

# Prophylaxis and treatment of infective endocarditis in adults: concise guidelines

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**ABSTRACT** – Infective endocarditis (IE) is a life-threatening disease with substantial morbidity and mortality which affects individuals with underlying structural cardiac defects who develop bacteraemia, often as a result of dental, gastrointestinal, genitourinary, respiratory or cardiac invasive/surgical procedures. Prompt recognition of the clinical diagnosis by a wide variety of medical personnel, early involvement of specialist cardiologists, cardiac surgeon and a microbiologist, and prompt treatment with the most appropriate antimicrobial agents offer the greatest chance of improving the outcome for these patients. The guidance given here to clinicians involved in the management of patients with IE briefly covers diagnosis, antibiotic prophylaxis, medical treatment and the indications for surgery.

**KEY WORDS:** antibiotics, guidelines, infective endocarditis, prophylaxis, surgery

## Background

Infective endocarditis (IE) is associated with substantial morbidity and mortality, despite improved techniques to aid diagnosis and modern antibiotics and surgical therapies.<sup>1</sup> It affects individuals with structural cardiac defects who develop bacteraemia as a result of dental, gastrointestinal, genitourinary, respiratory or cardiac invasive/surgical procedures.<sup>2</sup> Most organ systems can be involved and the fact that IE may present to doctors in a variety of specialties means that they must be made aware of IE as a potential diagnosis warranting prompt specialist investigation and treatment. Guidelines for diagnosis and treatment are therefore important and worthy of widespread dissemination, such as those produced by the European Society of Cardiology: [www.escardio.org/knowledge/guidelines/Guidelines\\_Infective\\_Endocarditis.htm](http://www.escardio.org/knowledge/guidelines/Guidelines_Infective_Endocarditis.htm)

## Symptoms and diagnosis

### *When to suspect infective endocarditis*

Infective endocarditis should be suspected in ill patients with known cardiac disease or new cardiac murmurs, especially if there is a history of recent dental, invasive diagnostic or surgical treatment and/or signs of embolic or vasculitic complications.

### *Clinical features*

- *Systemic features:* high remitting pyrexia, rigors, anorexia, weight loss, arthralgia and fatigue.<sup>3</sup>
- *Cardiac manifestations:* new or worsening cardiac murmurs – typically due to valvular regurgitation; or the development of cardiac failure. Abscesses of the heart and fistulous connections between cardiac structures are serious complications.<sup>4</sup>
- *Extracardiac manifestations* consist of *embolic* as well as *vasculitic* phenomena.<sup>5</sup> All major vessels may be the recipient of infected emboli from valve vegetations. Renal, splenic and neurological complications may be particularly serious. Right-sided IE results in pulmonary infarcts and abscesses and is often associated with iv drug abuse, infected pacemakers or central iv lines.<sup>6</sup> Culture-negative IE, including fungal IE, often have specific clinical features.<sup>7,8</sup>
- *The Duke criteria* form the basis of the diagnosis of which blood cultures, echocardiography and sometimes serology are most important.<sup>9,10</sup>

## Bacteriology

The majority of native valve IE and of late prosthetic valve endocarditis (PVE) is caused by viridans streptococci (50–70%), *Staphylococcus aureus* (25%) and enterococci (10%). In early PVE, *S. epidermidis* and *S. aureus* are the commonest organisms. Gram-positive and Gram-negative bacilli, the HACEK group of organisms (*Haemophilus*, *Actinobacillus*, *Cardiobacterium*, *Eikenella* and *Kingella* species) and fungi are less common but serious causes of IE.

