

# Pocket Guide to Diagnosis & Treatment of Cardiovascular Implantable Electronic Device (CIED) Infections



Draft Version 1:  
1 November 2018

## DEFINITION

**Pocket infection**, if all 4 criteria are fulfilled:

Investigation/sign	Criteria
<b>Local signs of infection and/or microbiology (at least one of them)</b>	<ul style="list-style-type: none"> <li>Local signs of inflammation<sup>1</sup></li> <li>Purulent wound secretion or sinus tract or abscess</li> <li>Wound dehiscence or implant on view (generator or subcutaneous leads)</li> <li>Positive culture<sup>3</sup> from pocket tissue or explanted CIED</li> </ul>
<b>Fever or rigors</b>	Absent
<b>Blood cultures (2-3 sets)</b>	Negative
<b>TEE</b>	No vegetations on leads <sup>2</sup> or valves

<sup>1</sup> Erythema, swelling, warmth, pain or tenderness

<sup>2</sup> Fibrous strands visible of older leads seen in TEE may represent aseptic thrombus, especially if blood cultures are negative (without antimicrobial therapy)

<sup>3</sup> For highly virulent organisms (e.g. *S. aureus*, *E. coli*) one positive culture needed, for low-virulent organisms (e.g. *S. epidermidis*, *C. acnes*) 2 or more positive cultures are needed to confirm infection

**Systemic CIED infection**, if  $\geq 1$  criterion is fulfilled:

### Device-associated endocarditis (intravenous leads)

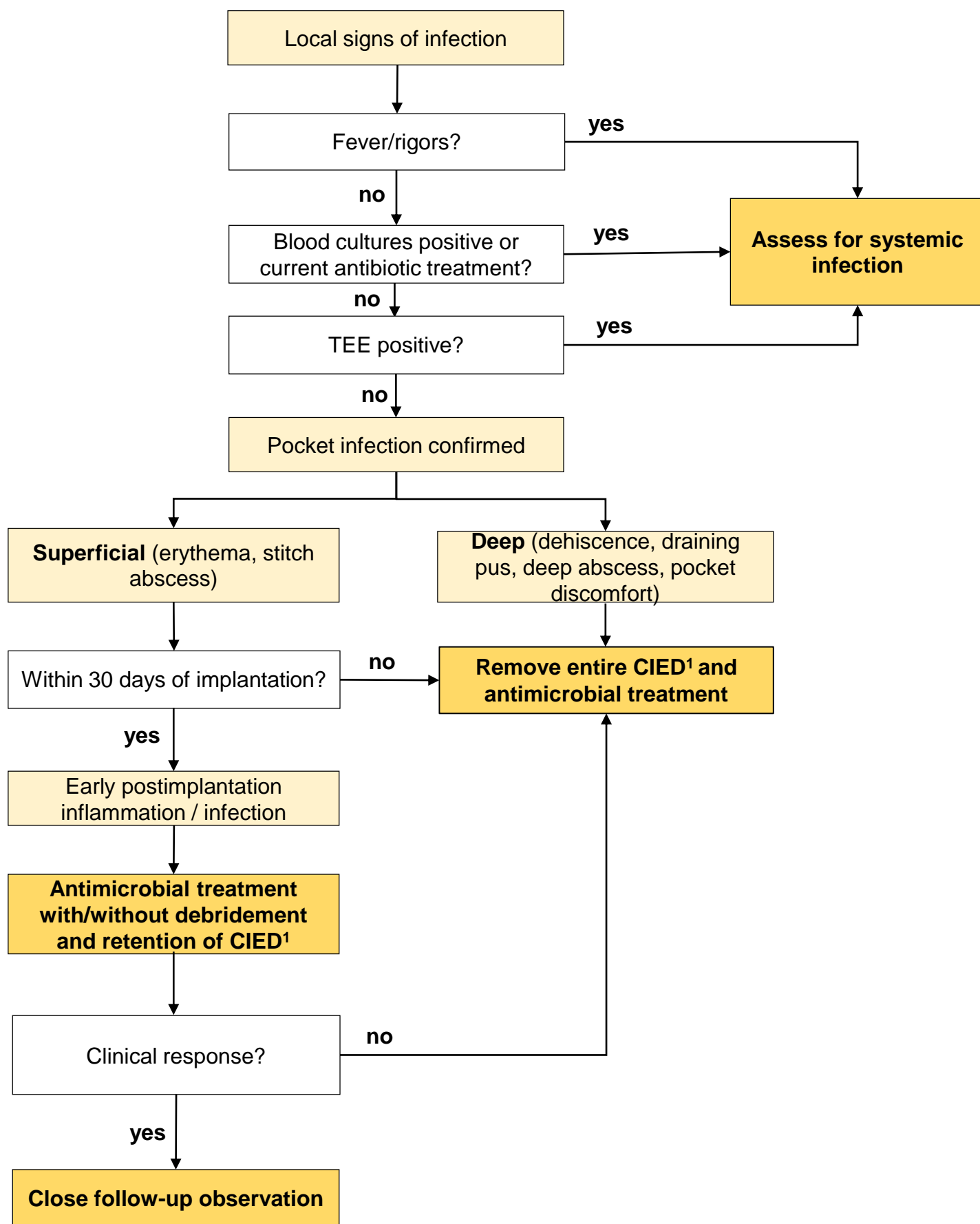
- Pocket infection with positive blood cultures
- Positive TEE (with lead or valve vegetation) with positive blood cultures
- Positive blood cultures with gram-positive bacteria or *Candida* spp. at two different occasions **without** evidence of infectious focus or portal of entry (e.g. intravascular catheter)
- Infective endocarditis defined by modified Duke criteria

