglycoside to β-lactams for sepsis should be discouraged. Combination treatment carries a significant risk of nephrotoxicity without survival benefits (164–165).

3. With the exception of *Enterococcus* endocarditis (166), aminoglycosides should not be given for more than one or two doses.

4. As concentration-dependent antibiotics, dosing of gentamicin and amikacin should keep the maximum serum concentration (C<sub>max</sub>) to minimum inhibitory concentration (MIC) ratio to 8–10 for optimal treatment outcome (167).
3.9 Ceftaroline

1. Ceftaroline is a newer cephalosporin with in vitro activity against MRSA.
2. Ceftaroline is inactive against ESBL-producing or AmpC-overexpressing Enterobacteriaceae and has limited activity against non-fermenting Gram-negative bacilli such as Pseudomonas aeruginosa and Acinetobacter baumannii (168).
3. Dosing
   a). Community acquired pneumonia: 600 mg I.V. q12h
   b). Skin and soft tissue infection: 600 mg I.V. q12h
4. Consult clinical microbiologist or infectious disease physician for the use of ceftaroline.
3.10 Antifungal agents

1. The mechanism of action for the major antifungal classes is summarised in Table 3.2.

2. It is important to note that there are significant within and between class variations in the antifungal spectrum of the agents (Table 3.3). They also differ in their pharmacokinetic properties and dosage adjustment in renal and hepatic dysfunction (Table 3.4).

3. Echinocandins are not active or show very limited activity against Cryptococcus neoformans, Trichosporon beigeli, dematiaceous moulds, Zygomycetes, Fusarium spp. and dimorphic fungi (Blastomyces, Histoplasma, Coccidioides) because these fungi do not have the target for the echinocandins to act.

4. Fluconazole shows activity against Candida albicans. It is also active against non-albicans Candida but MICs are higher, especially for C. glabrata.

5. Analysis of fungaemia data in local hospitals showed that about 10% of the isolates were potentially resistant to fluconazole and the echinocandins (Figure 3.1).

6. Table 3.5 showed a suggested scheme for choosing antifungals.

7. Table 3.6 summarised the antifungal agents that have been evaluated in randomised controlled trials for their five major indications. In general, the different agents were non-inferior to each other for the major outcomes. In several studies, superior results were demonstrated for certain outcomes.

Table 3.2 Mechanisms of antifungal action

<table>
<thead>
<tr>
<th></th>
<th>Primary mode of action</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Azoles</strong></td>
<td>Inhibit ergosterol biosynthesis</td>
<td>Fungal cytochrome P-450 dependent 14 α-sterol demethylase</td>
</tr>
<tr>
<td>(fluconazole,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>itraconazole,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>voriconazole)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Echinocandins</strong></td>
<td>Inhibit fungal cell wall glucan</td>
<td>Fungal β-1, 3-glucan synthase</td>
</tr>
<tr>
<td>(caspofungin,</td>
<td>synthesis</td>
<td></td>
</tr>
<tr>
<td>anidulafungin,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>micafungin)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Amphotericin B</strong></td>
<td>Bind to and make fungal cell</td>
<td>Fungal cell membrane</td>
</tr>
<tr>
<td></td>
<td>membrane ‘leaky’</td>
<td></td>
</tr>
</tbody>
</table>
### Table 3.3 General patterns of antifungal susceptibility

<table>
<thead>
<tr>
<th>Yeasts</th>
<th>FLU</th>
<th>ITR</th>
<th>5FC</th>
<th>AMB</th>
<th>VOR</th>
<th>POS</th>
<th>CAS</th>
<th>MFG</th>
<th>AFG</th>
</tr>
</thead>
<tbody>
<tr>
<td>C. albicans</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>C. tropicalis</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>C. glabrata (S-DD to R)</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S-I</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S-I</td>
<td>S</td>
</tr>
<tr>
<td>C. krusei (R)</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>C. lusitaniae</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>C. parapsilosis</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>I</td>
<td>S</td>
</tr>
<tr>
<td>C. guillermondii</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>I</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>Cryptococcus neoformans</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>Trichosporon</td>
<td>R</td>
<td>I</td>
<td>R</td>
<td>I</td>
<td>S</td>
<td>S</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>Moulds</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fusarium</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>Aspergillus</td>
<td>R</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>+++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Pseudallescheria</td>
<td>R</td>
<td>S</td>
<td>R</td>
<td>R</td>
<td>++</td>
<td>++</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>Zygomycetes</td>
<td>R</td>
<td>+</td>
<td>R</td>
<td>+</td>
<td>R</td>
<td>+</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>Dimorphic fungus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H. capsulatum</td>
<td>+</td>
<td>++</td>
<td>R</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>P. marneffei</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
</tbody>
</table>

S, susceptible; S-DD, susceptibility is dose-dependent; I, intermediate; R, resistant

Amphotericin B (AMB); 5-flucytosine (5FC); fluconazole (FLU); itraconazole (ITR); posaconazole (POS); voriconazole (VOR); caspofungin (CAS); anidulafungin (AFG); micafungin (MFG)

Note:
1Sporadic cases of breakthrough *C. glabrata* and *C. parapsilosis* infection have been reported in the literature

Reference: (169–179)
## Table 3.4 Comparison of selected pharmacokinetic parameters for the azoles and caspofungin

<table>
<thead>
<tr>
<th>Generic name (Trade name)</th>
<th>Fluconazole (Diflucan)</th>
<th>Itraconazole (Sporanox)</th>
<th>Voriconazole (Vfend)</th>
<th>Posaconazole (Noxafil)</th>
<th>Caspofungin (Cancidas)</th>
<th>Anidulafungin (Eraxis)</th>
<th>Micafungin (Mycamine)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oral bioavailability</td>
<td>&gt;80%</td>
<td>Capsule: 30–55% Solution: 60–80%</td>
<td>90%</td>
<td>&gt; 90%</td>
<td>Only I.V.</td>
<td>Only I.V.</td>
<td>Only I.V.</td>
</tr>
<tr>
<td>C&lt;sub&gt;max&lt;/sub&gt;</td>
<td>10.2</td>
<td>0.2–0.4 µg/mL after 2–4 h of 200 mg P.O.</td>
<td>2 µg/mL after 200 mg P.O.</td>
<td>0.28 µg/mL after 5h</td>
<td>10 µg/mL end infusion</td>
<td>3.55 to 10.9 µg/mL end infusion</td>
<td>10 µg/mL end infusion</td>
</tr>
<tr>
<td>Time to C&lt;sub&gt;max&lt;/sub&gt; (hour)</td>
<td>2–4</td>
<td>4–5</td>
<td>1–2</td>
<td>3–5</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cerebrospinal fluid (CSF) penetration</td>
<td>50–94%</td>
<td>&lt;1%</td>
<td>20–50%</td>
<td>&lt;1%</td>
<td>Unknown (very low)</td>
<td>Unknown</td>
<td>Undetectable</td>
</tr>
<tr>
<td>Plasma half-life (hour)</td>
<td>22–35</td>
<td>24–42</td>
<td>6–24</td>
<td>35</td>
<td>9–11 (terminal half-life 40–50)</td>
<td>26</td>
<td>11–21</td>
</tr>
<tr>
<td>Tissue distribution</td>
<td>Widely distributed in most tissues including CSF.</td>
<td>Levels in body fluids/CSF low; concentrations in lung, liver &amp; bone 2–3 times &gt; serum. High concentration in stratum corneum due to drug secretion in sebum.</td>
<td>Widely distributed into body tissues &amp; fluid including brain &amp; CSF.</td>
<td>Widely distributed into body tissues except CSF.</td>
<td>Widely distributed; highest concentration in liver.</td>
<td>Widely distributed.</td>
<td>Widely distributed.</td>
</tr>
<tr>
<td>Principal route of elimination</td>
<td>Renal</td>
<td>Hepatic</td>
<td>Hepatic</td>
<td>Hepatic</td>
<td>Hepatic</td>
<td>-</td>
<td>Hepatic</td>
</tr>
</tbody>
</table>

62
<table>
<thead>
<tr>
<th>Generic name (Trade name)</th>
<th>Fluconazole (Diflucan)</th>
<th>Itraconazole (Sporanox)</th>
<th>Voriconazole (Vfend)</th>
<th>Posaconazole (Noxafil)</th>
<th>Caspofungin (Cancidas)</th>
<th>Anidulafungin (Eraxis)</th>
<th>Micafungin (Mycamine)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active drug in urine (%)</td>
<td>80%</td>
<td>&lt;1%</td>
<td>2%</td>
<td>14%</td>
<td>1%</td>
<td>&lt;1%</td>
<td>&lt;15%</td>
</tr>
<tr>
<td>Dosage</td>
<td>P.O. or I.V. 50–400 mg/day depending on indications</td>
<td>P.O. 200–400 mg/day</td>
<td>Adult, P.O. 200–400 mg q12h for 24 h, then 100–200 mg q12h; I.V. 6 mg/kg q12h for 24 h, then 4 mg/kg q12h</td>
<td>Adult, P.O. 400 mg q8h</td>
<td>Aspergillosis/ Candida: Adult, P.O. 200 mg q8h Mucormycosis/ Cryptococcus: Adult, P.O. 400 mg q12h</td>
<td>I.V. infusion of 70 mg loading, then 50 mg daily</td>
<td>I.V. infusion of 100–150 mg daily</td>
</tr>
<tr>
<td>Renal insufficiency</td>
<td>Reduce dose; removed by haemodialysis. Usual dose. At glomerular filtration rate &lt;10 mL/min, some recommend decrease dose 50%.</td>
<td>No dose adjustment need with P.O. voriconazole. Avoid I.V. voriconazole in renal failure.</td>
<td>No dose adjustment necessary</td>
<td>No dose adjustment needed. Not removed by haemodialysis.</td>
<td>No dose adjustment</td>
<td>No dose adjustment</td>
<td>No dose adjustment</td>
</tr>
<tr>
<td>Hepatic insufficiency</td>
<td>-</td>
<td>Avoid</td>
<td>Mild to moderate (Child A/B) same loading, reduce maintenance 50%. Avoid in severe impairment.</td>
<td>-</td>
<td>Reduce dose to 35 mg daily (after the 70 mg loading dose) in moderate (Child’s score 7–9). No data on usage in patient with severe hepatic failure.</td>
<td>No dose adjustment</td>
<td>No dose adjustment</td>
</tr>
</tbody>
</table>
### Table 3.5 A suggested scheme for systemic antifungal agents

<table>
<thead>
<tr>
<th></th>
<th>First-line</th>
<th>Alternative</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Invasive candidiasis/candidaemia</strong> (180)</td>
<td>Neutropenic or critically ill</td>
<td>Echinocandin • Lipid formulation amphotericin B</td>
</tr>
<tr>
<td></td>
<td>Stable and nonneutropenic</td>
<td>Echinocandin • Fluconazole, lipid formulation amphotericin B</td>
</tr>
<tr>
<td><strong>Invasive aspergillosis</strong> (181)</td>
<td>Voriconazole</td>
<td>Voriconazole • Amphotericin B and its lipid derivatives for initial and salvage therapy when voriconazole cannot be administered • Echinocandins</td>
</tr>
</tbody>
</table>
### Table 3.6 Selected clinical trials conducted on licensed antifungals

<table>
<thead>
<tr>
<th>Antifungal prophylaxis</th>
<th>Neutropenic fever</th>
<th>Invasive aspergillosis</th>
<th>Candidaemia or invasive candidiasis</th>
<th>Oesophageal candidiasis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voriconazole vs placebo (182)</td>
<td>Miacafungin vs caspofungin (183)</td>
<td>Posaconazole vs liposomal amphotericin B ± caspofungin (184)</td>
<td>Caspofungin vs amphotericin B (172); Caspofungin in newborn infants (185)</td>
<td>Caspofungin vs amphotericin B (186–187)</td>
</tr>
<tr>
<td>Miacafungin vs fluconazole (188); Miacafungin vs fluconazole (189); Miacafungin vs fluconazole, liposomal amphotericin B or caspofungin post-liver-transplant (190)</td>
<td>Caspofungin vs liposomal amphotericin B (191); Caspofungin vs liposomal amphotericin B (192)</td>
<td>Voriconazole vs amphotericin B (173,193)</td>
<td>Caspofungin (standard vs high dose) (194)</td>
<td>Caspofungin vs fluconazole (195)</td>
</tr>
<tr>
<td>Itraconazole vs fluconazole (196–197)</td>
<td>Voriconazole vs liposomal amphotericin B (198)</td>
<td>Liposomal amphotericin B (standard dose vs high loading dose) (199)</td>
<td>Anidulafungin vs fluconazole (200); Anidulafungin vs fluconazole in critically ill (201)</td>
<td>Anidulafungin vs fluconazole (202)</td>
</tr>
<tr>
<td>Posaconazole vs fluconazole or itraconazole (203–205)</td>
<td>Itraconazole vs amphotericin B (206–207)</td>
<td>Isavuconazole vs voriconazole (for invasive mould disease) (208)</td>
<td>Miacafungin vs caspofungin (177)</td>
<td>Miacafungin vs fluconazole (209–210)</td>
</tr>
<tr>
<td>Voriconazole/posaconazole vs fluconazole/itraconazole in AML/MDS undergoing chemotherapy (211); Voriconazole vs itraconazole in post allogeneic HSCT (212); Voriconazole vs fluconazole in post allogeneic HSCT (213)</td>
<td>Different amphotericin B formulations (214–215)</td>
<td>Voriconazole and anidulafungin vs voriconazole monotherapy (216)</td>
<td>Miacafungin vs liposomal amphotericin B (217–219)</td>
<td>Voriconazole vs fluconazole (220)</td>
</tr>
<tr>
<td>Antifungal prophylaxis</td>
<td>Neutropenic fever</td>
<td>Invasive aspergillosis</td>
<td>Candidaemia or invasive candidiasis</td>
<td>Oesophageal candidiasis</td>
</tr>
<tr>
<td>------------------------</td>
<td>-------------------</td>
<td>------------------------</td>
<td>-------------------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>Aerosolized liposomal amphotericin B vs placebo inhalation (221)</td>
<td>Micafungin vs itraconazole (222)</td>
<td>Voriconazole vs amphotericin B followed by fluconazole (223)</td>
<td>Isavuconazole vs fluconazole (224)</td>
<td></td>
</tr>
<tr>
<td>Voriconazole vs low dose amphotericin B in paediatric acute leukaemia induction (225)</td>
<td>Immediate voriconazole vs deferred placebo (226)</td>
<td>Micafungin vs voriconazole in kidney transplant recipients (227)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anidulafungin vs fluconazole in high-risk liver transplant patients (228)</td>
<td></td>
<td>Preemptive micafungin following gastrointestinal surgery (229)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caspofungin prophylaxis followed by preemptive therapy for invasive candidiasis (230)</td>
<td></td>
<td>Caspofungin vs micafungin (231)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note:
AML, acute myelogenous leukaemia
HSCT, haematopoietic stem cell transplantation
MDS, myelodysplastic syndromes
Agent with superior results for some outcomes is underlined.
Figure 3.1 Distribution by species for 595 episodes of fungaemia in HA, 2015-2016

Note:
1 Each species from each patient is only counted once.
2 Including one each of Candida doobushaemulonii, Candida guilliermondii, Candida haemulonii, Candida novegensis, Cryptococcus spp., Fusarium solani and Malassezia furfur.
Part IV: Recommendation for the empirical therapy of common infections
4.1 Guidelines for empirical therapy
### Table 4.1 Guidelines for empirical therapy

<table>
<thead>
<tr>
<th>Musculoskeletal infections</th>
<th>Usual organisms</th>
<th>Preferred regimens</th>
<th>Alternatives</th>
<th>Special considerations / [usual duration of treatment]</th>
</tr>
</thead>
</table>
| **Septic arthritis**, adult (232–234) | *S. aureus*; streptococci, *N. gonorrhoeae* | I.V. cloxacillin + ampicillin | I.V. ceftriaxone or cefazolin (if *N. gonorrhoeae* is suspected, ceftriaxone is the preferred regimen) | • Urgent diagnostic tapping for Gram stain to guide therapy.  
• If smear reveal Gram-negative cocci or bacilli: ceftriaxone or cefotaxime to replace cloxacillin.  
• Factors suggest *N. gonorrhoeae* aetiology: sexually active teenager/adult ± rash.  
• Consider dilute cloxacillin into larger volume of solution (e.g. 250 mL D5 solution) to avoid infusion related phlebitis.  
• CA-MRSA concern: local prevalence of invasive infection is still rare (24). Consider empirical vancomycin if known recurrent CA-MRSA infection or patient coming from highly endemic areas e.g. United States of America. |
<table>
<thead>
<tr>
<th>Usual organisms</th>
<th>Preferred regimens</th>
<th>Alternatives</th>
<th>Special considerations / [usual duration of treatment]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Osteomyelitis, haematogenous, adult (235)</strong></td>
<td><em>S. aureus</em></td>
<td>I.V. cloxacillin</td>
<td>• Occasionally <em>Salmonella</em> spp.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I.V. cefazolin or ceftriaxone</td>
<td>• Often vertebral.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Intravenous drug user (IVDU): <em>S. aureus</em> (vertebral); <em>P. aeruginosa</em> (ribs, sternoclavicular joint). Consider broaden empirical Gram-negative coverage if risk factors: concomitant urinary/intra-abdominal infections, immunocompromised, or elderly.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Associated with MRSA bacteraemia: vancomycin (236). Local prevalence of CA-MRSA invasive infection is still rare (24). Consider empirical vancomycin if known recurrent CA-MRSA infection or patient coming from highly endemic areas e.g. United States of America.</td>
</tr>
<tr>
<td>Diabetic foot infection (237–238)</td>
<td>Usual organisms</td>
<td>Preferred regimens</td>
<td>Alternatives</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>-----------------</td>
<td>--------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>(a) Previously untreated, no osteomyelitis</td>
<td><em>S. aureus</em>, ß-haemolytic streptococci</td>
<td>I.V./P.O. amoxicillin-clavulanate or ampicillin-sulbactam (239)</td>
<td>I.V./P.O. clindamycin or P.O. cephalexin</td>
</tr>
<tr>
<td>(b) Chronic, recurrent, limb threatening</td>
<td>Polymicrobial: aerobes + anaerobes</td>
<td>I.V./P.O. levofloxacin/ciprofloxacin + I.V./P.O. clindamycin or I.V./P.O. amoxicillin-clavulanate or ampicillin-sulbactam (239)</td>
<td>I.V./P.O. moxifloxacin or I.V. ertapenem (237,240–241)</td>
</tr>
<tr>
<td>Skin and soft tissue infections</td>
<td>Usual organisms</td>
<td>Preferred regimens</td>
<td>Alternatives</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-----------------</td>
<td>-------------------</td>
<td>--------------</td>
</tr>
</tbody>
</table>
| Erysipelas or cellulitis (242) | Groups A, B, C, G streptococci (± S. aureus) | (I.V. penicillin or I.V. ampicillin or P.O. amoxicillin) + I.V./P.O. cloxacillin | P.O. cephalexin or I.V./P.O.amoxicillin-clavulanate or ampicillin-sulbactam | • In HK, 50–80% group A streptococci are resistant to clindamycin (243–244).  
• Consider CA-MRSA coverage in cases of purulent cellulitis if risk factors present (26), non-responsive to first line treatment and/or severe infection (systemic signs of infection, hypotension)(24). |
## Necrotising fasciitis