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**Box 1. Guideline development process.** These guidelines were developed in accordance with the principles laid down by the AGREE (Appraisal of Guidelines for REsearch and Evaluation Instrument) Collaboration ([www.agreecollaboration.org/](http://www.agreecollaboration.org/)). An extensive referenced document is also available on the British Cardiac Society's website: [www.bcs.com](http://www.bcs.com)

SCOPE AND PURPOSE

<b>Overall objective of the guidelines</b>	To provide practical advice on the diagnosis, prevention and treatment of IE in adults.
<b>The patient group covered</b>	<ul style="list-style-type: none"> <li>● Individuals at risk of developing IE, eg those with congenital heart disease, valvular heart disease, prosthetic heart valves, previous IE or IV drug abuse.</li> <li>● Individuals presenting with the symptoms/signs of IE (eg pyrexia, new or changing heart murmurs, positive blood cultures/serology or evidence of vegetations) who have recently undergone a dental, invasive diagnostic or therapeutic procedure or surgery.</li> </ul>
<b>Target audience:</b>	<ul style="list-style-type: none"> <li>● Health professionals who are responsible for treating patients with cardiac disease, or undertaking procedures in those at increased risk of developing IE.</li> <li>● Clinicians likely to be involved in its first presentation, who should be alerted to the possibility of this life-threatening condition.</li> </ul>
<b>Clinical areas covered:</b>	<ul style="list-style-type: none"> <li>● How does IE present clinically?</li> <li>● What are the diagnostic criteria?</li> <li>● How can IE be prevented?</li> <li>● Once diagnosed, how do we treat IE medically?</li> <li>● What are the indications for cardiac surgery?</li> </ul>

STAKEHOLDER INVOLVEMENT

<b>Guideline Advisory Group</b>	A multidisciplinary group of clinicians with patient representation (for full list, see end of article).
<b>Funding</b>	Development of the guidelines was supported by the British Cardiac Society (BCS).
<b>Conflicts of interest</b>	No conflicts of interest existed and the writing group had full editorial independence.

RIGOUR OF DEVELOPMENT

<b>Evidence gathering</b>	The recommendations reflect an extensive review of the literature (Medline and PubMed 1964–2003) and the personal knowledge and experience of the members of the Guideline Advisory Group.
<b>Links between evidence and recommendations</b>	The strength of evidence and the recommendations drawn from it were classified according to the definitions used by the Scottish Intercollegiate Guidelines Network ( <a href="http://www.sign.ac.uk">www.sign.ac.uk</a> ). The recommendations were graded independently by four reviewers (see end of article). <i>Given the lack of controlled trial data from which to draw, the guidelines reflect expert consensus opinion, supported by published reports where available.</i>
<b>Piloting and peer review</b>	The guidelines were reviewed by two senior UK cardiologists, both members of the BCS.

IMPLEMENTATION

<b>Tools for application</b>	No specific audit tools have been developed so far.
<b>Plans for update</b>	The guidelines are due for review in 2007 by the Endocarditis Working Group of the BCS.

**Table 1. Patients considered to be at moderate or high risk for developing IE.<sup>a</sup>**

**High risk**

- Previous IE
- Prosthetic heart valves
- Mitral valve prolapse with mitral regurgitation or thickened valve leaflets<sup>b</sup>
- Complex congenital heart disease
- Surgically constructed systemic pulmonary shunts or conduits

**Moderate risk**

- Acquired valvular heart disease, eg rheumatic valve disease
- Non-cyanotic congenital cardiac defects, eg patent ductus arteriosus, coarctation of aorta, ventricular septal defect, primum atrial septal defect, bicuspid aortic valve
- Other structural cardiac abnormalities, eg hypertrophic obstructive cardiomyopathy, aortic root replacement

<sup>a</sup> Antibiotic prophylaxis is recommended for up to 12 months after atrial septal defect/patent foramen ovale/patent ductus arteriosus catheter-based closure procedures.

<sup>b</sup> Mitral regurgitation should be obvious clinically or deemed to be more than physiological on Doppler echocardiography.

**NB:** If there is uncertainty as to the nature of the heart murmur and the need for prophylaxis, an opinion from a cardiologist should be sought. In an emergency or when it is difficult to obtain specific advice, then prophylaxis should be given prior to dental or surgical treatment.