### Device-associated mediastinitis or pericarditis (epicardial leads)

For individual recommendations contact our Consultation Portal at: [cp.pro-implant-foundation.org](http://cp.pro-implant-foundation.org)

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# MANAGEMENT ALGORITHM POCKET INFECTION



<sup>1</sup> Intraoperative diagnostics including pocket swab, tissue culture, +/- lead tip culture and device sonication. Consider molecular diagnostic in culture-negative cases.

If lead extraction is too risky, consider isolated generator exchange with consecutive lifelong antimicrobial suppression.

# MANAGEMENT ALGORITHM SYSTEMIC CIED INFECTION

Suspected systemic CIED-infection

- Fever/rigors (unexplained)
- Unexplained bacteremia
- Evidence of distant seeding<sup>1</sup>

- Blood cultures (≥ 2 sets)
- TEE

TEE positive?

yes

no

Blood cultures positive?

no

**Assess for pocket infection**

- If pretreated: **stop antibiotics**
- **Repeat blood cultures and follow-up closely**

yes

- *Staphylococcus aureus*
- Coagulase-negative staphylococci
- *Cutibacterium* spp.
- *Candida* spp.
- *Streptococcus* spp. (viridans group, beta-hemolytic)
- *Enterococcus* spp.

≥ 2 cultures positive and/or other source excluded?