*(242, 245–246)*

<table>
<thead>
<tr>
<th>Usual organisms</th>
<th>Preferred regimens</th>
<th>Alternatives</th>
<th>Special considerations / [usual duration of treatment]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Necrotising fasciitis</strong></td>
<td></td>
<td></td>
<td>- Immediate radical surgical intervention essential. Urgent consult clinical microbiologist or infectious disease physician.</td>
</tr>
<tr>
<td>1. Following exposure to freshwater; seawater or seafood</td>
<td><em>Aeromonas hydrophilia, A. caviae; Vibrio vulnificus</em></td>
<td>I.V. fluoroquinolone + I.V. amoxicillin-clavulanate</td>
<td>- If CA-MRSA is a concern (e.g. risk factors) (24), consider empirical coverage with linezolid (26).</td>
</tr>
<tr>
<td>2. Following cuts and abrasion; recent chickenpox; IVDU; healthy adults</td>
<td>Group A streptococci</td>
<td>I.V. penicillin G + I.V. linezolid (247)</td>
<td>Add high dose intravenous immunoglobulin (IVIG) (1g/kg day 1, followed by 0.5g/kg on days 2 and 3) for streptococcal toxic shock syndrome (248–251).</td>
</tr>
<tr>
<td>3. Following intra-abdominal; gynaecological or perineal surgery (255)</td>
<td>Polymicrobial: <em>Enterobacteriaceae</em>, streptococci, anaerobes</td>
<td>I.V. imipenem or I.V. meropenem</td>
<td>In HK, Group A streptococci: more often resistant to clindamycin (50–80%) (243–244). No clinical data exists on the benefit of clindamycin in clindamycin-resistant strains. In vitro and mice data are limited and contradictory (251–254).</td>
</tr>
</tbody>
</table>

In HK, Group A streptococci: more often resistant to clindamycin (50–80%) (243–244). No clinical data exists on the benefit of clindamycin in clindamycin-resistant strains. In vitro and mice data are limited and contradictory (251–254).
<table>
<thead>
<tr>
<th><strong>Usual organisms</strong></th>
<th><strong>Preferred regimens</strong></th>
<th><strong>Alternatives</strong></th>
<th><strong>Special considerations / [usual duration of treatment]</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>• Up to 18% of dog bites become infected; 28–80% of cat bites become infected (258).</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>• Monotherapy with penicillin, cloxacillin or first generation cephalosporin inadequate.</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>• Penicillin allergy: clindamycin plus (levofloxacin/moxifloxacin).</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>• Increasing prevalence of resistance in anaerobes (259); consider adding metronidazole empirically if poor response to cover anaerobes resistant to β-lactams or β-lactam/β-lactamase inhibitor combinations.</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>• Preemptive antimicrobial therapy for 3–5 days is recommended for patients who (a) are immunocompromised, (b) are asplenic, (c) have advanced liver disease, (d) have pre-existing or resultant oedema of the affected area, (e) have moderate to severe injuries, especially to the hand or face, or (f) have injuries that may have penetrated the periosteum or joint capsule (242).</strong></td>
</tr>
<tr>
<td>Central nervous system infections</td>
<td>Usual organisms</td>
<td>Preferred regimens</td>
<td>Alternatives</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>----------------</td>
<td>-------------------</td>
<td>-------------</td>
</tr>
</tbody>
</table>
| **Brain abscess (260–261)**     | Usually polymicrobial with aerobes and anaerobes | I.V. [ceftriaxone or cefotaxime] plus I.V. metronidazole | I.V. meropenem | • Urgent consult neurosurgical.  
  • Exclude primary focus in middle ear, mastoid, paranasal sinuses, dental and lung.  
  • Carbapenem use is associated with a small increased risk of seizures compared with non-carbapenem group of antibiotics (262). |
| **Meningitis (263–265)**        | *S. suis, S. pneumoniae, N. meningitidis, Group B Streptococcus* | I.V. [ceftriaxone or cefotaxime] plus I.V. vancomycin (266) | I.V. meropenem plus I.V. vancomycin (266) | • If impaired cellular immunity e.g. high dose steroid, add ampicillin to cover *Listeria* spp.  
  • If rapid test (e.g. Gram smear, antigen detection) or other clues suggest *S. pneumoniae*, add vancomycin until sensitivity data available.  
  • An adjuvant 4-day regimen dexamethasone 0.15 mg/kg I.V. q6h 10–20 min before the first dose of antibiotic or simultaneously with first antibiotic dose (267). In adults, adjunctive steroids have been shown to reduce mortality and/or hearing loss only in meningitis caused by *Streptococcus pneumoniae* or *Streptococcus suis*. The benefit of steroids in meningitis caused by other bacteria is unclear (267–268).
<table>
<thead>
<tr>
<th>Usual organisms</th>
<th>Preferred regimens</th>
<th>Alternatives</th>
<th>Special considerations / [usual duration of treatment]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Intra-abdominal and gastrointestinal system infections (community-acquired)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Secondary peritonitis</strong>&lt;br&gt;(269–272)&lt;br&gt;(perforated peptic ulcer, other bowel perforation, ruptured appendicitis, diverticulitis)</td>
<td><em>Enterobacteriacea</em>, <em>B. fragilis</em>, other anaerobes, enterococci</td>
<td>I.V. amoxicillin-clavulanate&lt;br&gt;Severe infections (e.g. due to ruptured colon): I.V. piperacillin-tazobactam</td>
<td>• Surgical intervention essential.&lt;br&gt;• ß-lactam/ß-lactamase inhibitors usually can provide coverage against anaerobes. However, due to increasing prevalence of resistance in anaerobes to ß-lactams and ß-lactam/ß-lactamase inhibitors (259), consider adding metronidazole empirically if poor response or treatment failure.</td>
</tr>
<tr>
<td><strong>Cholangitis, cholecystitis or other biliary sepsis</strong>&lt;br&gt;(271,273)</td>
<td><em>Enterobacteriacea</em>, enterococci, <em>Bacteroides</em></td>
<td>I.V. amoxicillin-clavulanate&lt;br&gt;I.V. piperacillin-tazobactam or (I.V. cefuroxime + I.V. metronidazole)</td>
<td>• Adequate biliary drainage essential.&lt;br&gt;• Send bile for culture.&lt;br&gt;• ß-lactam/ß-lactamase inhibitors cover most <em>Enterobacteriacea</em>, enterococci and anaerobes.</td>
</tr>
<tr>
<td>Usual organisms</td>
<td>Preferred regimens</td>
<td>Alternatives</td>
<td>Special considerations / [usual duration of treatment]</td>
</tr>
<tr>
<td>-----------------</td>
<td>--------------------</td>
<td>--------------</td>
<td>--------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Liver abscess</strong> (community-acquired)</td>
<td><em>Klebsiella pneumoniae</em> and other <em>Enterobacteriaceae</em>, <em>Bacteroides</em>, enterococci, <em>Entamoeba histolytica</em>, <em>Streptococcus milleri</em> group</td>
<td>I.V. ceftriaxone + I.V./P.O. metronidazole (for <em>E. histolytica</em>)</td>
<td>For all cases: serology for <em>E. histolytica</em>.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I.V. amoxicillin-clavulanate + I.V./P.O. metronidazole (for <em>E. histolytica</em>)</td>
<td>Computerised tomography guided or open drainage for large abscess.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>For amoebic infection: metronidazole for 10 days then followed by diloxanide.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ophthalmological assessment to rule endophthalmitis if pus aspirate grew <em>Klebsiella pneumoniae</em>.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Endogenous endophthalmitis in patient with <em>Klebsiella</em> liver abscess occurred in 3% to 10.4%, especially if diabetes mellitus (273–280).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ceftriaxone (meningitic dose) is the drug of choice for better central nervous system penetration if concomitant central nervous system involvement is likely to occur. Use of amoxicillin-clavulanate should be reserved for patients with drained abscess, clinical responding and without evidence of endophthalmitis.</td>
</tr>
<tr>
<td><strong>Mild to moderate gastroenteritis</strong></td>
<td>Food poisoning (<em>B. cereus, S. aureus, C. perfringens</em>), <em>Salmonella</em> spp., <em>E. coli, Campylobacter</em> spp., <em>Aeromonas</em> spp.</td>
<td>Routine antibiotic therapy not recommended</td>
<td>Fluid and electrolytes replacement.</td>
</tr>
<tr>
<td>Condition</td>
<td>Usual organisms</td>
<td>Preferred regimens</td>
<td>Alternatives</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>---------------------------------------</td>
<td>--------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Moderate to severe gastroenteritis (presume bacterial) in persons with immunosuppressive disease (e.g. for human immunodeficiency virus (HIV) +ve; high dose steroid when laboratory results not available)</td>
<td><em>Salmonella</em> spp., <em>Campylobacter</em> spp.</td>
<td>P.O. fluoroquinolone</td>
<td></td>
</tr>
<tr>
<td>Severe gastroenteritis (281–285) (laboratory results not available)</td>
<td>≥6 unformed stool /day, fever ≥38.5°C; tenesmus; blood or faecal WBC +ve</td>
<td>P.O. fluoroquinolone</td>
<td></td>
</tr>
</tbody>
</table>
| Traveller’s diarrhoea (285–287) Incidence 10–40%, usually self-limiting | Enterotoxigenic *E. coli* and Enteroaggregative *E. coli*, *Shigella* spp., *Salmonella* spp., *Campylobacter* spp., rarely *Aeromonas*, *Plesiomonas* | P.O. ciprofloxacin 500–750 mg daily, P.O. levofloxacin 500 mg daily or P.O. moxifloxacin 400 mg daily for 1–3 days | P.O. azithromycin 500 mg daily for 3 days or 1g once (first choice in Southeast Asia, India and Nepal, high quinolone resistant *Campylobacter* spp.) | • Chemoprophylaxis is not advised except in immunocompromised patients or HIV patients with CD4 < 200.  
• Avoid loperamide (Imodium) if fever or blood in stool (enteroinvasive).  
• Rifaximin 200 mg t.d.s. for 3 days as alternative in non-invasive disease. |
### Cardiovascular infections

<table>
<thead>
<tr>
<th>Usual organisms</th>
<th>Preferred regimens</th>
<th>Alternatives</th>
<th>Special considerations / [usual duration of treatment]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Subacute infective endocarditis</strong> (chronic rheumatic heart disease, degenerative or congenital valvular diseases) (166,288–293)</td>
<td><em>S. viridans</em>, <em>Haemophilus</em> spp., <em>Aggregatibacter</em> spp., <em>Cardiobacterium hominis</em>, <em>Eikenella corrodens</em>, <em>Kingella</em> spp. (HACEK), enterococci</td>
<td>I.V. ampicillin 2 g q4h + gentamicin 3 mg/kg q24h or 1 mg/kg q8h</td>
<td>The choice of empirical therapy should take into account of the most likely pathogens. Obtain at least 3 sets of blood cultures by 3 different venepuncture over 24 h (put down ‘suspected infective endocarditis’ in test request); then start I.V. antibiotics (294). HACEK organisms: ceftriaxone</td>
</tr>
</tbody>
</table>
| **Acute infective endocarditis** (IVDU) (166,288–293) | *S. aureus* | I.V. cloxacillin 2 g q4h I.V. cefazolin 2 g q8h | - Usually tricuspid valve infection ± metastatic lung abscesses.  
- Blood culture for 3 sets (label ‘? IE’ in laboratory form); then start I.V. antibiotics immediately (294).  
- MRSA concern: Local prevalence of CA-MRSA is low and invasive infection is still rare (24). Consider adding empirical vancomycin if known recurrent CA-MRSA infection, or in critically ill IVDU patients.  
- Consider adding empirical coverage for Gram-negative and fungal organism such as *Pseudomonas aeruginosa* and *Candida* spp. in critically ill IVDU patients. |
The choice of empirical therapy should take into account of the most likely pathogens. Obtain at least 3 sets of blood cultures by 3 different venepuncture over 24 h (put down ‘suspected infective endocarditis’ in test request); then start I.V. antibiotics (294).

<table>
<thead>
<tr>
<th>Gynaecological infections</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pelvic inflammatory disease (PID)</strong> (or upper genital tract infection) (295–298)</td>
</tr>
<tr>
<td><strong>Breast abscess</strong> (303–305)</td>
</tr>
<tr>
<td><strong>Head and neck infections</strong></td>
</tr>
<tr>
<td><strong>Odontogenic or neck infection</strong> (306–307)</td>
</tr>
</tbody>
</table>
### Urinary tract infections

<table>
<thead>
<tr>
<th><strong>Usual organisms</strong></th>
<th><strong>Preferred regimens</strong></th>
<th><strong>Alternatives</strong></th>
<th><strong>Special considerations / [usual duration of treatment]</strong></th>
</tr>
</thead>
</table>
| **Cystitis** (308–311) | *E. coli; S. saprophyticus*, Group B *Streptococcus* | P.O. nitrofurantoin or P.O. amoxicillin-clavulanate | • Encourage fluid intake.  
• Nitrofurantoin should be used with caution in elderly patients; avoid in patients with creatinine clearance <30 mL/min (312).  
• U.S. FDA has recently warned against the use of fluoroquinolones in uncomplicated cystitis due to concern for serious side effects, unless there are no alternative options (313–315). |
| **Acute pyelonephritis** (308–311,316) | *Enterobacteriaceae*, *Enterococcus*, *(Pseudomonas in catheter-related, obstruction, transplant)* | I.V. amoxicillin-clavulanate (I.V. piperacillin-tazobactam if suspect *P. aeruginosa*) or I.V. imipenem or I.V. meropenem | • Blood culture and midstream urine (MSU) cultures, need to rule out obstructive uropathy.  
• I.V. until afebrile 24–48 h, then complete 14 days course with oral drugs.  
• Carbapenem is recommended for severe or rapid deteriorating clinical cases. |
### Respiratory tract infections

<table>
<thead>
<tr>
<th>Usual organisms</th>
<th>Preferred regimens</th>
<th>Alternatives</th>
<th>Special considerations / [usual duration of treatment]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Acute bacterial exacerbation of chronic bronchitis (ABECB)</strong> (317–321)</td>
<td>Respiratory viruses, <em>S. pneumoniae</em>, <em>H. influenzae</em>, <em>M. catarrhalis</em></td>
<td>I.V./P.O. amoxicillin-clavulanate</td>
<td>I.V. cefotaxime [I.V./P.O. fluoroquinolone may be considered for penicillin allergy, or suspected <em>Pseudomonas aeruginosa</em> infection]</td>
</tr>
</tbody>
</table>

Appropriate use of antibiotics in ABECB is imperative to help control the emergence of multidrug resistant organisms.

- Latest Global Initiative for Chronic Obstructive Lung Disease 2017 Recommendation:
  - Antibiotics should be given to patients with:
    - a. Following three cardinal symptoms: increased dyspnoea, increased sputum volume, increased sputum purulence;
    - b. Increased sputum purulence and one other cardinal symptom;
    - c. Requiring mechanical ventilation (invasive or non-invasive).

- *S. pneumoniae* (MIC 1–2 μg/mL) can be treated by high dose P.O. amoxicillin e.g. at least 1.5 g/day or I.V. penicillin G (high dose amoxicillin-clavulanate e.g. 1 g b.d. if co-infection by ampicillin-resistant *H. influenzae*) (318).

- U.S. FDA has recently warned against the use of fluoroquinolones in ABECB due to concern for serious side effects, unless there are no alternative options (313–315).
<table>
<thead>
<tr>
<th>Acute bacterial exacerbation or pneumonia in patient with bronchiectasis (322–324)</th>
<th>Usual organisms</th>
<th>Preferred regimens</th>
<th>Alternatives</th>
<th>Special considerations / [usual duration of treatment]</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. aeruginosa H. influenzae, M. catarrhalis, S. pneumoniae</td>
<td>I.V. piperacillin-tazobactam</td>
<td>I.V. ceftazidime</td>
<td>For P. aeruginosa, levofloxacin should be given at high dose (e.g. P.O. 500–750 mg once daily).</td>
<td></td>
</tr>
<tr>
<td>Aspiration pneumonia (325)</td>
<td>Oral anaerobes: Bacteroides, Peptostreptococci, Fusobacterium, S. milleri group</td>
<td>I.V./P.O. amoxicillin-clavulanate or (I.V. ceftriaxone + P.O. metronidazole)</td>
<td>I.V. ticarcillin-clavulanate or I.V. piperacillin-tazobactam</td>
<td>Penicillin allergy: levofloxacin plus (clindamycin or metronidazole).</td>
</tr>
<tr>
<td>Community-acquired pneumonia (CAP)</td>
<td>S. pneumoniae, H. influenzae, M. pneumoniae, C. pneumoniae, C. psittaci (influenza A, M. tuberculosis)</td>
<td>P.O. amoxicillin-clavulanate (e.g. 1 g b.d.) ± doxycycline or P.O. high dose amoxicillin (at least 1.5 g/day) ± doxycycline</td>
<td>P.O. levofloxacin</td>
<td>Penicillin allergy: levofloxacin meta-analysis of 127 studies (n=33,148): S. pneumoniae (73%); H. influenzae (14%); S. aureus (3%); Gram-negative rods (2%). In HK, macrolide/azalide, tetracycline or cotrimoxazole should not be used alone for empiric treatment of CAP. Locally, 50–70% penicillin-sensitive and penicillin-resistant S. pneumoniae isolates (both community and hospital isolates) are multi-resistant to these agents (1,328–329).</td>
</tr>
<tr>
<td>Usual organisms</td>
<td>Preferred regimens</td>
<td>Alternatives</td>
<td>Special considerations / [usual duration of treatment]</td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td>-------------------</td>
<td>--------------</td>
<td>------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>2. CAP, hospitalised in general ward (326–327,330–333)</td>
<td>As above</td>
<td>I.V./P.O. amoxicillin-clavulanate ± P.O. doxycycline</td>
<td>I.V. ceftriaxone ± P.O. doxycycline</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Modifying factors: bronchiectasis: either (ticarcillin-clavulanate or piperacillin-tazobactam or cefepime) + a macrolide; or fluoroquinolone + an aminoglycoside.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Rapid test for diagnosis of <em>Legionella</em> infection:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Urine antigen for <em>Legionella pneumophila</em> serogroup 1 (sensitivity 70%, specificity 100%). Or</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Detection of nucleic acid of <em>Legionella</em> spp. from respiratory specimens by a validated assay (e.g. PCR) in selected cases.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Local prevalence of MRMP is estimated to be &gt;40%, hence doxycycline is the preferred atypical coverage for hospitalised patients in general wards (118).</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• With concern for influenza: add oseltamivir 75 mg b.d.</td>
<td></td>
</tr>
</tbody>
</table>
3. CAP, hospitalised in ICU or serious pneumonia (326–327, 330–333)

<table>
<thead>
<tr>
<th>Usual organisms</th>
<th>Preferred regimens</th>
<th>Alternatives</th>
<th>Special considerations / [usual duration of treatment]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enterobacteriaceae</td>
<td>As above + I.V. piperacillin-tazobactam or ceftiraxone + a macrolide (doxycycline is preferred over macrolides for young patients at low risk of Legionella pneumonia, to cover MRMP)</td>
<td>I.V. cefepime + a macrolide (or P.O. doxycycline)</td>
<td>• Ticarcillin-clavulanate and ceftazidime are not useful against penicillin-non-susceptible S. pneumoniae.</td>
</tr>
<tr>
<td></td>
<td>[+P.O. oseltamivir 75 mg b.d. during influenza season]</td>
<td></td>
<td>• Rapid test for diagnosis of Legionella infection:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Urine antigen for Legionella pneumophila serogroup 1 (sensitivity 70%, specificity 100%). Or</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Detection of nucleic acid of Legionella spp. from respiratory specimens by a validated assay (e.g. PCR) in all cases.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• With concern for CA-MRSA: (e.g. presence of Gram-positive cocci in cluster, history of recurrent boils/abscesses or skin infections or preceding “flu-like” illness, together with features suggestive the presence of PVL +ve S. aureus: shock, haemoptysis, leucopenia, multilobular infiltrates, etc.), then add I.V. linezolid 600 mg q12h (preferred) or I.V. vancomycin 1 g q12h.</td>
</tr>
</tbody>
</table>
**Hospital-acquired pneumonia (HAP)**

<table>
<thead>
<tr>
<th>Hospital-acquired pneumonia (HAP)</th>
<th>Usual organisms</th>
<th>Preferred regimens</th>
<th>Alternatives</th>
<th>Special considerations / [usual duration of treatment]</th>
</tr>
</thead>
<tbody>
<tr>
<td>HAP, onset &lt;4 days after admission + no previous antibiotics (326,334–335)</td>
<td><em>S. pneumoniae</em>, <em>H. influenzae</em>, <em>M. catarrhalis</em>, <em>S. aureus</em></td>
<td>I.V./P.O. amoxicillin-clavulanate</td>
<td>I.V. ceftriaxone</td>
<td></td>
</tr>
</tbody>
</table>
| HAP, onset ≥4 days after admission + had antibiotics recently, OR onset ≥5 days after admission OR mechanical ventilation (326,334–335) | *MRSA*, *P. aeruginosa*, *Acinetobacter*, *Klebsiella spp.*, *Enterobacter spp.* | I.V. piperacillin-tazobactam | I.V. imipenem-cilastatin OR I.V. meropenem | • With ESBL concern: I.V. imipenem/meropenem  
• With MRSA concern: Add vancomycin |

---

**Footnote**

1 Classification and definition of group A streptococcal toxic shock syndrome (336)

*Definite case* = criteria IA + IIA + IIB; *probable case* = criteria IB + IIA + IIB

**Criteria IA:** Isolation of Group A streptococci (*Streptococcus pyogenes*) from a normally sterile site (e.g. blood, cerebrospinal, pleural, or peritoneal fluid, tissue biopsy, surgical wound).