**Box 2. Guidelines on infective endocarditis: prophylaxis, diagnosis and treatment.**

Recommendation	Grade	Recommendation	Grade
<b>Prophylaxis</b>		<b>Treatment</b>	
<p>In order to prevent IE, prophylactic antibiotic treatment is recommended prior to dental or other 'surgical' procedures for those at moderate or high risk of developing IE, should bacteraemia be induced (Table 1). A list of dental and 'surgical' procedures requiring antibiotic prophylaxis is provided in Appendix 1.</p>		<p>12 Once the diagnosis is established, treatment should be commenced according to the guidelines or with alternative antibiotics if microbiological tests suggest that more appropriate agents are suitable (Table 4).<sup>11,12,51-54</sup></p>	
1 Patients should be informed of their risk of IE and the need for antibiotic prophylaxis, and be told to inform any doctor or dentist who is responsible for providing care. They should be given a card to carry indicating the type of cardiac lesion, the risk and how to avoid IE. <sup>11-14</sup>	C	13 <i>In a sick patient</i> , antibiotic treatment should be commenced immediately after blood cultures have been collected and the regimen adjusted once the microbiological data are available. The initial antibiotics of choice depend on the most likely suspected organism based upon the particular clinical presentation, but should cover Gram-positive and Gram-negative organisms. <sup>11,12,51-54</sup>	D
2 Patients at moderate-risk or high-risk of IE should be given antibiotic prophylaxis with appropriate antibiotics based upon the type of dental or surgical procedure being performed (Table 2). <sup>11,12,15-18</sup>	C	14 Generally, prolonged iv antibiotic therapy is necessary (4-6 weeks), administered via a large central vein. Only the most penicillin-sensitive streptococci should be considered for treatment with shorter courses of penicillin. <sup>11,12,51-54</sup>	D
<b>Diagnosis</b>		15 More unusual organisms, eg nutritionally variant streptococci, HACEK group and fungi, demand special regimens, and help should be sought from a microbiologist. <sup>11,12,51-54</sup>	
<p>When IE is suspected, the following recommendations should be followed to establish the presence or absence of the Duke criteria (Table 3).</p>		16 Patients with a history of penicillin allergy or who develop penicillin allergy should be treated with (or changed to) vancomycin or teicoplanin, and gentamicin or other appropriate antibiotics. <sup>11,12,51-55</sup>	
3 Admit the patient to hospital for full and careful investigation, including:		<b>Follow-up</b>	
<ul style="list-style-type: none"> <li>• blood cultures,</li> <li>• recording of temperatures,</li> <li>• haematological and biochemical investigation,</li> <li>• ECG, chest X-ray and</li> <li>• comprehensive transthoracic echocardiography (TTE).<sup>3,9,19,20</sup></li> </ul>	C	17 Patients receiving treatment for IE need to be regularly examined by an expert team for early detection of complications, relapses or recurrence. <sup>56</sup>	D
4 Take three sets of blood cultures at intervals of >1 hour within the first 24 hours when clinical evidence suggests the diagnosis is highly likely in a sick patient. <sup>18,21-24</sup>	D	18 Examination should include detailed cardiac assessment for new or changing murmurs, careful observation for embolic or immunological complications, and <i>repeat echocardiography</i> . <sup>57-59</sup>	D
5 If the patient is not acutely ill or when the diagnosis is not obvious clinically, six sets of blood cultures should be taken within the first 24-48 hours. <sup>21-23</sup>	D	<b>Surgery</b>	
6 If the diagnosis is confirmed by blood culture, the patient should be referred to a cardiologist. <sup>25-28</sup>	D	19 Surgery is indicated in patients with severe valvular incompetence, annular or aortic abscess, with infections resistant to antibiotics and with fungal IE. Large, mobile vegetations, recurrent emboli after antibiotic therapy and PVE are indications for surgery. <sup>60-66</sup>	D
7 A microbiologist should be involved from the outset. <sup>*24</sup>		20 In haemodynamically stable patients, early consultation with a cardiac surgeon is recommended in case surgery is suddenly required. <sup>61,67-72</sup>	D
8 Transoesophageal echocardiography (TOE) should be:		21 Patients with life-threatening congestive heart failure, pulmonary oedema or cardiogenic shock due to treatable valvular disease should undergo emergency cardiac surgery, if the patient has reasonable prospects of recovery and a satisfactory quality of life after surgery. <sup>61,62,68-75</sup>	D
<ul style="list-style-type: none"> <li>• performed if TTE is suboptimal, to obtain further information on the size, site or mobility of vegetations, abscess or fistula formation, or valve perforation etc</li> <li>• performed in all patients with PVE.<sup>29-39</sup></li> </ul>	B		
9 Cultures which are negative for the commoner organisms (see above) (5-10%), should be closely scrutinised for unusual and slow-growing microorganisms and fungi. <sup>19,40-43</sup>	D		
10 Serological tests for <i>Coxiella burnetii</i> , <i>Bartonella</i> spp and <i>Chlamydia</i> spp should be performed if the diagnosis is still suspected and there is still no growth after 7 days in blood cultures. <sup>44-46</sup>	D		
11 Microscopy and culture of any excised tissue is essential. Molecular assays for specific gene targets and universal loci for bacteria and fungi are being developed. <sup>46-50</sup>	D		