yes

no

- Gram-negative bacteria
- *Streptococcus pneumoniae*

Systemic CIED infection confirmed

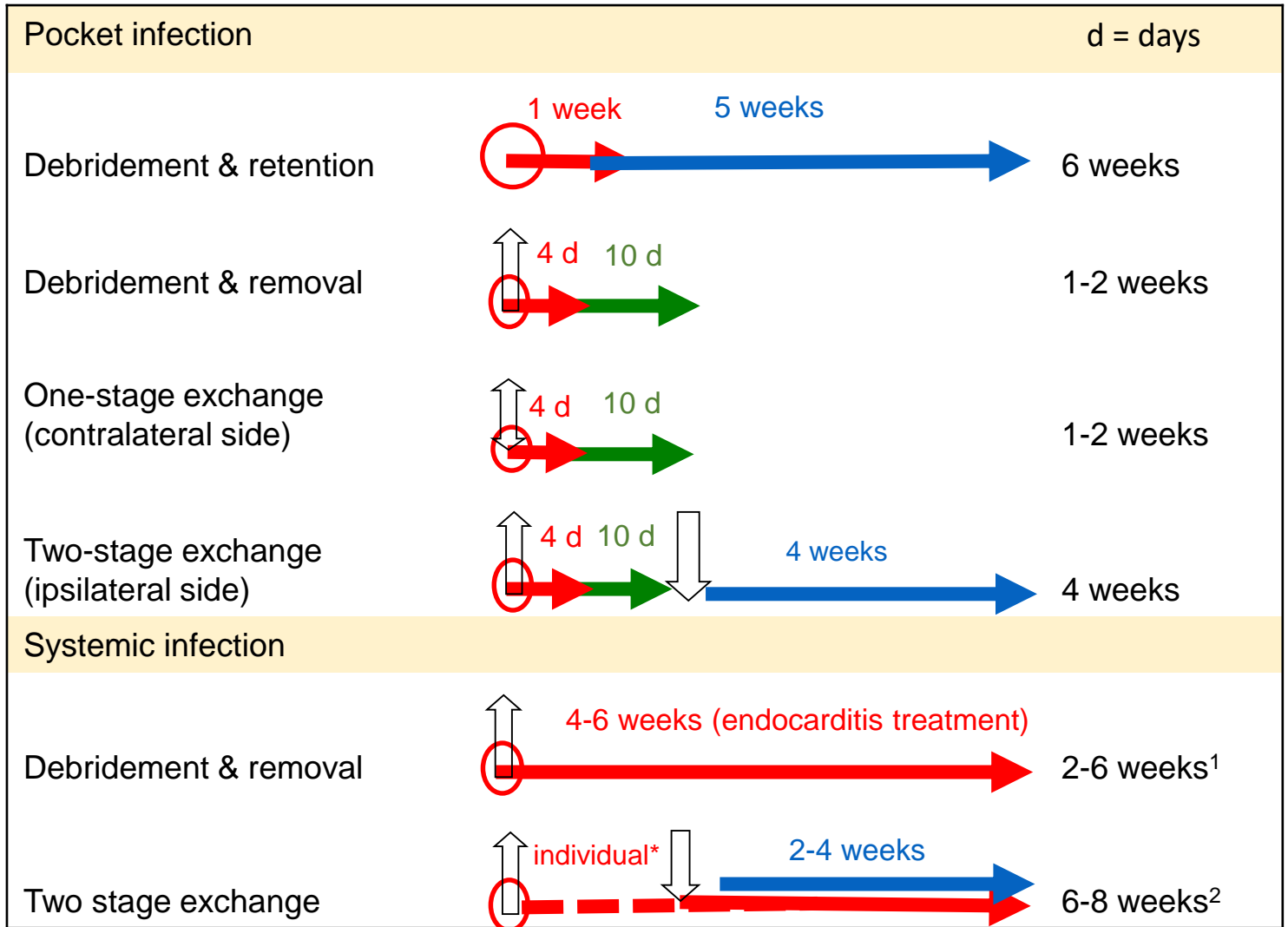
- **Remove entire CIED<sup>2</sup>**
- **Treat with antimicrobials according to endocarditis guidelines**
- **Collect surveillance blood cultures (after 48-72 h)**
- If persistent indication for CIED → see **Treatment algorithm for CIED infections**

**Treat bloodstream infection**  
**Closely follow-up after discontinuation of antibiotics**

<sup>1</sup> e.g. hematogenous seeding of mitral or aortic valve, spondylodiscitis, joints, liver, and spleen, lungs

<sup>2</sup> Intraoperative diagnostics, including pocket swab, tissue culture, lead tip culture, sonication of the device