**Criteria IB:** Isolation of Group A streptococci (*Streptococcus pyogenes*) from a nonsterile site (e.g. throat, sputum, vagina, superficial skin lesion).
Criteria IIA: Hypotension, systolic blood pressure ≤90 mmHg in adults or <5th percentile for age in children, and;

Criteria IIB: ≥2 of the following signs:

(a) Renal impairment: creatinine ≥177 µmol/L for adults or >2× the upper limit of normal for age. In patients with pre-existing renal disease, a ≥2-fold elevation over the baseline level.

(b) Coagulopathy: platelets ≤100,000/mm³ or disseminated intravascular coagulopathy defined by prolonged clotting times, low fibrinogen level, and the presence of fibrin degradation products.

(c) Liver involvement: alanine aminotransferase (ALT), asparate aminotransferase (AST), or total bilirubin levels >2× the upper limit of normal for age. In patients with pre-existing liver disease, a ≥2-fold elevation over the baseline level.

(d) Adult respiratory distress syndrome defined by acute onset of diffuse pulmonary infiltrates and hypoxaemia in the absence of cardiac failure, or evidence of diffuse capillary leak manifested by acute onset of generalised oedema, or pleural or peritoneal effusions with hypoalbuminaemia.

(e) A generalised erythematous macular rash that may desquamate.

(f) Soft tissue necrosis, including necrotising fasciitis or myositis, or gangrene.
4.2 Guidelines on the use and choice of antibiotics in severe acute pancreatitis (SAP)

1. **Criteria for severity assessment of acute pancreatitis** *(Table 4.2)*
   Most acute pancreatitis is mild. SAP occurs in about 5–13% of all patients with mortality rates of 30% (337–341). SAP is currently defined as having persistent (>48h) single or multiple organ failure as a result of acute pancreatitis, which is most often associated with local (such as peri-pancreatic collections) and/or systemic complications. Patients diagnosed to have SAP are advised to be transferred for close monitoring and treatment in an ICU. Numerous clinical and laboratory findings have been shown to be associated with severe disease course in acute pancreatitis. A number of well-known scoring systems have been employed to predict disease severity at or shortly after admission, though none of which is clearly superior in performance: (a) Ranson score (≥3); (b) persistent systemic inflammatory response syndrome >48h (Table 4.2); (c) bedside index for severity in acute pancreatitis score (≥3); and acute physiology and chronic health evaluation II (APACHE II) criteria (≥8) (340,342–346). A C-reactive protein value of ≥150 µg/mL has also been shown to be useful in predicting the severity of acute pancreatitis (347).

2. **Routine antibiotic prophylaxis not beneficial**
   Despite previous uncertainty over this issue due to conflicting evidence in the literature (348–356), the current consensus is that prophylactic use of antibiotics in acute pancreatitis is not advisable (343–346,357–361). Documented drawbacks of prophylactic antibiotics included selection of multidrug-resistant organisms (MRSA, CRAB, resistant *Enterobacteriaceae*), increased *Candida* infections, and antibiotic-related adverse event which may lead to poorer patient outcomes (337,362–370). Therefore, broad-spectrum antibiotics should only be used when clinical factors point to infected pancreatic necrosis (greatest risk in those with >30% pancreatic necrosis) (371).
3. **Management of pancreatic necrosis when infection is suspected**

(Figure 4.1) (340–341, 343–346, 360–361)

Infected necrosis should be considered in patients with pancreatic or extrapancreatic necrosis who deteriorate or fail to improve after 7–10 days of hospitalisation. The finding on computerised tomography of gas within a collection or necrotic area is considered strong evidence of infection. When infected necrosis is suspected, computerised tomography or ultrasound guided-fine-needle aspiration of necrotic area for culture can be performed, or empirical antibiotics with good penetration into pancreatic tissue and providing broad coverage against enteric Gram-negatives bacilli and anaerobes may be given (e.g. an I.V. carbapenem) (338–339, 372–373). Although unstable patients with infected necrosis should undergo urgent debridement, current consensus is that the initial management of infected necrosis for patients who are clinically stable should be a course of antibiotics before intervention to allow the inflammatory reaction to become better organised. If the patient remains ill and the infected necrosis has not resolved, minimally invasive necrosectomy by endoscopic, radiologic, video-assisted retroperitoneal, laparoscopic approach, or combination thereof, or open surgery is recommended once the necrosis is walled-off.

### Table 4.2 Severity grading of acute pancreatitis according to revised Atlanta criteria (2012) (374)

<table>
<thead>
<tr>
<th><strong>Mild acute pancreatitis</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>No organ failure</td>
</tr>
<tr>
<td>No local or systemic complications</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Moderately severe acute pancreatitis</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Organ failure that resolves within 48 h (transient organ failure) and/or Local or systemic complications without persistent organ failure</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Severe acute pancreatitis</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Persistent organ failure (&gt;48 h)</td>
</tr>
<tr>
<td>• Single organ failure</td>
</tr>
<tr>
<td>• Multiple organ failure</td>
</tr>
</tbody>
</table>
**Figure 4.1 Management of pancreatic necrosis when infection is suspected** (343)

Pancreatic necrosis: suspected of infection

- Obtain CT-guided fine-needle aspiration
  - Negative Gram stain and culture
    - STERILE NECROSIS: supportive care, consider repeat fine-needle aspiration every 5 days if clinically indicated
  - Positive Gram stain and/or culture
    - Infected necrosis
      - Clinically stable: Continue antibiotics and observe... delayed minimally invasive surgical, endoscopic, or radiologic debridement. If asymptomatic: consider no debridement
      - Clinically unstable: Prompt surgical debridement

- Empiric use of necrosis penetrating antibiotics
4.3 Management of community-acquired pneumonia (CAP)

4.3.1 General considerations and principles

1. A number of guidelines on the management of CAP were released or updated recently. While these guidelines were drawn on the basis of the same set of literature, patient stratification and specific suggestions still vary quite a bit (326,330–332).

2. Newer studies (375–376) continue to support the notion stated in guidelines that *S. pneumoniae* is one of the most common pathogens identified in CAP. Hence, the choice of agents for empirical therapy should consider the regional data on prevalence and risk factors for drug-resistant *S. pneumoniae* (DRSP).

3. Appropriate antimicrobial therapy should be initiated as soon as possible (333,377–378).

4. **Factors to be considered in choosing empirical therapy for CAP:**
   a). **Place of therapy** (outpatient, inpatient ward, or ICU).
   b). **Role of atypical pathogens** (e.g. *Chlamydia pneumoniae*, *Mycoplasma pneumoniae* and *Legionella* spp.) is increasingly being recognised. Coverage for atypical pathogens should always be given for hospitalised patients with moderate to severe disease, although it is considered optional for non-hospitalised patients with low-severity CAP (326,330).
   c). **Presence of modifying factors** including risk factors for DRSP (e.g. age >65 years, ß-lactam therapy within past 3 months, alcoholism, multiple medical comorbidities, exposure to a child in a day care centre), enteric Gram-negatives (residence in a nursing home, underlying cardiopulmonary disease, multiple medical comorbidities, recent antibiotic therapy), and *P. aeruginosa* (e.g. bronchiectasis).
   d). **Emerging resistance patterns** among the major pathogens. In Asia, including HK, high prevalence of macrolide resistance has been reported among *Mycoplasma pneumoniae* strains in recent years (113–115,118,379–380).
   e). **Emerging pathogens** including those of regional significance such as CA-MRSA (association with necrotising pneumonia and influenza virus coinfection), *Klebsiella pneumoniae* (association with disseminated infection, liver abscess and diabetes mellitus) and *Burkholderia pseudomallei* (occur in melioidosis endemic area during rainy season) (381–382).
5. Several antibiotics active against *P. aeruginosa*, including cefepime, imipenem, meropenem and piperacillin-tazobactam are generally active against DRSP. They can be used for patients having specific risk factors for *P. aeruginosa*.

6. If a macrolide is relied upon for coverage of *H. influenzae*, the newer macrolides (e.g. clarithromycin or azithromycin) should be used instead of erythromycin.

7. For most patients, appropriately chosen initial antibiotic therapy should not be changed in the first 72 hours, unless there is marked clinical deterioration.

8. Most patients with CAP will have an adequate clinical response within 72 hours. After the patient has met appropriate criteria, switch from I.V. to P.O. therapy can be made.

### 4.3.2 Management of community-acquired pneumonia (CAP) in the era of pneumococcal resistance: conclusions from the CDC working group

1. Comparative studies of adults and children have reported that pneumonia due to penicillin-nonsusceptible pneumococci (most had MIC >0.1–1 µg/mL) does not influence the outcome of pneumonia treatment (383–384). At higher level of resistance (penicillin MIC 2–4 µg/mL), recent evidence suggests that risk of mortality or suppurative complications were increased (385–386). In one study (387), the observed increase in mortality was confined to patients with pneumococcal isolates with penicillin MIC of ≥4 µg/mL.

2. Since 2012, different breakpoints have been used for interpretation of penicillin susceptibility according to the site of infections and route of drug administration (388–389).

#### Table 4.3 Interpretation of penicillin susceptibility for *S. pneumoniae*

<table>
<thead>
<tr>
<th>Syndrome, route of administration and agent</th>
<th>Penicillin or amoxicillin MIC (µg/mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meningitis, Parenteral penicillin</td>
<td>Susceptible: ≤ 0.06</td>
</tr>
<tr>
<td>Non-meningitis, Parenteral penicillin</td>
<td>Susceptible: ≤ 2</td>
</tr>
<tr>
<td>Non-meningitis, Oral (high dose) amoxicillin or amoxicillin-clavulanic acid</td>
<td>Susceptible: ≤ 2</td>
</tr>
<tr>
<td>Oral penicillin V</td>
<td>Susceptible: ≤ 0.06</td>
</tr>
</tbody>
</table>
By modifying the breakpoints, it is hope that there will be decreased use of broad-spectrum antimicrobial therapy in favour of more narrow-spectrum therapy. Patients with pneumococcal pneumonia caused by strains with penicillin MIC ≤1 µg/mL can be treated appropriately with optimal dosage of I.V. penicillin and several other P.O./I.V. ß-lactams. Comparative anti-pneumococcal activities of commonly used ß-lactams are shown in Table 4.4.

3. Vancomycin is not routinely indicated for treatment of CAP or for pneumonia caused by DRSP.

4. The CDC working group does not advocate the use of newer fluoroquinolones for first line treatment of CAP. The reasons are:

   a). Most penicillin-nonsusceptible *S. pneumoniae* pneumonia can be appropriately treated with a ß-lactam with good anti-pneumococcal activity at optimal dosage.

   b). Concerns that resistance among pneumococci will rapidly emerge after widespread use of this class of antibiotics.

   c). Their activity against pneumococci with high level penicillin resistance (MIC ≥4 µg/mL) makes it important that they should be reserved for selected patients with CAP.

5. Indications for use of fluoroquinolones in CAP

   a). Adults for whom one of the first line regimen has already failed.

   b). Allergic to alternative agents.

   c). Documented infection due to pneumococci with high level penicillin resistance (penicillin MIC ≥4 µg/mL).

### 4.3.3 Regional considerations for *S. pneumoniae*

1. In HK, reduced susceptibility to penicillin (Figure 4.2) and resistance to macrolides were high in both hospital (328,390–393) and community settings (394–397). Recent evidence suggests increase in carriage of certain serotypes (such as 15) after introduction of childhood vaccination by pneumococcal conjugate vaccine-13 (392–393,397), although the significance of this phenomenon remains uncertain at this stage.

2. Erythromycin resistant isolates are also resistant to the newer macrolides/azalides such as clarithromycin and azithromycin (398). In 2012–2016, the age group-specific rates of macrolide resistance among 775 invasive pneumococcal isolates were as follows: 76% in <5 years, 92% in 5–17 years, 74% in 18–64 years and 75% in ≥65 years. Accordingly, macrolides should not be used as sole therapy for empirical treatment of presumed pneumococcal infection.
3. Globally, resistance to fluoroquinolones among the pneumococci is low (<1–2%). HK is one of the rare exceptions in which fluoroquinolone resistance (levofloxacin MIC ≥8 µg/mL) is emerging among the *S. pneumoniae*, especially among respiratory isolates from elderly patients with chronic lung diseases (390). One regional study found an association between levofloxacin resistance and mortality in adult patients with invasive pneumococcal disease (399).

4. In view of the above, adherence to the CDC guidelines on the use of the fluoroquinolones seems appropriate. Moreover, tuberculosis (TB) is prevalent in HK and was reported to account for ~10% of CAP in the elderly. Excess use of fluoroquinolones in CAP may lead to: (1) delay in diagnosis of TB; (2) increased fluoroquinolone resistance among *Mycobacterium tuberculosis* (400–401). Hence, this class of agents is not recommended as first line (or routine) therapy in HK for CAP. In this regard, extra care need to be exercised in using fluoroquinolones in patients with risk factors for fluoroquinolone-resistant *S. pneumoniae* (402–403):
   a). Presence of chronic obstructive pulmonary disease;
   b). Underlying cerebrovascular disease;
   c). Residence in old age home;
   d). Past exposure to fluoroquinolones; and
   e). Healthcare-associated/nosocomial pneumococcal infection.

5. Ciprofloxacin and ofloxacin should not be used to treat pneumococcal infection. Use of a suboptimal dose of fluoroquinolone should be avoided (e.g. the dose/frequency approved by FDA for levofloxacin in CAP is 500 mg/day). Use of <500 mg and in divided doses should be avoided as these have been showed to be associated with the emergence of fluoroquinolone-resistant *S. pneumoniae* (329). If a respiratory fluoroquinolone is indicated, there is evidence to suggest that the more potent ones (e.g. moxifloxacin) are less likely to lead to development of resistance.

6. Penicillin G (I.V.) or ampicillin (P.O./I.V.) or amoxicillin (P.O./I.V.) are generally viewed as the β-lactam drugs of choice for treating infections with penicillin-susceptible and penicillin-intermediate strains of *S. pneumoniae*. The following β-lactams are not recommended because of poor intrinsic activities against *S. pneumoniae*: penicillin V, all first generation cephalosporins, cefaclor, cefixime, ceftibuten, and loracarbef.

7. Lung infections involving strains with intermediate susceptibility to penicillin (MIC 0.1–1 µg/mL) may be treated with I.V. penicillin G or P.O. amoxicillin (high dose).
8. Penicillins combined with β-lactamase inhibitors (ampicillin-sulbactam, amoxicillin-clavulanate, piperacillin-tazobactam) are active against β-lactamase-producing organisms including *H. influenzae*, *M. catarrhalis*, and methicillin-sensitive *S. aureus*. Except in patients with mixed infection, these drugs offer no advantage over penicillin G or amoxicillin for the treatment of *S. pneumoniae* pneumonia, including those due to penicillin-resistant strains because β-lactamase is not produced by *S. pneumoniae*. The MIC of ampicillin, amoxicillin, piperacillin for most local strains were similar to that of penicillin. However, the MIC of ticarcillin is increased disproportionally among penicillin non-susceptible strains.

**Figure 4.2 Susceptibility of 775 invasive pneumococcal isolates to penicillin and cefotaxime according to patient age groups, 2012–2016, HK**
Table 4.4 Comparative activities of commonly used β-lactams against *S. pneumoniae* with different levels of penicillin susceptibility

<table>
<thead>
<tr>
<th>Agent</th>
<th>Penicillin MIC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≤0.06 µg/mL</td>
</tr>
<tr>
<td>Penicillin V</td>
<td>+++</td>
</tr>
<tr>
<td>Penicillin G</td>
<td>+++</td>
</tr>
<tr>
<td>Ampicillin P.O.</td>
<td>+++</td>
</tr>
<tr>
<td>Ampicillin I.V.</td>
<td>+++</td>
</tr>
<tr>
<td>Amoxicillin P.O.</td>
<td>+++</td>
</tr>
<tr>
<td>Piperacillin</td>
<td>+++</td>
</tr>
<tr>
<td>Ticarcillin</td>
<td>++</td>
</tr>
<tr>
<td>Cefotaxime</td>
<td>+++</td>
</tr>
<tr>
<td>Ceftriaxone</td>
<td>+++</td>
</tr>
<tr>
<td>Cefepime</td>
<td>+++</td>
</tr>
<tr>
<td>Cefuroxime I.V.</td>
<td>+++</td>
</tr>
<tr>
<td>Cefuroxime P.O.</td>
<td>+++</td>
</tr>
<tr>
<td>Cefpodoxime</td>
<td>+++</td>
</tr>
<tr>
<td>Ceftazidime</td>
<td>+++</td>
</tr>
<tr>
<td>Cefaclor</td>
<td>+++</td>
</tr>
<tr>
<td>Cefixime/ceftibuten</td>
<td>+++</td>
</tr>
<tr>
<td>Imipenem/meropenem</td>
<td>+++</td>
</tr>
</tbody>
</table>

Penicillin MIC interpretation criteria (µg/mL) for I.V. penicillin G: meningitis ≤0.06 sensitive, ≥0.12 resistant; nonmeningitis ≤2 sensitive, 4 intermediate and ≥8 resistant.