\*No specific evidence to support statement but a good practice point.

**Table 2. Prophylactic antibiotic regimens.**

Clinical situation	Drug	Regimen
<b>Prophylactic antibiotic regimens for dental, oral, respiratory tract or oesophageal procedures</b>		
High-risk and moderate-risk patients including patients with prosthetic heart valves*	Amoxicillin	3 g oral 1h pre-procedure or 2 g iv <30 min pre-procedure <sup>a</sup>
If allergic to penicillin <sup>b</sup>	Clindamycin <sup>c</sup>	600 mg oral 1h pre-procedure or 300 mg iv <30 min pre-procedure <sup>d</sup> then oral or iv clindamycin 150 mg 6 h later
Patients with previous infective endocarditis <sup>e</sup>	Amoxicillin + gentamicin	2 g iv <30 min pre-procedure and 1g iv or orally 6 h post procedure 1.5 mg/kg iv <30 min pre-procedure <sup>a</sup>
If allergic to penicillin <sup>b</sup>	Vancomycin + gentamicin or Clindamycin	1g iv over 2 h, 1-2 h pre-procedure 1.5 mg/kg iv <30 min pre-procedure <sup>a</sup> 300 mg iv <30 min pre-procedure <sup>d</sup> then iv clindamycin 150 mg 6 h later
<b>Prophylactic antibiotic regimens for genitourinary or gastrointestinal procedures</b>		
High-risk and moderate-risk patients	Ampicillin or amoxicillin + gentamicin	2 g iv – <30 min pre-procedure <sup>a</sup> and 1g iv or orally 6 h post procedure 1.5 mg/kg iv <30 min pre-procedure <sup>a</sup>
If allergic to penicillin <sup>b</sup>	Vancomycin + gentamicin	1 g iv over 2 h, 1-2 h pre-procedure 1.5 mg/kg iv <30 min pre-procedure <sup>a</sup>

\*Particular care should be taken to ensure that patients with prosthetic heart valves are protected by prophylactic antibiotics, since the consequences of infective endocarditis are particularly serious. It is essential that they receive prophylactic antibiotics orally at least 1 hour before the procedure. If not, they should be given iv antibiotics immediately before the procedure or the procedure should be postponed.

<sup>a</sup> For those undergoing general anaesthetic, iv antibiotics should be given either on induction or within 30 min before starting the procedure; oral amoxicillin (3 g) should be given 4 hours before induction. Where oral antibiotics are not ideal and in whom iv access is difficult or impossible, eg iv drug abusers, im clindamycin 600 mg 1 hour pre-op or im teicoplanin (2 mg/kg) 1 hour pre-op may be alternative treatments.