# SURGICAL PROCEDURES FOR CIED INFECTIONS



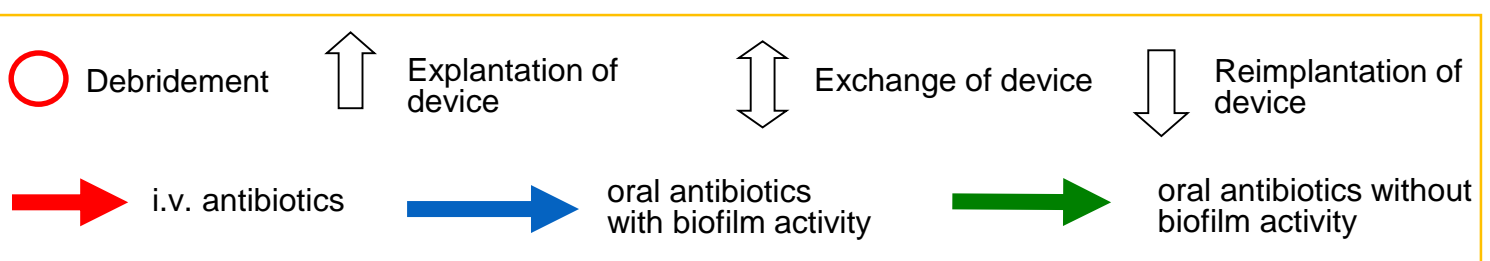
\* Interval individual, as follows:

- if no valve or lead vegetation visible: >72 h after negative blood cultures following device removal
- If valve vegetation: >14 d after negative blood cultures following device removal

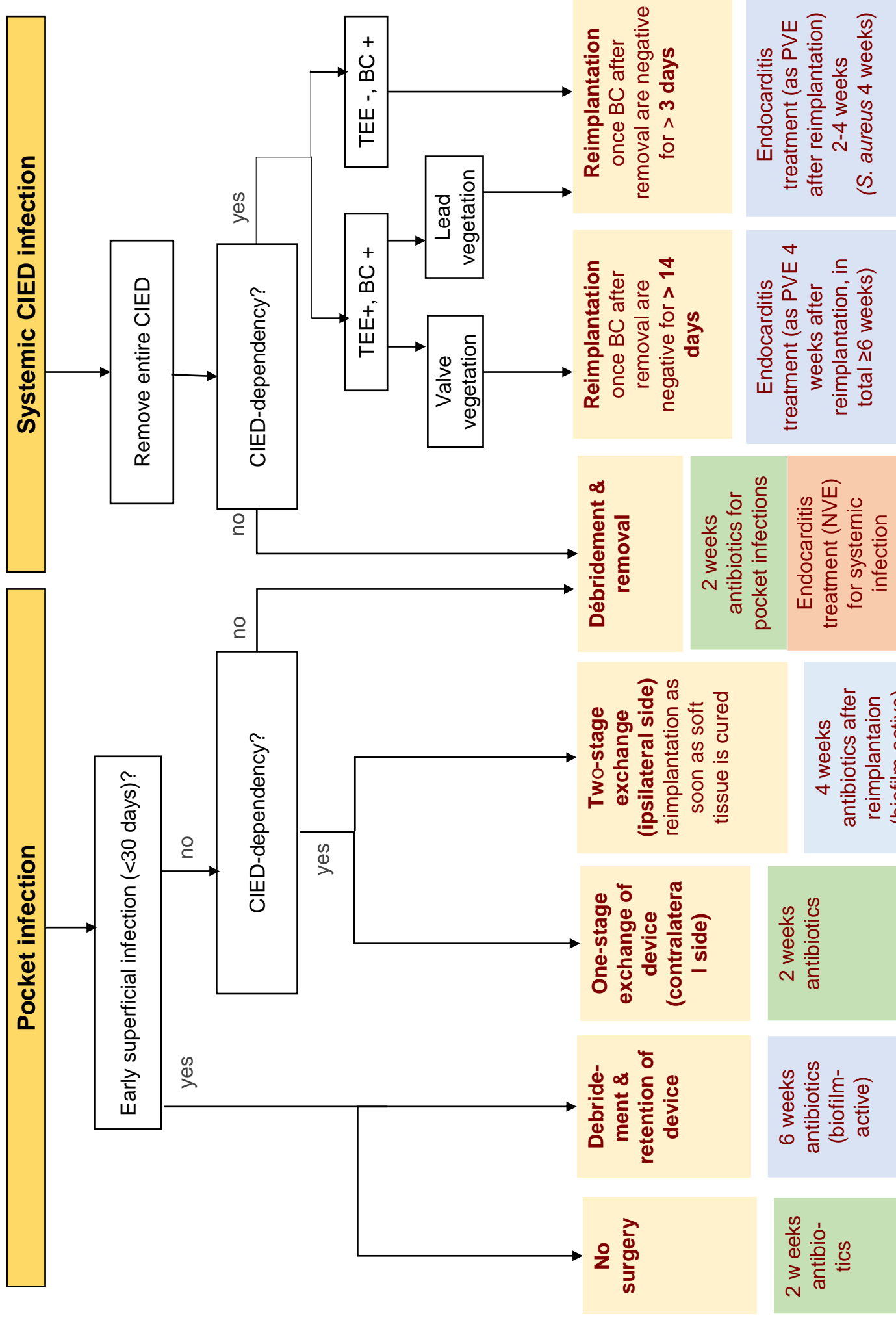
## Duration of antimicrobial treatment:

<sup>1</sup> **TEE negative:** *S. aureus* 2-4 weeks, other pathogens 2 weeks; **TEE positive:** valve vegetation: 4-6 weeks for *S. aureus*, enterococci, non-HACEK gram-negative bacteria; 4 weeks for streptococci (2 weeks in combination with gentamicin in high susceptibility to penicillin), HACEK; lead vegetation and hematogenous seeding: 6 weeks, uncomplicated lead vegetation: 2-4 weeks

<sup>2</sup> At least 6 weeks (4 weeks after reimplantation) analogous to prosthetic valve endocarditis: if no valve vegetation present, early switch after 2-4 weeks i.v. to oral treatment possible; in persistent bacteremia after removal, treat according to endocarditis guidelines



# TREATMENT ALGORITHM FOR CIED INFECTIONS



BC, blood cultures, TEE transesophageal echocardiography, both examination before removal of CIED

# ANTIMICROBIAL TREATMENT

## Empirical intravenous treatment

Ampicillin/sulbactam 3-4x3g **or** amoxicillin/clavulanic acid 3-4x2.2g (higher dose, if systemic infection)  
+ vancomycin 2x15mg/kg **or** daptomycin 1x10mg/kg

→ if patient septic or polymicrobial infection possible: **add** gentamicin 1x240mg i.v. (adapt to body weight)

→ if patient is allergic to penicillin: cefazolin 4x2 (**or** meropenem 3x2g, if anaphylaxis)

→ if fungal infection suspected: **add** caspofungin 1x70mg

## Pocket infections

	Intravenous treatment	Oral treatment (no device in situ)	Oral treatment (with device in situ)
<b><i>Staphylococcus</i> spp.</b> <ul style="list-style-type: none"> <li>Oxacillin-susceptible</li> <li>Anaphylactic reaction to penicillins or methicillin-resistant</li> </ul>	Flucloxacillin 4x2g or Cefazolin 3x2g  Vancomycin 2x15mg/kg or Daptomycin 1x 6-8mg/kg	Cotrimoxazol 2x960mg or Clindamycin 3x600mg or Doxycyclin 2x100mg or Amoxicillin/clavulanic acid 3x1g	Rifampin 2x450mg plus  Levofloxacin 2x500mg or Cotrimoxazol 3x960mg or Doxycyclin 2x100mg
<b><i>Streptococcus</i> spp.</b> <ul style="list-style-type: none"> <li>Penicillin-susceptible</li> <li>Anaphylactic reaction to penicillin or penicillin-resistant</li> </ul>	Penicillin G 4x5 Mio E or Ceftriaxon 1x2g  Vancomycin 2x15mg/kg or Daptomycin 1x 6-8mg/kg	Amoxicillin 3x1g or Clindamycin 3x600mg or Levofloxacin 2x500mg	Amoxicillin 3x1g or Clindamycin 3x600mg or Levofloxacin 2x500mg
<b><i>Enterococcus</i> spp.</b> <ul style="list-style-type: none"> <li>Penicillin- and gentamicin (HL)-susceptible</li> <li>Anaphylactic reaction to penicillins or penicillin-resistant</li> </ul>	Amoxicillin 4x2g <sup>3</sup> (plus gentamicin 1x3 mg/kg, if device in situ)  Vancomycin 2x15mg/kg or Daptomycin 1x10mg/kg (plus gentamicin 1x3 mg/kg, if device in situ)	Amoxicillin 3x1g or Linezolid 2x600mg	Amoxicillin 3x1g or Linezolid 2x600mg
<b>Enterobacteriaceae</b> <ul style="list-style-type: none"> <li>Anaphylactic reaction to penicillin/cephalosporins</li> </ul>	Ceftriaxon 1x2g or Piperacillin/tazobactam 3x4.5g  Ciprofloxacin 2-3x400mg or meropenem 3x1g	Cotrimoxazol 2x960mg or Ciprofloxacin 2x750mg	Ciprofloxacin 2x750mg  (if resistant to ciprofloxacin, consider long-term suppression)