Approximate in vitro activity was indicated by: - inactive, + weak activity, ++ good activity, +++ excellent activity, ± variable or dose-dependent
Part V: Guidelines for known-pathogen therapy
### Table 5.1 Guidelines for known-pathogen therapy

<table>
<thead>
<tr>
<th>Drug of choice</th>
<th>Alternatives</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Acinetobacter baumannii</strong></td>
<td>I.V. cefoperazone-sulbactam + an aminoglycoside (mixed infection with <em>P. aeruginosa</em>)</td>
<td>Sulbactam is highly active against <em>Acinetobacter</em></td>
</tr>
<tr>
<td></td>
<td>Fluoroquinolone + an aminoglycoside (if allergic to penicillin)</td>
<td>Resistance rates in 2010: ampicillin-sulbactam (24%), cefoperazone-sulbactam (24%), imipenem (37%), gentamicin (32%), amikacin (25%), ciprofloxacin (50%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For multidrug-resistant isolates: consult microbiologist or infectious disease physician</td>
</tr>
<tr>
<td><strong>Clostridium difficile</strong></td>
<td>P.O. vancomycin (if metronidazole fails as documented microbiologically)</td>
<td>Mild/moderate disease: clinical efficacy of metronidazole = vancomycin</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Severe disease, ileus or toxic megacolon: I.V. metronidazole + P.O. vancomycin + consult surgeon</td>
</tr>
<tr>
<td></td>
<td></td>
<td>First recurrence: same as primary infection based on severity of disease</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Multiple recurrence: consult microbiologist or infectious disease physician, options include vancomycin taper or faecal microbiota transplant (406)</td>
</tr>
<tr>
<td><strong>Drug of choice</strong></td>
<td><strong>Alternatives</strong></td>
<td><strong>Remarks</strong></td>
</tr>
<tr>
<td>-------------------</td>
<td>-----------------</td>
<td>-------------</td>
</tr>
</tbody>
</table>
| *Enterobacter cloacae complex* | - P.O./I.V. levofloxacin/ciprofloxacin for urinary tract infection  
- I.V. cefepime (+ an aminoglycoside) for severe infection  
- I.V. piperacillin-tazobactam | - I.V. carbapenem (for severe infection and/or ESBL-producing strain) | - Cefepime is highly active in vitro against almost all *Enterobacter* isolates  
- Emergence of AmpC derepressed mutants emerge in 20–40% of infections treated with the second or third generation cephalosporins. Use of these agents for serious infections is not recommended  
- One study in HK found high prevalence of ESBL production among *E. hormaechei* (a member of the *E. cloacae* complex) (407)  
- Resistance rate in 2010: levofloxacin (8%), gentamicin (4%), amikacin (1%)  
- For multidrug-resistant isolates: consult microbiologist or infectious disease physician |
<table>
<thead>
<tr>
<th>Drug of choice</th>
<th>Alternatives</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>E. coli</strong> (ESBL-neg)</td>
<td>I.V./P.O. cefuroxime (if resistant to amoxicillin-clavulanate), add I.V./P.O. metronidazole (if mixed infection with anaerobes likely)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>I.V. piperacillin-tazobactam + an aminoglycoside (if <em>P. aeruginosa</em> or <em>Acinetobacter</em> are co-pathogens)</td>
<td></td>
</tr>
<tr>
<td><strong>Haemophilus influenzae</strong></td>
<td>P.O. amoxicillin or P.O./I.V. ampicillin-sulbactam or amoxicillin-clavulanate or cefotaxime or ceftriaxone</td>
<td>Fluoroquinolones (if allergic to penicillin)</td>
</tr>
<tr>
<td>Drug of choice</td>
<td>Alternatives</td>
<td>Remarks</td>
</tr>
<tr>
<td>----------------</td>
<td>--------------</td>
<td>---------</td>
</tr>
<tr>
<td><strong>Klebsiella pneumoniae (ESBL-neg)</strong></td>
<td>I.V./P.O. ampicillin-sulbactam or amoxicillin-clavulanate (add an aminoglycoside if rapid bactericidal action desirable on clinical grounds)</td>
<td>I.V./P.O. cefuroxime (if resistant to amoxicillin-clavulanate), add I.V./P.O. metronidazole (if mixed infection with anaerobes likely)</td>
</tr>
<tr>
<td><strong>E. coli / K. pneumoniae (ESBL-pos)</strong></td>
<td>P.O. nitrofurantoin or P.O. amoxicillin-clavulanate (uncomplicated urinary tract infection and other mild infections)</td>
<td>Carbapenem or I.V. β-lactam/β-lactamase inhibitor for bacteraemia or other serious infection</td>
</tr>
<tr>
<td>Drug of choice</td>
<td>Alternatives</td>
<td>Remarks</td>
</tr>
<tr>
<td>----------------</td>
<td>--------------</td>
<td>---------</td>
</tr>
</tbody>
</table>
| **Pseudomonas aeruginosa** | I.V. piperacillin or ticarcillin-clavulanate or piperacillin-tazobactam + an aminoglycoside | I.V. cefoperazone-sulbactam + an aminoglycoside (mixed infection with *Acinetobacter*)  
I.V./P.O. levofloxacin/ciprofloxacin + an aminoglycoside (if allergic to penicillin) | Combination therapy recommended (for synergism) for all serious infection except for uncomplicated catheter-related bacteraemia  
Piperacillin-tazobactam used instead of ceftazidime due to rapid rise in AmpC type and ESBL-producers in *Enterobacteriaceae*  
For multidrug-resistant isolates: consult microbiologist or infectious disease physician |
| **Methicillin-sensitive S. aureus** | P.O./I.V. cloxacillin or amoxicillin-clavulanate or ampicillin-sulbactam or first generation cephalosporin | I.V. cefazolin (if allergic to penicillin, but limited to those with minor allergy such as rash alone)  
Clindamycin (if allergic to penicillin) |
<table>
<thead>
<tr>
<th>Drug of choice</th>
<th>Alternatives</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Methicillin-resistant <em>S. aureus</em></strong></td>
<td>I.V. vancomycin (bacteraemia or other invasive infections)</td>
<td>• I.V./P.O. linezolid or I.V. daptomycin if (1) vancomycin allergy - extensive rash, other than red-man syndrome develop after vancomycin, or (2) bacteraemia caused by MRSA with vancomycin ≥ 2 µg/mL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Cotrimoxazole, fusidic acid or rifampicin are useful adjuncts for deep-seated infections (e.g. osteomyelitis) but these agents should not be administered as monotherapy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Most abscesses or uncomplicated skin and soft tissue infection caused by CA-MRSA could be treated with drainage and oral antibiotics with in vitro activities (e.g. clindamycin or cotrimoxazole)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Vancomycin intermediate <em>Staphylococcus aureus</em>/vancomycin resistant <em>Staphylococcus aureus</em>: consult microbiologist or infectious disease physician</td>
</tr>
<tr>
<td><strong>Mycoplasma pneumoniae</strong></td>
<td>• P.O. doxycycline (or I.V. minocycline)</td>
<td>• P.O. azithromycin</td>
</tr>
<tr>
<td></td>
<td>• I.V./P.O. levofloxacin or moxifloxacin</td>
<td>• Doxycycline preferred over azithromycin in view of increasing macrolide resistant <em>Mycoplasma pneumoniae</em> (379)</td>
</tr>
</tbody>
</table>

**IMPACT Fifth Edition (version 5.0)**

104
<table>
<thead>
<tr>
<th>Strain</th>
<th>Drug of choice</th>
<th>Alternatives</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Stenotrophomonas maltophilia</em></td>
<td>P.O./I.V. cotrimoxazole + I.V. ticarcillin-clavulanate</td>
<td>● I.V./P.O. cotrimoxazole + fluoroquinolone</td>
<td>● Cotrimoxazole + ticarcillin-clavulanate is synergistic in vitro. Cotrimoxazole is a key component in therapy</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>● Combination therapy recommended for synergy and to prevent resistance</td>
</tr>
<tr>
<td><em>Streptococcus pneumoniae</em></td>
<td>● Penicillin-sensitive: I.V. penicillin G (4–8 million unit/day, q6h)</td>
<td>● β-lactam/β-lactamase inhibitor combination with the exception of cefoperazone-sulbactam (for mixed infections)</td>
<td>● Most pneumococcal pneumonia can be treated with high dose amoxicillin or high dose amoxicillin-clavulanate</td>
</tr>
<tr>
<td></td>
<td>● Penicillin-intermediate: I.V. penicillin G (high dose, 12–18 million unit/day, q4h)</td>
<td>● P.O./I.V. levofloxacin or P.O./I.V. moxifloxacin (if allergic to penicillin) for non-meningeal infections and penicillin-sensitive strains</td>
<td>● For pure pneumococcal infection, penicillin G instead of amoxicillin-clavulanate is preferred, switch therefore recommended</td>
</tr>
<tr>
<td></td>
<td>● Penicillin-resistant: I.V. cefotaxime or ceftriaxone</td>
<td></td>
<td>● &gt;70% resistant to erythromycin. Cross-resistance to clindamycin is very common</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>● Resistance to erythromycin = resistance to other newer macrolides (clarithromycin, azithromycin)</td>
</tr>
<tr>
<td>Drug of choice</td>
<td>Alternatives</td>
<td>Remarks</td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td>--------------</td>
<td>---------</td>
<td></td>
</tr>
<tr>
<td><strong>Streptococcus pneumoniae</strong> (for central nervous system infection)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Penicillin-sensitive (MIC ≤ 0.06 µg/mL): I.V. penicillin G (18–24 million unit/day, q4h) or I.V. ampicillin 2 g q4h</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Penicillin-resistant (MIC ≥ 0.12 µg/mL) and third-generation cephalosporin (MIC &lt;1 µg/mL): I.V. cefotaxime 2 g q4h or I.V. ceftriaxone 2 g q12h</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Penicillin-resistant (MIC ≥ 0.12 µg/mL) and third-generation cephalosporin (MIC ≥ 1 µg/mL): I.V. vancomycin plus I.V. cefotaxime 2 g q4h or ceftriaxone 2 g q12h</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• MIC (meningitis) breakpoints for penicillin, ceftriaxone and cefotaxime to be used here</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• In S. pneumoniae, cross resistance between penicillin and ceftriaxone/cefotaxime is common (391,408). Local data indicates that approximately half of the penicillin-resistant (meningitis) isolates are intermediate/resistant (meningitis) to cefotaxime</td>
<td></td>
</tr>
</tbody>
</table>

Note:

1 CLSI MIC (µg/mL) breakpoints for penicillin G: sensitive ≤ 0.06; intermediate 0.12–1; resistant ≥ 2. These breakpoints were decided mainly for the relevance on meningitis. For pneumococcal pneumonia, pharmacokinetic/dynamic data indicates that isolates with MIC of up to 1–2 µg/mL should be considered ‘sensitive’ to appropriate dose of penicillin, ampicillin and amoxicillin.
Part VI: Guidelines for surgical prophylaxis
1. **Duration of prophylaxis**: The duration of antimicrobial prophylaxis should not routinely exceed 24 hours (1 dose at induction and 2 more doses postoperatively, i.e. 3 doses in total). There is wide consensus that only a single dose of I.V. antimicrobial agent is needed for surgical prophylaxis in the great majority of cases including orthopaedic surgery with prosthesis. Published evidence shows that antimicrobial prophylaxis after wound closure is unnecessary even in the presence of a drain. Most studies comparing single- with multiple-dose prophylaxis have not shown benefit of additional doses.

2. **Timing**: For many prophylactic antimicrobial agents, the administration of an initial dose should be given within 30 minutes before incision (coinciding with the induction of anaesthesia) to achieve a bactericidal serum and tissue concentration at the time of initial incision. This can be facilitated by having the anaesthesiologist administer the drug in the operating room at induction.

3. **Antimicrobial dosing**: The dose should be adequate based on the patient’s body weight. An additional dose of antimicrobial agent should be given (intraoperatively) if the operation is still continuing after two half-lives of the initial dose or massive intraoperative blood losses occur.

References: (409–491)
Table 6.1  Suggested initial dose and time to re-dose for selected antimicrobial agents used for surgical prophylaxis

<table>
<thead>
<tr>
<th>Antimicrobial agent</th>
<th>Standard(^1) I.V. dose</th>
<th>Recommended re-dosing interval (hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cefazolin</td>
<td>1–2 g</td>
<td>2–5</td>
</tr>
<tr>
<td>Cefuroxime</td>
<td>1.5 g</td>
<td>3–4</td>
</tr>
<tr>
<td>Clindamycin</td>
<td>600–900 mg</td>
<td>3–6</td>
</tr>
<tr>
<td>Amoxicillin-clavulanate</td>
<td>1.2 g</td>
<td>2–3</td>
</tr>
<tr>
<td>Ampicillin-sulbactam</td>
<td>1.5 g</td>
<td>2–3</td>
</tr>
<tr>
<td>Metronidazole</td>
<td>500 mg</td>
<td>6–8</td>
</tr>
<tr>
<td>Vancomycin</td>
<td>1 g infuse over 60 min</td>
<td>6–12</td>
</tr>
</tbody>
</table>

\(^1\)In patient with normal renal function and not morbidly obese.
<table>
<thead>
<tr>
<th>Type of operation</th>
<th>Indications</th>
<th>Recommended drugs¹</th>
</tr>
</thead>
</table>
| Cardiac²          | • Prosthetic valve  
                  • Coronary artery bypass  
                  • Pacemaker implant  
                  • Open heart surgery  | • I.V. cefazolin 1 g³ then every 4 hours  
                   **Note:** The duration of antimicrobial prophylaxis should not be longer than 48 hours. |
| Thoracic²         | • Pulmonary resection  
                  • Closed tube thoracostomy for chest trauma  | • I.V. cefazolin 1 g³  
                  • I.V. cefuroxime 1.5 g  
                  • I.V. amoxicillin-clavulanate 1.2 g⁴ |
| Vascular          | • Abdominal aortic operations  
                  • Prosthesis  
                  • Groin incision  
                  • Lower extremity amputation for ischaemia  | • I.V. cefazolin 1 g³  
                  • I.V. cefuroxime 1.5 g  
                  • I.V. amoxicillin-clavulanate 1.2 g⁴ |
| Neurosurgery²     | • Craniotomy  
                  • Ventriculoperitoneal shunt  
                  • Implantation of intrathecal pump (492)  
                  • Re-exploration or microsurgery  | • I.V. cefazolin 1 g³  
                  • I.V. cefuroxime 1.5 g  
                  • I.V. amoxicillin-clavulanate 1.2 g⁴ |
<table>
<thead>
<tr>
<th>Type of operation</th>
<th>Indications</th>
<th>Recommended drugs¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orthopaedic &amp; Traumatology²</td>
<td>• Total joint replacement with prosthesis</td>
<td>• I.V. cefazolin 1 g³ OR</td>
</tr>
<tr>
<td></td>
<td>• Internal fixation of closed fractures</td>
<td>• I.V. cefuroxime 1.5 g</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Note:</strong> Antimicrobial agents should be completely infused before inflating the tourniquet if applied.</td>
</tr>
<tr>
<td></td>
<td>• Prophylactic antibiotic is indicated for all open fractures and should be given as soon as possible⁵</td>
<td>• I.V. amoxicillin-clavulanate ± gentamicin⁵ OR</td>
</tr>
<tr>
<td></td>
<td>• Wound cultures and sensitivity testing are useful for informing subsequent choice of antimicrobials (493–495)</td>
<td>• I.V. ceftriaxone 2 g ± I.V. penicillin G⁵ OR</td>
</tr>
<tr>
<td></td>
<td>• For Gustilo type III tibial fractures, prophylaxis given within 1 hr was associated with reduced infection risk (496)</td>
<td>• other third generation cephalosporin ± I.V. penicillin G⁵</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Note:</strong> The duration of prophylactic antibiotic for open fractures depends on the classification: 24 hr (for Gustilo type I and II open fractures) and up to 72 hr (for Gustilo type III open fractures). Antibiotics should not be given for more than 24 hr after soft tissue coverage of the wound, whichever occurs first.</td>
</tr>
<tr>
<td>Thyroid &amp; parathyroid glands</td>
<td></td>
<td>• Antimicrobial prophylaxis is not indicated</td>
</tr>
</tbody>
</table>
### Table 6.3 Antimicrobial prophylaxis in clean-contaminated operations

<table>
<thead>
<tr>
<th>Type of operation</th>
<th>Indications</th>
<th>Recommended drugs¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oral-pharyngeal/nasal</td>
<td>• Tonsillectomy</td>
<td>• I.V. amoxicillin-clavulanate 1.2 g⁴</td>
</tr>
<tr>
<td></td>
<td>• Maxillofacial</td>
<td>OR</td>
</tr>
<tr>
<td></td>
<td>• Rhinoplasty</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Turbinate/septoplasty</td>
<td>If <em>Pseudomonas</em> is suspected:</td>
</tr>
<tr>
<td></td>
<td>• I.V. amoxicillin-clavulanate 1.2 g⁴</td>
<td>• I.V. amoxicillin-clavulanate 1.2 g⁴</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ I.V. gentamicin OR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• I.V. amoxicillin-clavulanate 1.2 g⁴</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ I.V. ceftazidime 1–2 g</td>
</tr>
<tr>
<td>Ear</td>
<td>• Myringotomy</td>
<td>• Quinolone or Sofradex eardrop</td>
</tr>
<tr>
<td></td>
<td>• Tympanostomy tube insertion</td>
<td></td>
</tr>
<tr>
<td>Upper gastro-intestinal tract</td>
<td>Gastro-duodenal (high risk):</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Obstruction</td>
<td>• I.V. cefuroxime 1.5 g</td>
</tr>
<tr>
<td></td>
<td>• Haemorrhage</td>
<td>OR</td>
</tr>
<tr>
<td></td>
<td>• Gastric ulcer</td>
<td>• I.V. amoxicillin-clavulanate 1.2 g⁴</td>
</tr>
<tr>
<td></td>
<td>• Malignancy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• H₂ blocker</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Proton pump inhibitor</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Morbid obesity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Gastric bypass</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Percutaneous endoscopic gastrostomy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Oesophageal operation with manipulation of pharynx</td>
<td>• I.V. cefuroxime 1.5 g OR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• I.V. cefazolin 1 g³ ± metronidazole 500 mg</td>
</tr>
</tbody>
</table>

¹: I.V. = Intravenous
<table>
<thead>
<tr>
<th>Type of operation</th>
<th>Indications</th>
<th>Recommended drugs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hepato-biliary system</td>
<td>High risk:</td>
<td>• I.V. amoxicillin-clavulanate 1.2 g^4 OR</td>
</tr>
<tr>
<td>Laparoscopic gall bladder surgery</td>
<td>• Age more than 70 years</td>
<td>• I.V. cefuroxime 1.5 g + I.V. metronidazole 500 mg</td>
</tr>
<tr>
<td></td>
<td>• Acute cholecystitis/pancreatitis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Obstructive jaundice</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Common bile duct stones</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Morbid obesity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Intraoperative cholangiogram</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Bile spillage</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Pregnancy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Immunosuppression</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Insertion of prosthetic devices</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Laparoscopic converts to laparotomy</td>
<td></td>
</tr>
<tr>
<td>Endoscopic retrograde cholangio-pancreatography (ERCP)</td>
<td>• Biliary obstruction</td>
<td>• P.O. ciprofloxacin 500–750 mg 2 hours prior to procedure OR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• I.V. piperacillin-tazobactam 4.5 g 1 hour prior to procedure</td>
</tr>
<tr>
<td>Appendectomy</td>
<td></td>
<td>• I.V. amoxicillin-clavulanate 1.2 g^4 OR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• I.V. cefuroxime 1.5 g + I.V. metronidazole 500 mg</td>
</tr>
<tr>
<td>Colorectal</td>
<td>• Most procedures require parenteral ± oral prophylaxis (497–500)</td>
<td>Parenteral • I.V. amoxicillin-clavulanate 1.2 g^4 OR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• I.V. cefuroxime 1.5 g + I.V. metronidazole 500 mg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Oral • P.O. neomycin and erythromycin base 1 g each t.d.s. the day before operation</td>
</tr>
<tr>
<td>Type of operation</td>
<td>Indications</td>
<td>Recommended drugs¹</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>----------------------------------------------------------------------------</td>
<td>------------------------------</td>
</tr>
<tr>
<td>Abdominal/vaginal hysterectomy</td>
<td></td>
<td>I.V. cefazolin 1 g³ OR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>When vaginal wound is present:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I.V. cefuroxime 1.5 g + I.V. metronidazole 500 mg OR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I.V. amoxicillin-clavulanate 1.2 g⁴</td>
</tr>
<tr>
<td>Caesarean section (502)</td>
<td>All caesarean sections are indicated for antibiotic prophylaxis (503)</td>
<td>I.V. cefazolin 1 g³ OR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>When vaginal wound is present:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I.V. cefuroxime 1.5 g + I.V. metronidazole 500 mg OR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I.V. amoxicillin-clavulanate 1.2 g⁴</td>
</tr>
</tbody>
</table>