<sup>b</sup> or received penicillin within last 4 weeks.

<sup>c</sup> Azithromycin 500 mg, as an oral suspension, given 1 hour before the procedure may be an alternative if dysphagia is a problem.

<sup>d</sup> Clindamycin to be infused over 10-15 min.

<sup>e</sup> These patients are considered to be at highest risk of IE.

**Table 3. Duke criteria for diagnosis of infective endocarditis and definitions used in the modified diagnostic criteria.****Definite infective endocarditis***Pathological criteria*

- Microorganisms: demonstrated by culture or histology in a vegetation that has embolised, or in an intracardiac abscess, or
- Pathologic lesions: vegetation or intracardiac abscess present, confirmed by histology showing active endocarditis

*Clinical criteria (see below)*

- 2 major criteria, or
- 1 major and 3 minor criteria, or
- 5 minor criteria

**Definitions***Major criteria*

- 1 Positive blood culture for IE – from at least two separate blood cultures drawn 12 hours apart, or all of three blood cultures, or a majority of four blood cultures with first and last drawn 12 hours apart.
- 2 Evidence of endocardial involvement, eg echocardiogram showing mobile intracardiac mass on valve or supporting structures, abscess, new partial dehiscence of prosthetic valve or new valve regurgitation.
- 3 Clinical evidence of new valvular regurgitation.
- 4 Positive serology for Q-fever or other causes of culture-negative IE, eg *Bartonella*, *Chlamydia psittaci*.
- 5 Identification of a microorganism from blood culture or excised tissue using molecular biology methods.

*Minor criteria*

- 1 Predisposition: predisposing heart condition or iv drug abuse.
- 2 Fever: >38.0°C.
- 3 Vascular phenomena: major arterial emboli, septic pulmonary infarcts, mycotic aneurysm, intracranial haemorrhage, conjunctival haemorrhages, Janeway lesions, *newly diagnosed clubbing*, *splinter haemorrhages*, *splenomegaly*.\*
- 4 Immunologic phenomena: glomerulonephritis, Osler's nodes, Roth spots, +ve rheumatoid factor, *high ESR (>1.5 times upper limit of normal)*, *high C-reactive protein level (>100 mg/l)*.\*
- 5 Microbiologic evidence: positive blood culture, but not meeting major criteria as defined above.

\* Additional modifications to the Duke criteria, shown in *italics*, appear to improve diagnostic sensitivity whilst retaining specificity. ESR = erythrocyte sedimentation rate.

Table 4. Treatment of infective endocarditis.