**Note:** For caesarean section, the initial dose of antimicrobial agents should be given before surgical incision instead of after clamping the umbilical cord (501).

| Abortion                       | Antimicrobial prophylaxis should be based on individual clinical condition and local epidemiology (504–505) | Refer to footnote 6         |
| Urology⁷                      | Significant bacteriuria                                                    | Treat according to mid-stream urine culture result prior to elective procedures |
|                                | Transurethral resection of the prostate (TURP), transurethral resection of bladder tumour (TURBT) |                              |
|                                | Stone operations                                                           |                              |
|                                | Nephrectomy                                                               |                              |
|                                | Total cystectomy                                                          |                              |
## Table 6.4  Antimicrobial prophylaxis in contaminated-infected operations

<table>
<thead>
<tr>
<th>Type of operation</th>
<th>Indications</th>
<th>Recommended drugs¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ruptured viscus⁹</td>
<td>For treatment of established infection</td>
<td>• I.V. cefuroxime 1.5 g + I.V. metronidazole 500 mg OR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• I.V. amoxicillin-clavulanate 1.2 g⁴</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Therapy is often continued for about 5 days)</td>
</tr>
<tr>
<td>Bite wound⁹</td>
<td>For treatment of established infection</td>
<td>• I.V. amoxicillin-clavulanate 1.2g⁴</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• P.O. amoxicillin-clavulanate 1g</td>
</tr>
<tr>
<td>Traumatic wound⁹</td>
<td>For treatment of established infection</td>
<td>• I.V. cefazolin 1–2 g³ OR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• I.V. cefuroxime 1.5 g OR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• I.V. amoxicillin-clavulanate 1.2 g⁴</td>
</tr>
</tbody>
</table>

### Hernia repair
- Non mesh hernia repair
  - Antimicrobial prophylaxis is not indicated
- Adult hernia mesh repair
  - I.V. cefazolin 1 g³ OR
  - I.V. cefuroxime 1.5 g

### Breast cancer surgery³ (506)
- I.V. cefazolin 1 g³ OR
- I.V. cefuroxime 1.5 g
Footnotes for Tables 6.2–6.4:

1 The dose of antimicrobial agents recommended in the guidelines is based on adult patient with normal renal function. Special attention should be paid to patient with renal impairment, on renal replacement therapy, or if there is potential drug-drug interaction. Consultation to clinical microbiologist, infectious disease physician and clinical pharmacist is required in complicated cases.

2 For hospitals or units with a high incidence of postoperative wound infections by MRSA or methicillin-resistant *Staphylococcus epidermidis*, screening for MRSA may be indicated to identify patients for additional preoperative measures such as chlorhexidine bath, 2% mupirocin nasal ointment [Bactroban Nasal] and/or the use of vancomycin as preoperative prophylaxis. Evidence is strongest for cardiothoracic and orthopaedic surgery with implantation (507–508).

3 Give cefazolin 2 g for patients with body weight greater than 80 kg. For patients allergic to cefazolin, vancomycin 1 g infused over 1 hour should be given after premedication with an antihistamine. Rapid I.V. administration of vancomycin may cause hypotension, which could be especially dangerous during induction of anaesthesia.

4 Amoxicillin-clavulanate and ampicillin-sulbactam are similar in spectrum coverage and centres may choose to use ampicillin-sulbactam.

5 Choice of agent(s) depends on the type of open fractures by the Gustilo classification and the likely organisms contaminating the wound. In general, prophylactic antibiotic should be directed against Gram-positive organisms for Gustilo type I and II open fractures; additional Gram-negative coverage should be added for Gustilo type III open fractures. In the setting of faecal or potential clostrial contamination (e.g. soil exposure), a penicillin should be included in the regimen.

6 The optimal antibiotic and dosing regimens for abortion are unclear. The antimicrobial prophylaxis for abortion stated in Royal College of Obstetricians and Gynaecologists (United Kingdom) (422) clinical guidelines is Level C recommendations and may be suitable. They include: metronidazole 1 g rectally at the time of abortion plus doxycycline 100 mg orally b.d. for 7 days, commencing on the day of abortion; OR metronidazole 1 g rectally at the time of abortion plus azithromycin 1 g orally on the day of abortion.

7 For transrectal ultrasound (TRUS)-guided biopsy of the prostate, prophylactic regimen is evolving because of increasing fluoroquinolone resistance in *E. coli* (509). If a fluoroquinolone is used, administer the drug 1–2 hours before the procedure to allow maximum tissue penetration (510). Ensure adequate drug level in the body by giving a full standard dose (500 mg to 750 mg for levofloxacin and ciprofloxacin). If post-biopsy infection develops, antibiotic treatment regimen should include coverage against ESBL-producing organisms given the high prevalence of this resistance mechanism in Hong Kong (Table 1.3).

8 Amoxicillin-clavulanate may be used if the operation is such that anaerobic coverage is needed, such as in diabetic foot, hernia repair with bowel strangulation or incarcerated/strangulated hernia or mastectomy with implant or foreign body.

9 Antimicrobial agents should be considered postoperatively for operations with suppurative, ruptured and gangrenous conditions.
Part VII: Cost and recommended dosage of commonly-used antimicrobial agents
Table 7.1 Preparation and recommended dosing regimens for antibiotics

<table>
<thead>
<tr>
<th>Agents</th>
<th>Supply source (brand/generic)</th>
<th>Dosage form (unit cost, HK$)</th>
<th>Usual adult regimen (daily dose, route, dosing interval)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amikacin (163) (Amikin)</td>
<td>Brand</td>
<td>250 mg vial ($41.6)</td>
<td>I.V. 15 mg/kg (750 mg)² q24h or 7.5 mg/kg q12h (max 1.5 g/day)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>500 mg vial ($60.6)</td>
<td></td>
</tr>
<tr>
<td>Amoxicillin</td>
<td>Generic</td>
<td>250 mg cap. ($0.11)</td>
<td>P.O. 500 mg t.d.s.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>125 mg/5 mL syr. ($0.18/mL)</td>
<td></td>
</tr>
<tr>
<td>Amoxicillin-clavulanate</td>
<td>Brand / Generic</td>
<td>600 mg vial ($14.5)</td>
<td>I.V. 1.2 g q8h</td>
</tr>
<tr>
<td>(Augmentin)</td>
<td></td>
<td>1.2 g vial ($8.07)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>375 mg tab. ($0.88)</td>
<td>P.O. 375 mg t.d.s.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 g tab. ($ 1.31)</td>
<td>P.O. 1 g b.d.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>156 mg/5 mL syr. ($0.11/mL)</td>
<td>P.O. 312 mg (10 mL) t.d.s. (syr.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>457 mg/5 mL syr. ($0.36/mL)</td>
<td>P.O. 914 mg (10 mL) b.d. (syr.)</td>
</tr>
<tr>
<td>Ampicillin</td>
<td>Generic</td>
<td>500 mg vial ($2.22)</td>
<td>I.V. 1 g q6h</td>
</tr>
<tr>
<td></td>
<td></td>
<td>250 mg cap. ($0.28)</td>
<td>P.O. 250–500 mg q.i.d.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>500 mg cap. ($0.48)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>125 mg/5 mL syr. ($0.44/mL)</td>
<td></td>
</tr>
<tr>
<td>Ampicillin-sulbactam (Unasyn)</td>
<td>Brand / Generic</td>
<td>750 mg vial ($8.20)</td>
<td>I.V. 1.5–3 g q6h (max 12 g/day)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>375 mg tab. ($6.92)</td>
<td>P.O. 375–750 mg b.d.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>250 mg/5 mL syr. ($1.55/mL)</td>
<td></td>
</tr>
<tr>
<td>Azithromycin (Zithromax)</td>
<td>Brand / Generic</td>
<td>500 mg vial ($109)</td>
<td>I.V. 500 mg q24h</td>
</tr>
<tr>
<td></td>
<td></td>
<td>250 mg tab. ($1.78)</td>
<td>P.O. 500 mg on first day then 250 mg once daily</td>
</tr>
<tr>
<td></td>
<td></td>
<td>250 mg cap. ($13.1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>200 mg/5 mL syr. ($1.39/mL)</td>
<td></td>
</tr>
<tr>
<td>Cefazolin</td>
<td>Generic</td>
<td>1 g vial ($2.74)</td>
<td>I.V. 1 g q8h</td>
</tr>
<tr>
<td>Cefepine (Maxipime)</td>
<td>Brand</td>
<td>1 g vial ($40.2)</td>
<td>I.V. 1–2 g q12h (max 6 g/day)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 g vial ($204)</td>
<td></td>
</tr>
<tr>
<td>Cefoperazone-sulbactam</td>
<td>Generic</td>
<td>1 g vial ($5.60)</td>
<td>I.V. 1–2 g q12h (max 8 g/day)</td>
</tr>
<tr>
<td>(Sulperazon)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agents</td>
<td>Supply source (brand/generic)</td>
<td>Dosage form (unit cost, HK$)</td>
<td>Usual adult regimen (daily dose, route, dosing interval)</td>
</tr>
<tr>
<td>-------------------</td>
<td>-------------------------------</td>
<td>-----------------------------</td>
<td>--------------------------------------------------------</td>
</tr>
<tr>
<td>Ceftazidime (Fortum)</td>
<td>Brand / Generic</td>
<td>500 mg vial ($10.0)</td>
<td>I.V. 1–2 g q8h (max 6 g/day)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 g vial ($12.1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 g vial ($209)</td>
<td></td>
</tr>
<tr>
<td>Cefotaxime (Claforan)</td>
<td>Generic</td>
<td>1 g vial ($3.99)</td>
<td>I.V. 1 g q6–8h (max 12 g/day)</td>
</tr>
<tr>
<td>Cefaroline (Zinforo)</td>
<td>Brand</td>
<td>600 mg vial ($344)</td>
<td>I.V. 600 mg q12h</td>
</tr>
<tr>
<td>Ceftriaxone (Rocephin)</td>
<td>Brand / Generic</td>
<td>250 mg vial for I.M. injection ($80.8)</td>
<td>I.M. 250 mg once</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 g vial for I.M. or I.V. injection ($4.85)</td>
<td>I.M./I.V. 1–2 g/day q12–24h (max 4 g/day)</td>
</tr>
<tr>
<td>Cefuroxime (Zinacef)</td>
<td>Brand / Generic</td>
<td>250 mg vial ($14.0)</td>
<td>I.V. 750 mg–1.5 g q8h (max 6 g/day)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>750 mg vial ($2.94)</td>
<td></td>
</tr>
<tr>
<td>Cefuroxime-axetil (Zinnat)</td>
<td>Brand / Generic</td>
<td>125 mg tab. ($4.01)</td>
<td>P.O. 250–500 mg b.d.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>250 mg tab. ($0.77)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>125 mg/5 mL suspension ($1.24/mL)</td>
<td></td>
</tr>
<tr>
<td>Cephalexin</td>
<td>Generic</td>
<td>250 mg cap. ($0.39)</td>
<td>P.O. 250–500 mg q.i.d.</td>
</tr>
<tr>
<td>Ciprofloxacin (Ciproxin)</td>
<td>Brand / Generic</td>
<td>200 mg vial ($60.4)</td>
<td>I.V. 200–400 mg q12h</td>
</tr>
<tr>
<td></td>
<td></td>
<td>400 mg vial ($677)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>250 mg tab. ($0.41)</td>
<td></td>
</tr>
<tr>
<td>Clarithromycin (Klacid)</td>
<td>Brand / Generic</td>
<td>500 mg vial ($118)</td>
<td>I.V. 500 mg q12h</td>
</tr>
<tr>
<td></td>
<td></td>
<td>250 mg tab. ($0.99)</td>
<td>P.O. 250–500 mg b.d.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>500 mg tab. ($1.81)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>500 mg modified release tab. ($28.4)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>125 mg/5 mL suspension ($0.52/mL)</td>
<td></td>
</tr>
<tr>
<td>Clindamycin (Dalacin C)</td>
<td>Brand / Generic</td>
<td>300 mg vial ($9.51)</td>
<td>I.V. 600–900 mg q8h (max 4.8 g/day)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>300 mg ampoule ($9.26)</td>
<td>P.O. 150–450 mg q.i.d.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>150 mg cap. ($3.15)</td>
<td></td>
</tr>
<tr>
<td>Cloxacillin</td>
<td>Generic</td>
<td>500 mg vial ($4.14)</td>
<td>I.V. 500 mg–1 g q6h (max 8 g/day)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>250 mg cap. ($0.32)</td>
<td>P.O. 500 mg q.i.d.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>500 mg cap. ($0.39)</td>
<td></td>
</tr>
<tr>
<td>Colistin (Colomycin)</td>
<td>Brand</td>
<td>1 million unit vial ($153)</td>
<td>I.V. 1–2 million unit q8h (max 6 million unit/day)</td>
</tr>
<tr>
<td>Agents</td>
<td>Supply source (brand/generic)</td>
<td>Dosage form (unit cost, HK$)</td>
<td>Usual adult regimen (daily dose, route, dosing interval)¹</td>
</tr>
<tr>
<td>--------</td>
<td>-------------------------------</td>
<td>-----------------------------</td>
<td>----------------------------------------------------------</td>
</tr>
<tr>
<td>Daptomycin (Cubicin)</td>
<td>Brand</td>
<td>500 mg vial ($1,389)</td>
<td>I.V. 4 mg/kg (complicated skin and skin structure infections) or 6 mg/kg (S. aureus bloodstream infection) q24h</td>
</tr>
<tr>
<td>Doxycycline (Vibramycin)</td>
<td>Brand</td>
<td>100 mg tab. ($1.33)</td>
<td>P.O. 100 mg b.d.</td>
</tr>
<tr>
<td>Ertapenem (Invanz)</td>
<td>Brand</td>
<td>1 g vial ($230)</td>
<td>I.V. 1 g q24h</td>
</tr>
<tr>
<td>Erythromycin (Erythrocin)</td>
<td>Generic</td>
<td>500 mg vial ($583)</td>
<td>I.V. 500 mg q6h (max 4 g/day)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>250 mg tab. ($0.86)</td>
<td>P.O. (tab.) 250–500 mg q.i.d.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>200 mg/5 mL suspension ($0.21/mL)</td>
<td>P.O. (suspension) 400–800 mg q.i.d</td>
</tr>
<tr>
<td>Flucloxacillin</td>
<td>Generic</td>
<td>125 mg/5 mL solution ($0.14/mL)</td>
<td>P.O. 250–500 mg q.i.d.</td>
</tr>
<tr>
<td>Fosfomycin</td>
<td>Fosfocina³</td>
<td>4 g vial ($478)</td>
<td>I.V. 8–12 g/day (100–200 mg/kg/day)</td>
</tr>
<tr>
<td></td>
<td>Monurol</td>
<td>3 g sachet (not in HA formulary) ($30.3)</td>
<td>P.O. 3 g sachet for 1 dose for uncomplicated urinary tract infection 200–400 mg q8h</td>
</tr>
<tr>
<td>Gentamicin (163)</td>
<td>Generic</td>
<td>80 mg ampoule ($3.72)</td>
<td>I.V. 3.5 mg/kg (180 mg)² q24h or 1.2 mg/kg q8h</td>
</tr>
<tr>
<td>Imipenem-cilastatin (Tienam)</td>
<td>Brand</td>
<td>500 mg vial ($32.2)</td>
<td>I.V. 500 mg q6h (max 4 g/day)</td>
</tr>
<tr>
<td>Levofoxacin (Cravit)</td>
<td>Generic</td>
<td>500 mg infusion bottle ($58.4)</td>
<td>I.V. 500 mg q24h</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100 mg tab. ($0.89)</td>
<td>P.O. 500 mg once daily</td>
</tr>
<tr>
<td></td>
<td></td>
<td>250 mg tab. ($0.66)</td>
<td></td>
</tr>
<tr>
<td>Linezolid (Zyvox)</td>
<td>Brand</td>
<td>600 mg infusion bag ($480)</td>
<td>I.V. 600 mg q12h</td>
</tr>
<tr>
<td></td>
<td></td>
<td>600 mg tab. ($455)</td>
<td>P.O. 600 mg b.d.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100 mg/5 mL suspension ($15.1/mL)</td>
<td></td>
</tr>
<tr>
<td>Meropenem (Meronem)</td>
<td>Generic</td>
<td>500 mg vial ($19.5)</td>
<td>I.V. 1 g q8h</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1g vial ($32.8)</td>
<td></td>
</tr>
<tr>
<td>Agents</td>
<td>Supply source (brand/generic)</td>
<td>Dosage form (unit cost, HK$)</td>
<td>Usual adult regimen (daily dose, route, dosing interval)¹</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------------------------</td>
<td>-----------------------------</td>
<td>---------------------------------------------------------</td>
</tr>
<tr>
<td>Metronidazole (Flagyl)</td>
<td>Generic</td>
<td>500 mg vial ($4.53) 200 mg tab. ($0.12) 200 mg/5 mL syr. ($1.36/mL)</td>
<td>I.V. 500 mg q8h P.O. 400 mg t.d.s.</td>
</tr>
<tr>
<td>Minocycline</td>
<td>Generic</td>
<td>100 mg vial ($86.3) 100 mg cap. ($5.21) 50 mg cap. ($1.98)</td>
<td>I.V. 200 mg loading then 100 mg q12h P.O. 200 mg loading then 100 mg b.d.</td>
</tr>
<tr>
<td>Moxifloxacin (Avelox)</td>
<td>Brand</td>
<td>400 mg infusion bottle ($312) 400 mg tab. ($34.4)</td>
<td>I.V. 400 mg q24h P.O. 400 mg once daily</td>
</tr>
<tr>
<td>Penicillin G</td>
<td>Generic</td>
<td>1 million unit vial ($6.56)</td>
<td>I.V. 1–2 million unit q4–6h (max 24 million unit/day)</td>
</tr>
<tr>
<td>Piperacillin</td>
<td>Generic</td>
<td>4 g vial ($24.7)</td>
<td>I.V. 4 g q6–8h</td>
</tr>
<tr>
<td>Piperacillin-tazobactam (Tazocin)</td>
<td>Generic</td>
<td>4.5 g vial ($18.9)</td>
<td>I.V. 4.5 g q6–8h</td>
</tr>
<tr>
<td>Teicoplanin (Targocid)</td>
<td>Brand</td>
<td>200 mg vial ($473)</td>
<td>I.V. 6 mg/kg (400 mg) on first day, followed by 3 mg/kg (200 mg) q24h</td>
</tr>
<tr>
<td>Ticarcillin-clavulanate (Timentin)</td>
<td>Generic</td>
<td>3.2 g vial ($45.7)</td>
<td>I.V. 3.2 g q4–6h (max 19.2 g/day)</td>
</tr>
<tr>
<td>Tigecycline (Tygacil)</td>
<td>Brand</td>
<td>50 mg vial ($476)</td>
<td>I.V. 100 mg loading then 50 mg q12h</td>
</tr>
<tr>
<td>Tobramycin (163)</td>
<td>Generic</td>
<td>80 mg vial ($76.7)</td>
<td>I.V. 3.5 mg/kg (180 mg)² q24h or 1.2 mg/kg q8h (max 5 mg/kg/day)</td>
</tr>
<tr>
<td>Vancomycin (Vancocin)</td>
<td>Generic</td>
<td>500 mg vial ($13.6) 25 mg/mL oral solution (compounding supply from pharmacy)</td>
<td>I.V. 1 g q12h or I.V. 500 mg q6h (i.e. 30 mg/kg/day) P.O. 125 mg q.i.d. (for refractory <em>C. difficile</em> colitis)</td>
</tr>
</tbody>
</table>

Note: Unit cost of each preparation updated as of June 2016 in HA.