Antibiotic	Dose/route	Duration
<b>Treatment of IE due to penicillin-sensitive viridans streptococci and <i>S. bovis</i> (MIC &lt;0.1 mg/l) in adults</b>		
Benzylpenicillin	7.2–12 g iv/24 h in 4–6 divided doses	4–6 weeks <sup>a</sup>
+ gentamicin <sup>b</sup>	3–5 mg/kg iv daily in 2–3 divided doses (max 240 mg/day)	2 weeks
<i>For patients allergic to penicillin</i>		
Vancomycin	30 mg/kg iv in 24 h in 2 divided doses (infused over 2 h)	4 weeks
+ gentamicin <sup>b</sup>	3–5 mg/kg iv daily in 2–3 divided doses (max 240 mg/day)	2 weeks
<b>Treatment of IE due to penicillin-relative resistant viridans streptococci and <i>S. bovis</i> (MIC &gt;0.1 mg/l) in adults</b>		
Benzylpenicillin	12–14 g iv/24 h in 4–6 divided doses	4–6 weeks <sup>a</sup>
+ gentamicin <sup>b</sup>	3–5 mg/kg iv daily in 2–3 divided doses	2 weeks <sup>a</sup>
<i>For patients allergic to penicillin, see above.</i>		
<b>Treatment of IE due to staphylococci on native valve</b>		
<i>Penicillin-sensitive (non-B-lactamase producers)</i>		
Benzylpenicillin	12–14 g iv/24 h in 4–6 divided doses	6 weeks
+ gentamicin <sup>b</sup>	3–5 mg/kg iv daily in 2–3 divided doses	3–5 days
<i>Methicillin-sensitive staphylococci (B-lactamase producer)</i>		
Flucloxacillin	8–12 g iv/24 h in 4 divided doses	6 weeks
+ gentamicin <sup>b</sup>	3–5 mg/kg iv daily in 2–3 divided doses (max 240 mg/day)	3–5 days
<i>Methicillin-resistant staphylococci<sup>c</sup></i>		
Vancomycin <sup>d</sup>	30 mg/kg iv in 24 h in 2 divided doses (infused over 2 h)	6 weeks
+ gentamicin <sup>b</sup>	3–5 mg/kg iv daily in 2–3 divided doses	3–5 days
<i>For patients allergic to penicillin, see above.</i>		
<b>Treatment of IE due to enterococci in adults</b>		
<i>Gentamicin-sensitive or low-level resistant organism (MIC &lt;500 mg/l)</i>		
Benzylpenicillin	10–12 g iv/24 h in 4–6 divided doses	4–6 weeks
or ampicillin or amoxicillin	12 g iv/24 h in 4–6 divided doses	4–6 weeks <sup>e</sup>
+ gentamicin <sup>f,b</sup>	3–5 mg/kg iv daily in 2–3 divided doses (max 240 mg/day)	4–6 weeks <sup>e</sup>
<i>For those allergic to penicillin, see above.</i>		

<sup>a</sup>Duration adjusted according to clinical response and advice from microbiologist.

<sup>b</sup>Gentamicin blood levels must be checked regularly during this period: pre-dose (trough) level <2 mg/l and peak (1 hour post-dose) 5–10 mg/l is a reasonable target.

<sup>c</sup>Linezolid or Synercid<sup>®</sup> may be used in methicillin-resistant *Staphylococcus aureus* (MRSA).

<sup>d</sup>Vancomycin: 1 hour post infusion serum concentration of approximately 30 mg/l and trough concentration of 10–15 mg/l should ensure optimal efficacy, although the correlation between peak and trough levels with toxicity and efficacy is not high.

<sup>e</sup>Six weeks therapy recommended for patients with symptoms for >3 months.

<sup>f</sup>For strains highly resistant to gentamicin (MIC >500 mg/l), ampicillin or amoxicillin 12 g iv per day in six divided doses or as a continuous infusion for 6 weeks is advisable, a microbiologist's opinion sought, and surgery considered early for antibiotic-treatment failure. For ampicillin-resistant strains, and for patients allergic to penicillin, a vancomycin + gentamicin regimen may be effective.

Gentamicin and vancomycin dose will need adjustment in renal impairment.

MIC = minimum inhibitory concentration.

## Appendix 1

Table 5. Dental procedures and endocarditis antibiotic prophylaxis for high-risk and moderate-risk cases.