¹ Dosage for a 70 kg person with normal renal function. Dosage modification may be necessary for (i) the elderly; (ii) the very obese individuals (in whom the distribution volume of water-soluble drugs may be smaller than expected from body mass); (iii) those with renal failure and/or (iv) liver failure.
Dosage for a typical 50 kg person given. Once daily administration of aminoglycoside is appropriate for most infections with the possible exceptions of neutropenic fever, infective endocarditis and in the presence of severe renal failure.

Named patient basis only.
Table 7.2 Cost comparison of selected I.V. and P.O. antibiotics

<table>
<thead>
<tr>
<th>Antibiotics</th>
<th>Usual dosage</th>
<th>Cost (HK$/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aminoglycosides</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I.V. gentamicin(^1) (3.5 mg/kg/day)</td>
<td>180 mg q24h</td>
<td>11.2</td>
</tr>
<tr>
<td>I.V. tobramycin(^1) (3.5 mg/kg/day)</td>
<td>180 mg q24h</td>
<td>230</td>
</tr>
<tr>
<td>I.V. amikacin(^1) (15 mg/kg/day)</td>
<td>750 mg q24h</td>
<td>102</td>
</tr>
<tr>
<td><strong>Penicillins</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I.V. ampicillin</td>
<td>500 mg –1 g q6h</td>
<td>9–18</td>
</tr>
<tr>
<td>I.V. cloxacillin</td>
<td>500 mg –1 g q6h</td>
<td>17–33</td>
</tr>
<tr>
<td>I.V. amoxillin-clavulanate</td>
<td>1.2 g q8h</td>
<td>24</td>
</tr>
<tr>
<td>I.V. ampicillin-sulbactam</td>
<td>1.5 g q6h</td>
<td>66</td>
</tr>
<tr>
<td>I.V. ticarcillin-clavulanate</td>
<td>3.2 g q6h</td>
<td>183</td>
</tr>
<tr>
<td>I.V. piperacillin</td>
<td>4 g q8h</td>
<td>74</td>
</tr>
<tr>
<td>I.V. piperacillin-tazobactam</td>
<td>4.5 g q8h</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>(4.5 g q6h)</td>
<td>(76)</td>
</tr>
<tr>
<td><strong>Cephalosporins</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I.V. cefuroxime</td>
<td>750 mg q8h</td>
<td>9</td>
</tr>
<tr>
<td>I.V. cefazolin</td>
<td>1 g q8h</td>
<td>8</td>
</tr>
<tr>
<td>I.V. ceftriaxone</td>
<td>1 g q12h</td>
<td>10</td>
</tr>
<tr>
<td>I.V. cefotaxime</td>
<td>1 g q8h</td>
<td>12</td>
</tr>
<tr>
<td>I.V. cefoperazone-sulbactam (Sulperazon)</td>
<td>1 g q12h</td>
<td>11</td>
</tr>
<tr>
<td>I.V. cefepime</td>
<td>1 g q12h</td>
<td>80</td>
</tr>
<tr>
<td>I.V. ceftazidime</td>
<td>1 g q8h</td>
<td>36</td>
</tr>
<tr>
<td>I.V. ceftaroline</td>
<td>600 mg q12h</td>
<td>688</td>
</tr>
<tr>
<td><strong>Carbapenemmes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I.V. meropenem</td>
<td>500 mg q8h</td>
<td>59</td>
</tr>
<tr>
<td>I.V. meropenem</td>
<td>(1 g q8h)</td>
<td>(98)</td>
</tr>
<tr>
<td>I.V. imipenem-cilastatin</td>
<td>500 mg q6h</td>
<td>129</td>
</tr>
<tr>
<td>I.V. ertapenem</td>
<td>1 g q24h</td>
<td>230</td>
</tr>
<tr>
<td><strong>Fluoroquinolones</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I.V. moxifloxacin</td>
<td>400 mg q24h</td>
<td>312</td>
</tr>
<tr>
<td>P.O. moxifloxacin</td>
<td>400 mg once daily</td>
<td>34</td>
</tr>
<tr>
<td>I.V. levofloxacin</td>
<td>500 mg q24h</td>
<td>58</td>
</tr>
<tr>
<td>P.O. levofloxacin</td>
<td>500 mg once daily</td>
<td>1</td>
</tr>
<tr>
<td>I.V. ciprofloxacin</td>
<td>400 mg q12h</td>
<td>1,354</td>
</tr>
<tr>
<td>P.O. ciprofloxacin</td>
<td>500 mg b.d.</td>
<td>2</td>
</tr>
<tr>
<td>Antibiotics</td>
<td>Usual dosage</td>
<td>Cost (HK$/day)</td>
</tr>
<tr>
<td>-------------------</td>
<td>--------------</td>
<td>----------------</td>
</tr>
<tr>
<td><strong>Macrolides</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I.V. clarithromycin</td>
<td>500 mg q12h</td>
<td>236</td>
</tr>
<tr>
<td>I.V. azithromycin</td>
<td>500 mg q24h</td>
<td>109</td>
</tr>
<tr>
<td>I.V. erythromycin</td>
<td>500 mg q6h</td>
<td>2,332</td>
</tr>
<tr>
<td><strong>Others</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I.V. metronidazole</td>
<td>500 mg q8h</td>
<td>14</td>
</tr>
<tr>
<td>I.V. vancomycin</td>
<td>1 g q12h</td>
<td>54</td>
</tr>
<tr>
<td>I.V. linezolid</td>
<td>600 mg q12h</td>
<td>960</td>
</tr>
<tr>
<td>(P.O. linezolid)</td>
<td>(600 mg b.d.)</td>
<td>(910)</td>
</tr>
</tbody>
</table>

Note: Approximate cost updated as of June 2016 in HA.

^1 Dosage for a typical 50 kg person.
### Table 7.3 Cost comparison of systemic antifungal agents

<table>
<thead>
<tr>
<th>Antifungal agent</th>
<th>Usual dosage</th>
<th>Cost (HK$/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P.O. itraconazole (capsule)</td>
<td>200 mg b.d.</td>
<td>9</td>
</tr>
<tr>
<td>P.O. itraconazole (solution)</td>
<td>200 mg b.d.</td>
<td>285</td>
</tr>
<tr>
<td>I.V. itraconazole</td>
<td>200 mg q12h</td>
<td>1,473</td>
</tr>
<tr>
<td>P.O. fluconazole (capsule)</td>
<td>100–400 mg once daily</td>
<td>3–13</td>
</tr>
<tr>
<td>P.O. fluconazole (suspension)</td>
<td>100–400 mg once daily</td>
<td>81–323</td>
</tr>
<tr>
<td>I.V. fluconazole</td>
<td>200–400 mg q24h</td>
<td>82–165</td>
</tr>
<tr>
<td>P.O. posaconazole (suspension)</td>
<td>Prophylaxis:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>200 mg t.d.s.</td>
<td>564</td>
</tr>
<tr>
<td>P.O. voriconazole</td>
<td>200 mg b.d.</td>
<td>889</td>
</tr>
<tr>
<td>I.V. voriconazole&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Loading 6 mg/kg (300 mg) q12h (Day 1)</td>
<td>1,822–3,644</td>
</tr>
<tr>
<td></td>
<td>Maintenance 4 mg/kg (200 mg) q12h</td>
<td></td>
</tr>
<tr>
<td>I.V. anidulafungin</td>
<td>Candidaemia:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Loading 200 mg (Day 1)</td>
<td>768–1,535</td>
</tr>
<tr>
<td></td>
<td>Maintenance 100 mg q24h</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oesophageal candidiasis:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Loading 100 mg (Day 1)</td>
<td>768</td>
</tr>
<tr>
<td></td>
<td>Maintenance 50 mg q24h</td>
<td></td>
</tr>
<tr>
<td>I.V. micafungin</td>
<td>Prophylaxis in haematopoietic stem cell transplantation (HSCT):</td>
<td></td>
</tr>
<tr>
<td></td>
<td>50 mg q24h</td>
<td>321</td>
</tr>
<tr>
<td></td>
<td>Candidaemia, acute disseminated candidiasis, <em>Candida</em> peritonitis and abscesses:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>100 mg q24h</td>
<td>642</td>
</tr>
<tr>
<td></td>
<td>Oesophageal candidiasis:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>150 mg q24h</td>
<td>964</td>
</tr>
<tr>
<td>I.V. caspofungin</td>
<td>Invasive aspergillosis:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Loading 70 mg (Day 1)</td>
<td>2,000 (70 mg)</td>
</tr>
<tr>
<td></td>
<td>Maintenance 50 mg q24h</td>
<td>2,975 (50 mg)</td>
</tr>
<tr>
<td>I.V. amphotericin B</td>
<td>50 mg q24h</td>
<td>197</td>
</tr>
<tr>
<td>(1 mg/kg/day)&lt;sup&gt;1&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I.V. liposomal amphotericin B</td>
<td>150 mg q24h</td>
<td>5,045</td>
</tr>
<tr>
<td>(3 mg/kg/day)&lt;sup&gt;1&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Approximate cost updated as of June 2016 in HA.

<sup>1</sup> Dosage for a typical 50 kg person.
Table 7.4 Dosage of antimicrobial agents for central nervous system infections

<table>
<thead>
<tr>
<th>Antibiotics</th>
<th>Recommended doses</th>
<th>Cost (HK$/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.V. cefotaxime</td>
<td>2 g q4h</td>
<td>48</td>
</tr>
<tr>
<td>I.V. ceftriaxone</td>
<td>2 g q12h</td>
<td>19</td>
</tr>
<tr>
<td>I.V. cefepime</td>
<td>2 g q8h</td>
<td>612</td>
</tr>
<tr>
<td>I.V. meropenem</td>
<td>2 g q8h</td>
<td>197</td>
</tr>
<tr>
<td>I.V. ampicillin</td>
<td>2 g q4h</td>
<td>53</td>
</tr>
<tr>
<td>I.V. penicillin G</td>
<td>3–4 million unit q4h</td>
<td>118–157</td>
</tr>
<tr>
<td>I.V. metronidazole</td>
<td>500 mg q6h</td>
<td>18</td>
</tr>
<tr>
<td>I.V. vancomycin</td>
<td>1 g q12h</td>
<td>54</td>
</tr>
<tr>
<td>P.O. rifampicin²</td>
<td>600 mg once daily</td>
<td>1</td>
</tr>
</tbody>
</table>

Note:
1 Dosage for a typical body weight ≥70 kg and normal renal function.
2 Rifampicin should only be used in combination with another antibiotic for meningitis by certain bacteria (e.g. multi-resistant Streptococcus pneumoniae or MRSA) with documented sensitivity in susceptibility testing.
Table 7.5 Intra-peritoneal antibiotic dosing recommendations for patients with continuous ambulatory peritoneal dialysis peritonitis

<table>
<thead>
<tr>
<th>Antibiotics</th>
<th>Intermittent dosing (once daily)$^1$ (Add drug into 1 bag/day unless otherwise specified) (511)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aminoglycosides</strong></td>
<td></td>
</tr>
<tr>
<td>Amikacin</td>
<td>2 mg/kg</td>
</tr>
<tr>
<td>Gentamicin</td>
<td>0.6 mg/kg</td>
</tr>
<tr>
<td>Tobramycin</td>
<td>0.6 mg/kg</td>
</tr>
<tr>
<td><strong>Cephalosporins</strong></td>
<td></td>
</tr>
<tr>
<td>Cefazolin</td>
<td>15 mg/kg</td>
</tr>
<tr>
<td>Cefepime</td>
<td>1 g</td>
</tr>
<tr>
<td>Ceftazidime</td>
<td>1–1.5 g</td>
</tr>
<tr>
<td><strong>Others</strong></td>
<td></td>
</tr>
<tr>
<td>Ampicillin-sulbactam</td>
<td>2 g q12h</td>
</tr>
<tr>
<td>Imipenem-cilastatin</td>
<td>1 g q12h</td>
</tr>
</tbody>
</table>

Note:

$^1$ In patients with residual renal function, the drug dose should be empirically increased by 25%.
Part VIII: Other issues
8.1. Management of penicillin allergy

8.1.1 Background

1. Studies have shown that 70–90% of patients who gave a history of penicillin allergy could actually tolerate penicillin.

2. It has been estimated that less than 15% of patients with penicillin allergy are still allergic ten years after their last reaction.

3. There is extensive cross-reactivity between drugs in the penicillin family. Patients who are allergic to one penicillin drug must therefore avoid other members of the family.

4. On the other hand, unnecessary avoidance of penicillin in patients who are not actually allergic would result in extra cost and overuse of drugs that should be reserved for treating drug-resistant organisms, such as vancomycin.

5. Certain penicillin drugs are commonly associated with drug rashes. These reactions, although usually mild, can nevertheless result in patient dissatisfaction.

6. Skin testing with major and minor determinants of penicillin, together with benzylpenicillin and amoxicillin, as well as other suspected ß-lactams, can reliably rule out IgE-mediated penicillin allergy.

7. Patients with IgE-mediated ß-lactam allergy can be successfully desensitised just prior to starting treatment.

8.1.2 Dealing with patients with a remote history of penicillin allergy

1. Determine the date of the last reaction, the type of reaction, the timing of the reaction and other extenuating circumstances, such as infectious mononucleosis and other infections (Figure 8.1).

2. Patients who give a history consistent with severe drug allergy, including Stevens-Johnson syndrome, toxic epidermal necrolysis and drug hypersensitivity syndrome must not be given drugs from the same family again.

3. Patients who give a history consistent with an IgE-mediated reaction (urticaria, angioedema, anaphylaxis) should use an alternative agent (see 8.1.5 below). If penicillin is strongly indicated, skin testing can be performed to assess the risk of anaphylaxis (Figure 8.2). If skin testing is not available, rapid oral desensitisation can be performed (Table 8.1) with informed consent just prior to drug administration.

4. Serum specific IgE tests of ß-lactam drugs have such a low sensitivity that they only have a complementary role.
5. Basophil activation tests have a better sensitivity but they are not yet available for clinical service in HK (512).

6. In patients who give a history of minor drug rash, penicillin is not absolutely contraindicated. However, the physician should first consider using an alternative agent to avoid patient dissatisfaction. Under circumstances where the use of penicillin is clinically desirable, the treating physician should carefully explain the rationale and obtain the patient’s informed consent. This should be recorded in the patient’s medical record. It is also prudent to give a test dose of 1/10th of the treatment dose first and observed for one hour, as the history might not be completely reliable in excluding IgE-mediated reactions.

**8.1.3 Dealing with patients with a definite history of IgE-mediated penicillin allergy**

1. Patient who had reactions that were medically verified as IgE-mediated should use an alternative agent.

2. If penicillin is strongly indicated, desensitisation should be carried out with informed consent just prior to drug administration.

**8.1.4 Dealing with patients with a history of cephalosporin allergy**

1. Cephalosporins generally have a much lower risk of allergic reactions compared to penicillin because their β-lactam ring is rapidly broken down in vivo.

2. Cross-reactivity tends to occur between cephalosporins with similar side-chains. It is therefore possible to substitute a cephalosporin with side-chains different from that of the offending drug (Table 8.2).

3. Since cephalosporin allergy is due to side-chain reactivity, skin testing with the classic penicillin agents, together with the native drug can reliably predict the likelihood of IgE-mediated reactions.

4. Therefore, if the patient is allergic to a clearly identified cephalosporin and no satisfactory alternative is available, the physician can choose another cephalosporin with different side-chains. Skin testing should be performed with the classic penicillin agents and the drug to rule out the risk of IgE-mediated reaction. The drug can then be administered after obtaining the patient's informed consent.
8.1.5 Choosing an alternative drug for patients with ß-lactam allergy

1. As cephalosporins have a spectrum of antimicrobial activity similar to penicillin, they are actually good alternatives for patients with penicillin allergy.

2. Unfortunately, product inserts often list penicillin allergy as a contraindication to the use of cephalosporins. This information was based on early experiences with first generation cephalosporins and is no longer up to date. However, there are medico-legal implications when using cephalosporins in patients with penicillin allergy.

3. Second, third and fourth generation cephalosporins have negligible cross-reactivity with penicillin and are good alternatives, as long as one chooses agents that do not share similar side-chains with penicillin G, ampicillin or amoxicillin (Table 8.2). These drugs should be given by graded challenge after a negative skin test with this cephalosporin.

4. Patients with penicillin allergy have a higher risk of becoming allergic to any drug in general. This fact should be communicated to the patient and the rationale for using the alternative agent explained. Informed consent should be obtained and recorded in the medical record.

5. Carbapenems can also be safely used in patients with penicillin and cephalosporin allergy if clinically indicated.

6. Macrolides, fluoroquinolones, lincomycins and aminoglycosides do not cross-react with ß-lactams.

7. Vancomycin should only be considered as a substitute if clinical circumstances dictate its use, i.e. MRSA, Enterococcus, etc.
Table 8.1 Oral β-lactam desensitisation protocol

<table>
<thead>
<tr>
<th>Dose</th>
<th>Concentration (mg/mL)</th>
<th>Volume (mL)</th>
<th>Time (min)</th>
<th>Reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.1</td>
<td>0.3</td>
<td>0:00</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.1</td>
<td>0.6</td>
<td>0:15</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.1</td>
<td>1.2</td>
<td>0:30</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.1</td>
<td>2.5</td>
<td>0:45</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.1</td>
<td>5</td>
<td>1:00</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>1</td>
<td>1:15</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>2</td>
<td>1:30</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>4</td>
<td>1:45</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>10</td>
<td>0.8</td>
<td>2:00</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>1.6</td>
<td>2:15</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>10</td>
<td>3.2</td>
<td>2:30</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>10</td>
<td>6.4</td>
<td>2:45</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>100</td>
<td>1.2</td>
<td>3:00</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>100</td>
<td>2.5</td>
<td>3:15</td>
<td></td>
</tr>
</tbody>
</table>

1. Prepare stock solution of β-lactam drug that you wish to use at 100 mg/mL.
2. Make serial dilutions at 10 mg/mL, 1 mg/mL, 0.1 mg/mL.
3. Administer doses at 15-minute intervals.
4. Have epinephrine 1:1,000 on stand-by at bedside.
5. Once successfully desensitised, begin treatment immediately.
6. To maintain desensitised state, patient must not interrupt treatment for more than 2 days. Otherwise, patient would need to be desensitised again.

Note:

Reference: (513)
### Table 8.2 Cross-reacting side chains between β-lactam antibiotics

<table>
<thead>
<tr>
<th></th>
<th>Amoxicillin</th>
<th>Ampicillin</th>
<th>Cefaclor</th>
<th>Cefadroxil</th>
<th>Cefepime</th>
<th>Cefoperazone</th>
<th>Cefotaxime</th>
<th>Cefoxitin</th>
<th>Cefpodoxime</th>
<th>Ceftriaxone</th>
<th>Cefuroxime</th>
<th>Cephalaxin</th>
<th>Cefhahlothin</th>
<th>Cefhahlothin</th>
<th>Cephradine</th>
<th>Penicillin G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amoxicillin</td>
<td></td>
<td>6</td>
<td></td>
<td>6/7</td>
<td>6/7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6/7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ampicillin</td>
<td>6</td>
<td></td>
<td></td>
<td>6/7</td>
<td>6/7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6/7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cefaclor</td>
<td>6/7</td>
<td>6/7</td>
<td></td>
<td></td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cefadroxil</td>
<td>6/7</td>
<td>6/7</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cefepime</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cefoperazone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cefotaxime</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cefoxitin</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cefpodoxime</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ceftriaxone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cefuroxime</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cephalaxin</td>
<td>6/7</td>
<td>6/7</td>
<td>7</td>
<td>3,7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cephaloridine</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cephalothin</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cephradine</td>
<td>6/7</td>
<td>6/7</td>
<td>7</td>
<td>3,7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Penicillin G</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Numbers denote position of side chains: 3, similarity at the cephalosporin 3-position side chain; 7, similarity at the cephalosporin 7-position side chain; 6/7, similarity at the penicillin 6-position side chain and the cephalosporin 7-position side chain.

Each number in the matrix indicates side-chain similarity between two drugs. Cross-allergenicity is expected between each similar pair. For example, a patient allergic to amoxicillin would very likely manifest an allergic reaction to ampicillin, cefadroxil, cefaclor, cephalaxin, and cephradine. However, the patient would not be expected to exhibit an allergic response to cefepime, cefoperazone, cefotaxime, etc., unless he/she was also allergic to another cephalosporin or penicillin with a similar side chain to the reference drug.

Reference: (514)
### Table 8.3 Risk of cross-reactivity between different β-lactams

<table>
<thead>
<tr>
<th>Allergic to</th>
<th>Drug of concern</th>
<th>Risk of cross-reactivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cephalosporin</td>
<td>Penicillin</td>
<td>8.3%–25.5% in two series (515–516)</td>
</tr>
<tr>
<td></td>
<td><em>Cephalosporin with structures similar or identical to penicillin have 3-fold increase in risk</em></td>
<td></td>
</tr>
<tr>
<td>Carbapenems</td>
<td>Imipenem 2% and meropenem 1% in one series</td>
<td></td>
</tr>
<tr>
<td>Penicillin</td>
<td>Cephalosporins</td>
<td>10.9% with most involving cephalothin and cefamandole (517)</td>
</tr>
<tr>
<td></td>
<td>Carbapenems</td>
<td>Meropenem 0.9%, imipenem 0.9% (518–520)</td>
</tr>
<tr>
<td></td>
<td>All first generation cephalosporins</td>
<td>Odds ratio: first generation cephalosporins 4.2, second generation cephalosporins 1.1 and third generation cephalosporins 0.8 (521)</td>
</tr>
<tr>
<td></td>
<td>Cephalexin</td>
<td>31% in one series with 16 patients (522)</td>
</tr>
<tr>
<td>Amoxicillin</td>
<td>Cefadroxil</td>
<td>38% (cefadroxil has identical side chain to amoxicillin) (523)</td>
</tr>
<tr>
<td></td>
<td>Cefamandole</td>
<td>0% for 21 patients (different side chain to amoxicillin) (523)</td>
</tr>
</tbody>
</table>
Figure 8.1 Flow chart on assessment of β-lactam allergy

1 Stevens-Johnson syndrome, toxin epidermal necrolysis
2 Skin test only predicts anaphylactic reaction. Minor skin rash may occur
Figure 8.2 ß-lactam skin testing

Stock test solutions:
1. Penicilloyl polylysine (PPL) 0.04 mg/mL
2. Minor determinant mix (MDM) 0.5 mg/mL
3. Amoxicillin 20 mg/mL
4. Ampicillin 20 mg/mL
5. Cephalosporins 20 mg/mL

Note that all stock concentrations are in mg/mL

Precautions
This should only be conducted by persons with the proper training. Have epinephrine 1:1,000 on stand-by when performing skin tests.

Procedure

Perform skin prick tests at stock concentration
If negative

Perform intradermal skin tests 1:100 dilution
If negative

Perform intradermal skin tests 1:10 dilution
If negative

Perform intradermal skin tests stock concentration
If negative

Perform oral challenge with amoxicillin 250 mg
Observe for one hour
8.2. Tips on laboratory diagnostic tests

8.2.1 Urinary *Legionella* antigen test (UAT)

1. The majority of Legionnaires’ disease (LD) is caused by *Legionella pneumophila* serogroup 1 (524). The test kit most commonly used in HA hospitals detects *L. pneumophila* serogroup 1 ONLY (Table 8.4).

2. Most of the HA hospitals offering this test can guarantee a turnaround time of 1 day (525).

3. Although more than 80% of patients with LD excrete antigens in urine during day 1 to 3 of symptoms (524), the UAT can remain negative in the first 5 days of the illness. Therefore a negative UAT during the early phase of illness does not exclude LD, and UAT should be repeated (526).

4. The UAT of majority of LD patients will turn negative within 60 days (524). However, the longest documented duration of antigen excretion was 326 days (527). Therefore a positive UAT can indicate either current or past infection.

5. Pneumonia caused by *Streptococcus pneumoniae* and urinary tract infection caused by *E. coli* and *Staphylococcus aureus* can result in false positive UAT (very weak band after 15 minutes). The specificity is around 97.1%. If very weak bands in the first 15 minutes are discounted and re-examined after 45 minutes to look for increased band intensity, the specificity can increase to 100% as false positive bands would not intensify (528). Other causes of false positivity include rheumatoid-like factors, freeze-thawing of urine, and excessive urinary sediments (527).

6. The sensitivity of UAT is variable, ranging from 70% to 80% (527). A Spanish group evaluated the sensitivity of the test during a large *Legionella* outbreak in Spain. They found that severe LD had a higher sensitivity (>80%) (529). Therefore, a negative UAT in a patient with mild atypical pneumonia does not exclude the diagnosis of LD. Other laboratory investigations for diagnosing LD should be performed (paired serology, culture with buffered charcoal yeast extract BCYE agar ± supplements and PCR of lower respiratory tract specimens).
Table 8.4 Key points in the use of UAT

1. Can detect *L. pneumophila* serogroup 1 ONLY.
2. Short turnaround time (within 1 day).
3. UAT can be negative within the first 5 days.
4. A positive UAT result usually turns negative within 60 days.
5. Sensitivity: 70–80%
   Specificity: approaches 100%
6. Negative UAT does not exclude LD
7. False positive UAT:
   - Pneumonia caused by *S. pneumoniae*
   - Urinary tract infection caused by *E. coli, S. aureus*
   - Rheumatoid-like factors
   - Freeze-thawing of urine
   - Excessive urinary sediments

8.2.2 Diagnosis of catheter-associated bloodstream infection (CABSI)

1. The presence of bacteria in the blood stream is detected by the continuous-monitoring blood culture system in HA hospitals. The automatic device continuously measures the metabolic product produced by microorganisms. When a certain cutoff value is reached, the monitoring machine would indicate positivity of the blood culture bottle of interest, where the bottle would then be removed and subcultured. The time to positivity (TTP) would be affected by the initial bacterial inoculum, i.e. the higher the inoculum, the shorter the TTP (530–531).

2. In vitro studies have noted a linear relationship between the bacterial inoculum size and TTP of blood culture (532). The TTP in patients with bacteraemia is variable, ranging from <7 hours to >20 hours, depending on the infecting organism and severity of the disease (Table 8.5).

3. The differential time to positivity is a reliable and simple technique to diagnose CABSI without the need for removal of the catheter (533). A high central to peripheral blood culture colony ratio is indicative of CABSI. When blood is drawn simultaneously from central venous catheter and peripheral, catheter blood culture positive 2 hours earlier than peripheral blood culture is highly indicative of CABSI (532,534). (Information of TTP can usually be obtained from the microbiology laboratory) (Table 8.6).

4. In a meta-analysis, the sensitivity and specificity of differential time to positivity in diagnosing CABSI is 89% and 87% respectively (533).
### Table 8.5  TTP of blood culture of different organisms

<table>
<thead>
<tr>
<th>Organism</th>
<th>Time to positivity</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Staphylococcus aureus</em></td>
<td>19.9 ± 19.4 h</td>
<td>(535–536)</td>
</tr>
<tr>
<td>Methicillin-sensitive <em>Staphylococcus aureus</em> (MSSA)</td>
<td>15h (14.1 ± 9.8) h</td>
<td></td>
</tr>
<tr>
<td>Methicillin-resistant <em>Staphylococcus aureus</em> (MRSA)</td>
<td>17h (28.6 ± 26.1) h</td>
<td></td>
</tr>
<tr>
<td>Coagulase-negative <em>Staphylococcus</em></td>
<td>CFU &lt;10 : &gt;20 h</td>
<td>(533)</td>
</tr>
<tr>
<td></td>
<td>CFU &gt;100 : ≤16 h</td>
<td></td>
</tr>
<tr>
<td><em>S. pneumoniae</em></td>
<td>14 h</td>
<td>(537–538)</td>
</tr>
<tr>
<td><em>E. coli</em></td>
<td>9.7 – 11.2 h</td>
<td>(539)</td>
</tr>
<tr>
<td>ESBL-pos <em>E. coli</em></td>
<td>8.3 h</td>
<td>(531)</td>
</tr>
<tr>
<td><em>Klebsiella pneumoniae</em></td>
<td>&lt;7 h</td>
<td>(540)</td>
</tr>
<tr>
<td><em>Acinetobacter baumannii</em></td>
<td>10.4 ± 7.9 h</td>
<td>(541)</td>
</tr>
<tr>
<td>Drug-sensitive strain</td>
<td>14.5 ± 9.5 h</td>
<td></td>
</tr>
<tr>
<td>Drug-resistant strain</td>
<td>8.6 ± 3.2 h</td>
<td></td>
</tr>
<tr>
<td><em>Candida</em></td>
<td>25.9 ± 24.9 h</td>
<td>(542)</td>
</tr>
</tbody>
</table>
Table 8.6  Diagnosing CABSIs by differential time to positivity

1. Blood culture performed with aerobic and anaerobic blood culture bottle from central venous catheter and peripheral site respectively.

2. Approximately **equal volume** of peripheral blood and catheter blood (from ALL lumens) should be drawn **simultaneously** under aseptic technique.

3. Label clearly “Suspected catheter associated blood stream infection” to alert laboratory staff so that all bottles are incubated into the continuous monitoring blood culture system at the same time.

4. The time for blood culture broth to turn positive is recorded. (The TTP can be obtained from microbiology laboratory)

5. If catheter blood TTP is > **2 hours early** than peripheral blood TTP, then the patient is likely to have CABSIs.

6. The differential time to positivity is valid only if:
   - The **volume** of peripheral blood injected into the blood culture bottles is approximately **equal** to the catheter blood
   - Blood culture are taken **simultaneously**
   - Blood culture are incubated into the blood culture system **at the same time**

8.2.3 Prosthetic joint infection

1. Multiple intraoperative specimens (5 to 6 specimens) should be obtained during revision surgery of an infected prosthetic hip joint, since isolation of an indistinguishable organism from 3 or more independent specimen is highly predictive of infection. Use of separate instruments to obtain the specimen could reduce the chance of false positivity and cross-contamination (543).

2. Slow-growing, fastidious organisms and biofilm-forming sessile phase bacteria may be difficult to detect in routine bacterial culture. Seven days of culture can detect up to 70% of the infections, while prolonged bacterial culture for 2 weeks can detect the remainder (544).

3. BACTEC blood culture bottles could be used for the diagnosis of prosthetic joint infection. Intraoperative specimens (synovial fluid or homogenised infected tissue) could be injected into BACTEC blood culture bottles and incubated in an automated monitoring machine (545–547). BACTEC was found to have high sensitivity and specificity in diagnosing prosthetic joint infections, compared to conventional laboratory culture methods (547). BACTEC was also found to have the shortest TTP comparing with different laboratory enrichment methods (547).
8.2.4 Culture of sterile body fluid

1. Use of BACTEC blood culture bottles can increase the sensitivity for recovery of microorganisms from sterile body fluids (548–551). It can also reduce the time to detection and increase the yield of isolation of fastidious organisms (549–551).

2. Continuous ambulatory peritoneal dialysis peritonitis may be difficult to diagnose, especially when caused by fastidious organisms, when the dialysate contains very low number of organisms or when prior antibiotics have been given. Using BACTEC and BacT/ALERT bottles to culture the dialysate fluid can increase the sensitivity for recovering microorganisms, especially fastidious bacteria (550,552). Direct inoculation of ascitic fluid into blood culture bottles at the bedside was found to have a significantly higher sensitivity and shorter time for detection of bacterial growth (553).

3. The use of BACTEC and BacT/ALERT blood culture bottles could increase the yield of microorganisms from pleural fluid (550,552).

8.3 Tuberculosis (TB)

1. TB usually involves the lung but can practically affect any other body organs. It transmits mainly through the infectious airborne droplet nuclei generated during coughing, singing, speaking or sneezing by a patient with pulmonary TB, especially in the presence of open lung cavities or positive sputum smears (554).

2. Active disease develops months or years after infection in only about one in ten of infected individuals. There is a higher risk of developing active disease with recent infection, impaired systemic immunity (notably HIV infection, diabetes mellitus, chronic renal failure, leukaemia, immunosuppressive therapy, alcoholism, malnutrition, ageing) or local defence (notably silicosis, smoking). Early diagnosis of active disease and prompt initiation of effective treatment remains the key strategy to control this airborne infection at source.

3. Up to one-third of the local (and global) population has been infected with TB. To maximise cost-effectiveness and optimise benefit vs risk, screening and treatment of latent TB infection (asymptomatic and non-infectious) are normally targeted at high risk groups (555). Tuberculin skin test and interferon-gamma release assays (IGRAs) are tests for TB infection only, and they CANNOT either rule in or rule out active TB disease.
4. The typical site-specific symptoms, e.g. chronic cough +/- blood-streaked sputum for lung parenchymal involvement, and systemic symptoms, like chronic, often low-grade fever, night sweating, weight loss, are rather non-specific and may be absent altogether. Atypical presentations can also occur, e.g. acute onset of pneumonia or meningitis. TB may thus mimic or be mimicked by many other diseases. As TB is still a common disease in HK, it is useful to keep this differential diagnosis in mind, especially for chronic septic or lung conditions where an alternative cause has not been established.

5. Chest X-ray has reasonably good sensitivity for pulmonary TB and interval changes are useful to assess activity or response to alternative treatment. However, bacteriological work-up (AFB smear, culture & drug susceptibility tests and/or rapid molecular tests) is essential for confirming the diagnosis and detection of drug resistance. Rapid identification of positive mycobacterial isolates is required to differentiate *Mycobacterium tuberculosis* complex from non-tuberculous mycobacteria (NTM), infection or colonisation by which is increasingly seen nowadays, especially in patients with underlying lung diseases and/or compromised general immunity. Empirical trial of TB drugs may be considered if TB remains a likely possibility after exhaustive diagnostic workup for possible differential diagnoses.

6. TB disease requires combination drug therapy. The standard short-course TB treatment regimen consists of isoniazid and rifampicin given for six months, supplemented in the first two months with pyrazinamide and either ethambutol or streptomycin (556). Directly observed therapy is currently recommended to promote drug adherence, which is absolutely essential for ensuring treatment success and preventing progressive acquisition of drug resistance.

7. The standard TB regimen is given with the assumption that the patient does not have multidrug-resistant TB (MDR-TB), which is defined by bacillary resistance to both isoniazid and rifampicin. Although the prevalence of MDR-TB in HK is low (around 1%), clinical vigilance is still required, especially for patients with history of residence/prolonged stay in areas with high prevalence of TB drug resistance, previous history of treatment and/or poor response to treatment. As MDR-TB is increasingly seen among new TB patients without any known risk factors across a wide age spectrum, caution is also required in high risk institutional environments, where secondary transmission to vulnerable contacts is a key concern. Rapid molecular tests often help to establish a timely diagnosis and inform the initial choice of drugs under such situations.
8. Fluoroquinolones are essential in the treatment of MDR-TB. They should not be used as a convenient substitute for ethambutol or streptomycin, as fluoroquinolone resistance may easily develop in case of unrecognised MDR-TB. The use of a fourth drug, ethambutol or streptomycin, in the standard TB regimen may not be necessary if resistance to isoniazid can be excluded. When it is considered necessary to use a fluoroquinolone to replace ethambutol/streptomycin as the fourth drug, it would be worthwhile to screen for MDR-TB/rifampicin resistance by suitable rapid tests.

9. MDR-TB is much more difficult to treat, especially for extensively drug-resistant TB (XDR-TB) with additional bacillary resistance to fluoroquinolone and at least one of the second-line injectable drugs. It is best managed in centres with relevant experience and adequate laboratory support for both phenotypic and genotypic drug susceptibility testing. The newer-generation fluoroquinolones (levofloxacin or moxifloxacin) and second-line injectable drugs (if susceptible) are core drugs, which must be used together with an adequate number of other likely effective first-line or second-line accompanying drugs to prevent further acquisition of drug resistance. High dose isoniazid may be considered in case of low-level isoniazid resistance. Linezolid, in suitable dosage and dosing frequency to minimise toxicity, often plays an important role in the treatment of fluoroquinolone-resistant MDR-TB and XDR-TB. Novel drugs, such as delamanid and bedaquiline, may also need to be considered when drug choices are strictly limited.
### Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABECB</td>
<td>Acute bacterial exacerbation of chronic bronchitis</td>
</tr>
<tr>
<td>AMR</td>
<td>Antimicrobial resistance</td>
</tr>
<tr>
<td>ASP</td>
<td>Antimicrobial stewardship programme</td>
</tr>
<tr>
<td>b.d.</td>
<td>Twice a day</td>
</tr>
<tr>
<td>CABSi</td>
<td>Catheter-associated blood stream infection</td>
</tr>
<tr>
<td>CA-MRSA</td>
<td>Community-associated methicillin-resistant <em>Staphylococcus aureus</em></td>
</tr>
<tr>
<td>CAP</td>
<td>Community-acquired pneumonia</td>
</tr>
<tr>
<td>cap.</td>
<td>Capsule</td>
</tr>
<tr>
<td>CBA</td>
<td>Colistin base activity</td>
</tr>
<tr>
<td>CC17</td>
<td>Clonal complex17</td>
</tr>
<tr>
<td>CDC</td>
<td>Centers for Disease Control and Prevention</td>
</tr>
<tr>
<td>CFU</td>
<td>Colony-forming unit</td>
</tr>
<tr>
<td>CHP</td>
<td>Centre for Health Protection</td>
</tr>
<tr>
<td>CLSI</td>
<td>Clinical laboratory standards institute</td>
</tr>
<tr>
<td>CPE</td>
<td>Carbapenemase-producing <em>Enterobacteriaceae</em></td>
</tr>
<tr>
<td>CRAB</td>
<td>Carbapenem-resistant <em>Acinetobacter baumannii</em></td>
</tr>
<tr>
<td>CRE</td>
<td>Carbapenem-resistant <em>Enterobacteriaceae</em></td>
</tr>
<tr>
<td>CSF</td>
<td>Cerebrospinal fluid</td>
</tr>
<tr>
<td>DRSP</td>
<td>Drug-resistant <em>Streptococcus pneumoniae</em></td>
</tr>
<tr>
<td>ESBL</td>
<td>Extended-spectrum β-lactamase</td>
</tr>
<tr>
<td>FDA</td>
<td>Food and Drug Administration</td>
</tr>
<tr>
<td>g</td>
<td>Gram</td>
</tr>
<tr>
<td>HA</td>
<td>Hospital Authority</td>
</tr>
<tr>
<td>HACEK</td>
<td><em>Haemophilus</em> species, <em>Aggregatibacter</em> species, <em>Cardiobacterium hominis</em>, <em>Eikenella corrodens</em>, <em>Kingella</em> species</td>
</tr>
<tr>
<td>HA-MRSA</td>
<td>Healthcare-associated methicillin-resistant <em>Staphylococcus aureus</em></td>
</tr>
<tr>
<td>HAP</td>
<td>Hospital-acquired pneumonia</td>
</tr>
<tr>
<td>HDU</td>
<td>High dependency unit</td>
</tr>
<tr>
<td>HIV</td>
<td>Human immunodeficiency virus</td>
</tr>
<tr>
<td>HK</td>
<td>Hong Kong</td>
</tr>
<tr>
<td>HSCT</td>
<td>Haematopoietic stem cell transplantation</td>
</tr>
</tbody>
</table>
I.M. Intramuscular
I.V. Intravenous
ICU Intensive care unit
IU International units
IVDU Intravenous drug user
kg Kilogram
LD Legionnaires’ disease
MDR-TB Multidrug-resistant tuberculosis
µg Microgram
mg Milligram
MIC Minimal inhibitory concentration
mL Millilitre
MRAB Multidrug-resistant *Acinetobacter baumannii*
MRMP Macrolide-resistant *Mycoplasma pneumoniae*
MRSA Methicillin-resistant *Staphylococcus aureus*
MS-MRSA Multi-susceptible methicillin-resistant *Staphylococcus aureus*
MSSA Methicillin-sensitive *Staphylococcus aureus*
NDM New Delhi metallo-ß-lactamase
P.O. Per oral
PCR Polymerase chain reaction
PID Pelvic inflammatory disease
PVL Panton-Valentine leukocidin
q.i.d. Four times daily
SAP Severe acute pancreatitis
spp. Species
syr. Syrup
t.d.s. Three times daily
tab. Tablet
TB Tuberculosis
TTP Time to positivity
UAT Urinary *Legionella* antigen test
VRE Vancomycin-resistant enterococci
VREfm Vancomycin-resistant *Enterococcus faecium*
WBC White blood cell
XDR-TB Extensively drug-resistant tuberculosis
Reference


52. Clinical and Laboratory Standards Institute. Performance standards for antimicrobial susceptibility testing; Twenty-sixth informational supplement. 2016. (M100-S26).