Prophylaxis required	Prophylaxis not required
<b>Examination procedures</b>	
Periodontal probing	Dental examination with mirror and probe
<b>Investigative procedures</b>	
Sialography	Intra-oral radiographs Extra-oral radiographs
<b>Preventive procedures</b>	
	Fissure sealants Fluoride treatments
<b>Professional cleaning procedures</b>	
Polishing teeth with a rubber cup Oral irrigation with water jet Light scaling Deep scaling Scaling teeth with hand instrument Scaling with ultrasonic instrument	Air polishing
<b>Anaesthetic procedures</b>	
Intraligamental local anaesthetic injections	Infiltration local anaesthetic injections Nerve block local anaesthesia Oral airway for GA Nasal airway for GA Laryngeal mask airway for GA
<b>Comprehensive dental treatment under general anaesthetic</b>	
Extraction and fillings	
<b>Conservative (restorative) procedures<sup>a</sup></b>	
Rubber dam placement Matrix band and wedge placement Gingival retraction cord placement	Slow and fast drilling of teeth (without rubber dam)
<b>Periodontal procedures</b>	
Root planning (similar to scaling) Antibiotic fibres or strips placed subgingivally Gingivectomy Periodontal surgery	
<b>Endodontic procedures<sup>b</sup></b>	
Root canal instrumentation beyond the apex Avulsed tooth reimplantation Non-vital pulpotomy of primary molar	Root canal instrumentation within the root canal Vital pulpotomy of primary molar Pulpotomy of permanent tooth
<b>Orthodontic procedures</b>	
Tooth separation Expose or expose and bond tooth/teeth	Alginate impressions Placement of removable appliances Band placement and cementation Band removal Adjustment of fixed appliances
<b>Surgical procedures</b>	
Extraction of single tooth Extraction of multiple teeth Incision and drainage of an abscess with extraction Mucoperiosteal flap to gain access to tooth or lesion Dental implants (as for mucoperiosteal flap)	Incision and drainage of an abscess without extraction Dental implants – transmucosal fixture
<b>Post surgical procedures</b>	
	Suture removal Removal of surgical packs
<b>Daily or physiological events</b>	
	Exfoliation of primary teeth Tooth brushing Flossing Use of interdental wooden points

<sup>a</sup> It is common for a course of dental treatment to take several visits to the dentist. For patients at high or moderate risk of developing infective endocarditis, as much treatment as possible should be carried out at each visit. The antibiotic should be changed at alternate visits, eg amoxicillin – clindamycin – amoxicillin etc. For patients who are allergic to penicillin, then a period of 1 month must be allowed between visits.

<sup>b</sup> Dental treatment confined to the root canal does not require antibiotic prophylaxis. However, if a rubber dam is used, antibiotic prophylaxis should be used since significant bacteraemia often results in these circumstances.

GA = General anaesthesia.

**Table 6. Other procedures requiring endocarditis prophylaxis in high-risk and moderate-risk cases.**

	Prophylaxis required	Prophylaxis not required
Gastrointestinal tract	Oesophageal procedures Surgical operations on stomach, small or large bowel Endoscopic retrograde cholangiography/biliary obstruction Endoscopy with/without biopsy Endoscopic variceal sclerotherapy Percutaneous endoscopic gastrostomy Biliary tract surgery Lithotripsy of gall stones	Barium examinations
Genitourinary tract	Circumcision Prostatic surgery, transrectal biopsy Vasectomy Lithotripsy Cystoscopy Urethral catheterisation in presence of bacteriuria Urethral dilatation Gynaecological operations, eg hysterectomy, Caesarean section, vaginal delivery* Therapeutic abortion, uterine dilatation and curettage, sterilisation procedures, insertion of intrauterine device* Removal of infected intrauterine device* Smears*	Urethral catheterisation – unless bacteriuria evident
Respiratory tract	Tonsillectomy/adenoidectomy Surgical procedures on respiratory tract Bronchoscopy – particularly rigid bronchoscopy Nasal packing*	Endotracheal intubation
Cardiac	Implantation of cardiac pacemakers/defibrillators Cardiac surgical operations Implantation of occlusive devices, eg ductal occluders, septal occluders Transoesophageal echocardiography* Balloon valvuloplasty/balloon dilatation of coarctation of aorta* PTCA/PCI/stent implantation*	Diagnostic cardiac catheterisation
Ophthalmological	Lacrimal duct probing*	
Dermatological	Surgery* Thermal injury/burns* Acupuncture* Body piercing/tattooing*	

\*Although not considered 'high-risk' procedures, bacteraemia and/or IE have been reported after these procedures and antibiotic prophylaxis should be considered in those patients considered at high or moderate risk of IE (Table 1). However, the European Society of Cardiology did not recognise these to be indications for antibiotic prophylaxis in their Task Force Report.<sup>76,77</sup>

PCI = percutaneous coronary intervention; PTCA = percutaneous transluminal coronary angioplasty.

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