127. Australian Council on Healthcare Standards, Hong Kong (China), Steering Committee on Hospital Accreditation, Hospital Authority (Hong Kong C., Hong Kong Committee on Standards. Section 5 - Standards, criteria, elements and guidelines. Standard 1.5: The organisation provides safe care and services. In: ACHS EQuIP6 Hong Kong Guide. 2016. p. 135.


313. Center for Drug Evaluation and Research. Antimicrobial Drugs Advisory Committee (formerly known as the Anti-Infective Drugs Advisory Committee) - 2015 Meeting Materials, Antimicrobial Drugs Advisory Committee (formerly known as the Anti-Infective Drugs Advisory Committee) [Internet]. 2017 [cited 2017 Jan 20]. Available from: http://www.fda.gov/AdvisoryCommittees/CommitteesMeetingMaterials/Drugs/Anti-InfectiveDrugsAdvisoryCommittee/ucm424449.htm


416. An overview of laminar flow ventilation for operating theatres. The Technology Assessment Team, Policy Coordination Unit, Performance Management Branch, Queensland Health, Australia; 1997.


525. HA Central Committee on Infectious Disease and Emergency response. Legionnaires’ Disease (LD) – Clinical management. 2012.


Index
Note: Page numbers followed by f indicate figures; those followed by t indicate tables.

A
Abscess 27, 80t–81t, 86t, 104t, 125t
  - brain 76t
  - breast 81t
  - liver 78t, 92
Acinetobacter 20, 23t–24t, 35t, 37, 56, 87t, 99t, 101t–103t
  - A. baumannii 21t, 54, 59, 99t, 139t
  - A. baumannii, carbapenem-resistant (CRAB) 22t, 36–37, 39f, 53, 89
  - A. baumannii, multidrug-resistant (MRAB) 36–37, 39f
Acute bacterial exacerbation of chronic bronchitis (ABECB) 83t
Acute bacterial exacerbation or pneumonia in patient with bronchiectasis 84t
Acute pyelonephritis 82t
Aeromonas 74t, 78t–79t
Allergy 48, 51, 53, 75t, 83t–84t, 103t–104t, 129–131, 135f
Amikacin 23t, 39t, 58, 99t–100t, 118t, 123t, 127t
Aminoglycosides 22t, 30, 39t, 58, 123t, 127t, 131
  - once daily 58
Amoxicillin 73t, 83t–84t, 93t, 95–96, 97t, 101t, 105t–106t, 118t, 129, 131, 134t, 135f–136f
Amoxicillin-clavulanate 23t, 72t–75t, 77t–78t, 81t–85t, 87t, 93t, 96, 101t–103t, 105t, 109t–115t, 116, 118t
AmpC β-lactamase 32t, 33
Amphotericin B 60t–61t, 64t–66t, 125t
  - liposomal 65t–66t, 125t
Ampicillin 22t–23t, 29t, 70t, 73t, 75t–76t, 80t, 83t, 95–96, 97t, 106t, 118t, 123t, 126t, 131, 136f
Ampicillin-sulbactam 23t, 72t–73t, 96, 99t, 101t–103t, 109t, 116, 118t, 123t, 127t
Amputation, surgical prophylaxis 110t
Anidulafungin 60t–63t, 65t–66t, 125t
Antifungals 60, 61t, 64t–65t, 125t
  - prophylaxis 65t–66t
Antimicrobial stewardship programme (ASP) 42, 43t, 46t
Appendectomy, surgical prophylaxis 113t
Appendicitis 57, 77t
Arthritis, septic 70t
Aspergillosis, invasive 64t–66t, 125t
Aspergillus 61t
Aspiration pneumonia 84t
Azithromycin 24t, 79t, 93–94, 104t–105t, 116, 118t, 124t
Azoles 60t, 62t
Aztreonam 30, 33, 35t, 36

Bacillus spp. 21t
Bacterial vaginosis 81t
Bacteriuria, surgical prophylaxis 114t
Bacteroides 77t–78t, 84t
ß-lactam, allergy 48, 129, 131, 135f
Biliary sepsis 77t
- surgical prophylaxis 113t
Bite wound 75t
- surgical prophylaxis 115t
Blastomyces 60
Bronchiectasis 84t–85t, 92
Bronchitis 44, 83t

Caesarean Section 114t
Campylobacter, gastroenteritis 78t–79t
Candida 21t, 60, 63t, 67f, 80t, 89, 125t, 139t
- C. albicans 60, 61t, 67f
- C. glabrata 60, 67f
- C. guillermondii 61t, 67f
- C. krusei 61t, 67f
- C. lusitaniae 61t, 67f
- C. parapsilosis 61t, 67f
- C. tropicalis 61t, 67f
Candidaemia 64t, 66t, 125t
Candidiasis
- oesophageal 125t
- invasive 64t, 66t
Capnocytophaga spp. 75t
Carbapenemase 32–33, 35
Carbapenems 22t, 25, 30, 32, 35–37, 39t, 56, 76t, 82t, 90, 100t, 102t, 123t, 131, 134t
Cardiovascular infections 80t
Caspofungin 60t–63t, 65t–66t, 125t
Cat bite 75t
Catheter-associated bloodstream infection (CABSI) 138
  - time to positivity (TTP), diagnosis 138, 140t
Cefaclor 95, 97t
Cefadroxil 134t
Cefazolin 70t–71t, 80t–81t, 103t, 109t–112t, 114t–115t, 116, 118t, 123t
Cefepime 23t, 30, 32t, 85t–86t, 93, 97t, 100t, 118t, 123t, 126t–127t
Cefmetazole 32t
Cefoperazone-sulbactam 23t, 90t, 103t, 105t, 118t, 123t
Cefotaxime 32t, 70t, 76t, 83t, 96f, 97t, 101t, 105t–106t, 119t, 123t, 126t
Cefoxitin 32t, 81t
Cefpodoxime 97t
Ceftaroline 22t, 25, 59, 119t, 123t
Ceftazidime 23t, 30–31, 32t, 39f, 84t, 86t, 97t, 103t, 112t, 119t, 123t, 127t
Ceftibuten 81t, 95, 97t
Ceftizoxine 23t, 30, 32t, 70t–71t, 76t, 78t, 80t–81t, 84t–87t, 97t, 101t, 105t–106t,
  111t, 119t, 123t, 126t
Cefuroxime 23t, 77t, 97t, 101t–102t, 109t–115t, 119t, 123t
Cellulitis 27, 48, 73t
Central nervous system (CNS) infection 76t, 106t, 126t
Cephalexin 72t–73t, 119t, 134t
Cephalosporins 22t, 25, 30, 35t, 39f, 59, 75, 95, 100t, 103t, 106t, 111t, 123t, 127t,
  136f
  - allergy 130–131, 134t
Chickenpox 74t
Chlamydia phila pneumoniae 92
Chlorhexidine, bath, pre-operative prophylaxis against MRSA 48, 116
Cholangitis 57, 77t
Cholecystitis 57, 77t, 113t
Chronic obstructive pulmonary disease (COPD) 95
Ciprofloxacin 23t, 39f, 72t, 79t, 95, 99t–100t, 103t, 113t, 116, 119t, 123t
Citrobacter 32t
Clarithromycin 24t, 93–94, 105t, 119t, 124t
Clindamycin 22t, 72t–75t, 81t, 84t, 103t–105t, 109t, 119t
Clostridium difficile 24t, 42, 43t, 48–49, 79t, 99t
Cloxacillin 25, 70t–71t, 73t, 75t, 80t–81t, 103t, 119t–120t, 123t
Coagulase-negative staphylococci (CoNS) 21t, 26t, 48–49, 51, 139t
Colistin 33, 54, 119t
Colitis 48–49, 121t
Colorectal, surgical prophylaxis 113t
Community-acquired pneumonia (CAP) 38, 84t–86t, 92–95
Cotrimoxazole 22t–23t, 30, 73t, 84t, 104t–105t
Craniotomy, surgical prophylaxis 110
Cryptococcus neoformans 60, 61t, 63t, 67f
Cystitis 57, 82t

**D**

Daptomycin 52, 104t, 120t
Desensitisation 129–130, 132, 135f
Diabetic foot infection 53, 72t
Diloxanide 78t
Dimorphic fungus 60, 61t
Doxycycline 81t, 84t–86t, 104t, 116, 120t

**E**

Ear, surgical prophylaxis 112t
Echinocandins 60, 64t
Empirical therapy (ET), antimicrobial 49, 56–57, 70t–88t
Endocarditis 48, 52, 58, 80t, 112t
Entamoeba histolytica 78t
Enterobacter 21t, 23t, 32t, 87t, 100f
  - *E. cloacae* complex 100t
Enterobacteriaceae 32–33, 34f, 35t, 59, 77t–78t, 81t–82t, 86t, 89
  - carbapenem-resistant 22t, 32–33
  - ESBL-producing 20, 22t, 30, 55, 103t
Enterococcus 21t, 55, 58, 77t–78t, 80t, 82t, 131t
  - *E. faecalis*, vancomycin-resistant 51
  - *E. faecium*, vancomycin-resistant 20, 24t, 28–29, 51
  - *Enterococcus*, vancomycin-resistant 24t, 28–29, 51–53
Ertapenem 56–57, 72t, 120t, 123t
Erysipelas 73t
Erythromycin 22t, 24t, 93–94, 105t, 113t, 120t, 124t
*Escherichia coli* (*E.coli*) 20, 21t, 23t–24t, 30, 31t, 33, 56, 78t,–79t, 82t, 101t–102t, 116, 137, 138t–139t
Extended-spectrum β-lactamases (ESBL) 20, 22, 33–24, 30–33, 55–57, 59, 87, 100–103, 116, 139

**F**
- Flucloxacillin 25, 120
- Fluconazole 60, 61–66, 125
- Flucytosine 61
- Fluoroquinolones 22, 29, 30, 37, 74, 79, 81–85, 94–95, 99, 101, 105, 116, 123, 131, 143
- Fosfomycin 55, 120
- *Fusarium* 60, 61, 67
- Fusidic acid 104

**G**
- Gastroenteritis 78–79
- Gentamicin 23, 39, 58, 80–81, 99–100, 111–112, 120, 123, 127
- Global Initiative for Chronic Obstructive Lung Disease (GOLD) 83
- Gynaecological infections 81

**H**
- Haemodialysis 49, 63
- *Haemophilus influenzae* 21, 51, 83–84, 87, 93, 96, 101
- Head and neck infections 81
- *Histoplasma* 60
  - *H. capsulatum* 61
- Hospital-acquired pneumonia (HAP) 87
- Human immunodeficiency virus (HIV) 79, 81, 141

**I**
- Imipenem 23, 37, 56–57, 72, 74, 82, 87, 93, 97, 99, 120, 123, 127, 134
- Infectious mononucleosis 129
- Influenza 27, 84–86, 92
- Intra-abdominal, infections 30, 53, 71, 77
- Itraconazole 60, 61, 62–63, 65–66, 125

**K**
- *Klebsiella pneumoniae* 32–33, 55, 78, 92, 102–103
- Known-pathogen therapy (KPT) 57, 79, 99

**L**
- *Legionella* 85–86, 92, 137
  - urinary antigen test (UAT) 137, 138
- Levofloxacin 72, 74–75, 79, 84, 95, 100, 103–105, 116, 120, 123, 143
Lincomycin 131
Linezolid 29, 51, 74t, 86t, 104t, 120t, 124t, 143
Liver abscess, see abscess
Liver disease 53, 75t, 88

M
Meningitis 27, 76t, 93t, 97, 106t, 126, 142
Meropenem 39, 56–57, 74t, 76t, 82t, 87t, 93, 97t, 120t, 123t, 126t, 134t
Metallo-ß-lactamase 33, 35t, 36
Methicillin 25
Methicillin-resistant S. aureus, see Staphylococcus aureus
Metronidazole 48, 75t–79t, 81t, 84t, 99t, 101t–102t, 109t, 112t–115t, 116, 121t, 124t, 126t
Micafungin 60t, 61, 62t, 65t–66t, 125t
Minocycline 53, 104t, 121t
Monobactam 22t, 36
Moraxella catarrhalis 51, 54, 83t–84t, 87t, 96, 101t
Moxifloxacin 72t, 75t, 79t, 95, 104t–105t, 121t, 123t, 143
Mucormycosis 63t
Mupirocin, nasal, preoperative prophylaxis against MRSA 48, 116
Mycobacteria 51, 142
Mycobacterium tuberculosis 51, 84t, 95, 142
Mycoplasma 37–38, 40, 92, 104t
Myositis 88

N
Nasal
  - carriage, MRSA 48
Neck, infection 81t
Necrotising fasciitis 27, 72t, 74t, 88t
Neisseria
  - N. gonorrhoeae 70t, 81t
  - N. meningitidis, meningitis 76t
Neomycin 113t
Neurosurgery, surgical prophylaxis 110t
Neutropenic fever 49, 56, 66t, 122
New Delhi metallo-ß-lactamase 1 (NDM-1) 33, 35t
Nitrofurantoin 23t, 82t, 102t
O
Odontogenic, infection 81t
Orthopaedic & traumatology, surgical prophylaxis 111t
Oseltamivir 85t–86t
Osteomyelitis 71t–72t, 104t
Oxacillin 25

Pacemaker 110t
Pancreatitis 89, 90t, 113t
Pasteurella multocida 75t
Pelvic inflammatory disease 81t
Penicillin 22, 25, 30, 39, 73t, 75t, 81t, 84t, 93–97, 106t, 116, 123t, 129–131, 134t
  - allergy 75, 83t–84t, 99t, 101t, 103t, 129, 131
  - penicillin G 74t, 83t, 95–96, 97t, 105t–106t, 111t, 121t, 126t, 131
  - penicillin V 75t, 93t, 95, 97t
Penicillium marneffei 61t, 67f
Peritoneal dialysis see Continuous ambulatory peritoneal dialysis
Peritonitis 125t, 127, 141
  - secondary 57, 77t
  - continuous ambulatory peritoneal dialysis 49, 127, 141
Piperacillin 23t, 96, 97t, 121t, 123t
Piperacillin-tazobactam 23t, 39, 72t, 77t, 82t, 84t–87t, 93, 96, 100t–103t, 113t, 121t, 123t
Posaconazole 61, 62t, 65t, 125t
Pregnancy 113
Prosthetic joint, infection 140
Proteus mirabilis 21t
Pseudallescheria 61t
Pseudomonas aeruginosa 21t, 23t–24t, 54, 56, 59, 71t, 80t, 82t–84t, 87t, 92–93, 99t, 101t–103t
Pyelonephritis 82t

Q
Quinupristin-dalfopristin 51

R
Respiratory tract, infections 37, 44, 56, 83t, 137
Rifampicin 104t, 126t, 142–143
Ruptured viscus, surgical prophylaxis 115t
**S**

*Salmonella* 71t, 78t–79t

Sepsis 27, 58, 77t

*Serratia* 32, 54

Skin 48

- infections, skin and soft tissue 27, 48, 52, 57, 59, 73t, 104t
- testing, penicillin allergy 129–130

*Staphylococcus aureus* 21t, 25, 26t, 29, 51–52, 70t–73t, 75t, 78t, 80t–81t, 84t, 86t–87t, 96, 103t–104t, 120t, 137, 138t–139t

- *S. aureus*, methicillin-resistant (MRSA) 20, 22t, 24t, 25–27, 48–53, 55, 59, 71t, 80t, 87t, 89, 104t, 116, 126, 131, 139t
- *S. aureus*, methicillin-resistant, community-associated (CA-MRSA) 25–27, 28f, 48, 70t–71t, 73–74t, 80t, 86t, 92, 104t
- *S. aureus*, methicillin-resistant, healthcare-associated (HA-MRSA) 25–27

*Stenotrophomonas maltophilia* 21t, 23t, 53, 105t

Stevens-Johnson syndrome 48, 129

*Sanguinicola* 78t, 82t

- Group A, *S. pyogenes*, necrotising fasciitis 24t, 52, 87
- Group B 76t, 82t
- *S. milleri* 78t, 84t
- *S. pneumoniae* 76t, 83–84t, 86t–87t, 93t, 94–96, 97t, 101t, 106t, 138t–139t
- *S. pneumoniae*, drug-resistant (DRSP) 92–94
- *S. suis*, meningitis 76t
- *S. viridans*, endocarditis 80t

Surgical prophylaxis 48, 108, 109t

**T**

Teicoplanin 121t

Ticarcillin 23t, 96, 97t

Ticarcillin-clavulanate 23t, 39f, 84t–86t, 103t, 105t, 121t, 123t

Tigecycline 53t, 121t

Tobramycin 121, 123t, 127t

Toxic shock syndrome

- streptococcal 74t, 87t

Traumatic wound, surgical prophylaxis 115t

*Trichosporon* 60, 61t, 67f

Tricuspid valve, endocarditis 80t

Tuberculosis 95, 141
U
Urinary tract, infection 30, 33, 55, 82t, 100t, 102t, 137, 138t
Urticaria, penicillin allergy 129
V
Vancomycin 20, 24t, 25, 26t, 28, 29t, 48–50, 70t–71t, 73t, 76t, 80t, 86t–87t, 94, 99t, 104–106, 109t, 116, 121t, 124t, 126t, 129, 131
Vibrio vulnificus, necrotising fasciitis 74t
Voriconazole 41t, 60t, 62t, 64t–65t, 125t
W
Wound, infection 48, 116
Z
Zygomycetes 60, 61t