## Systemic CIED infections

	Intravenous treatment after device removal (before reimplantation)	Intravenous treatment <u>after</u> reimplantation
<b><i>Staphylococcus</i> spp.</b> <ul style="list-style-type: none"> <li>Oxacillin-susceptible</li> <li>Anaphylactic reaction to penicillins or methicillin-resistant<sup>1</sup></li> </ul>	Flucloxacillin 6x2g or Cefazolin 3x2g  Vancomycin <sup>2</sup> 2x15mg/kg or Daptomycin 1x 8-10mg/kg	Add Rifampin 2x450mg p.o. to regimen in the left column
<b><i>Streptococcus</i> spp.</b> <ul style="list-style-type: none"> <li>Penicillin-susceptible</li> <li>Anaphylactic reaction to penicillins or penicillin-resistant</li> </ul>	Penicillin G 4x5 Mio E or Amoxicillin 6x2g or Ceftriaxon 1x2g  Vancomycin <sup>2</sup> 2x15mg/kg or Daptomycin 1x 8-10mg/kg	Add Gentamicin <sup>2</sup> 1x 3mg/kg to regimen in the left column
<b><i>Enterococcus</i> spp.</b> <ul style="list-style-type: none"> <li>Penicillin- and gentamicin (HL)-susceptible</li> <li>Penicillin- susceptible and gentamicin (HL)-resistant (only <i>E. faecalis</i>)</li> <li>Anaphylactic reaction to penicillins or penicillin-resistant enterococci</li> </ul>	Amoxicillin 6x2g <sup>3</sup> plus Gentamicin <sup>2</sup> 1x3mg/kg  Amoxicillin 6x2g <sup>3</sup> plus Ceftriaxon 2x2g  Vancomycin <sup>2</sup> 2x15mg/kg or Daptomycin 1x10mg/kg plus Gentamicin <sup>2</sup> 1x3mg/kg or Fosfomycin 3x5g	Amoxicillin 6x2g <sup>3</sup> plus Gentamicin <sup>2</sup> 1x3mg/kg  Amoxicillin 6x2g <sup>3</sup> plus Ceftriaxon 2x2g  Vancomycin <sup>2</sup> 2x15mg/kg or Daptomycin 1x10mg/kg plus Gentamicin <sup>2</sup> 1x3mg/kg or Fosfomycin 3x5g
<b>Enterobacteriaceae</b> <ul style="list-style-type: none"> <li>Anaphylactic reaction to penicillins/cephalosporins</li> </ul>	Ceftriaxon 1x2g plus Gentamicin <sup>2</sup> 1x3mg/kg  Ciprofloxacin 2-3x400mg or meropenem 3x1g	Replace gentamicin with  Ciprofloxacin 2x750mg p.o.  to regimen in the left column
<b><i>Candida</i> spp.</b>	Amphotericin B (liposomal) 1x 3-5mg/kg or Caspofungin 1x150 mg or Anidulafungin 1x200 mg	Fluconazol 1x400-800mg p.o. (consider suppression for ≥1 year)

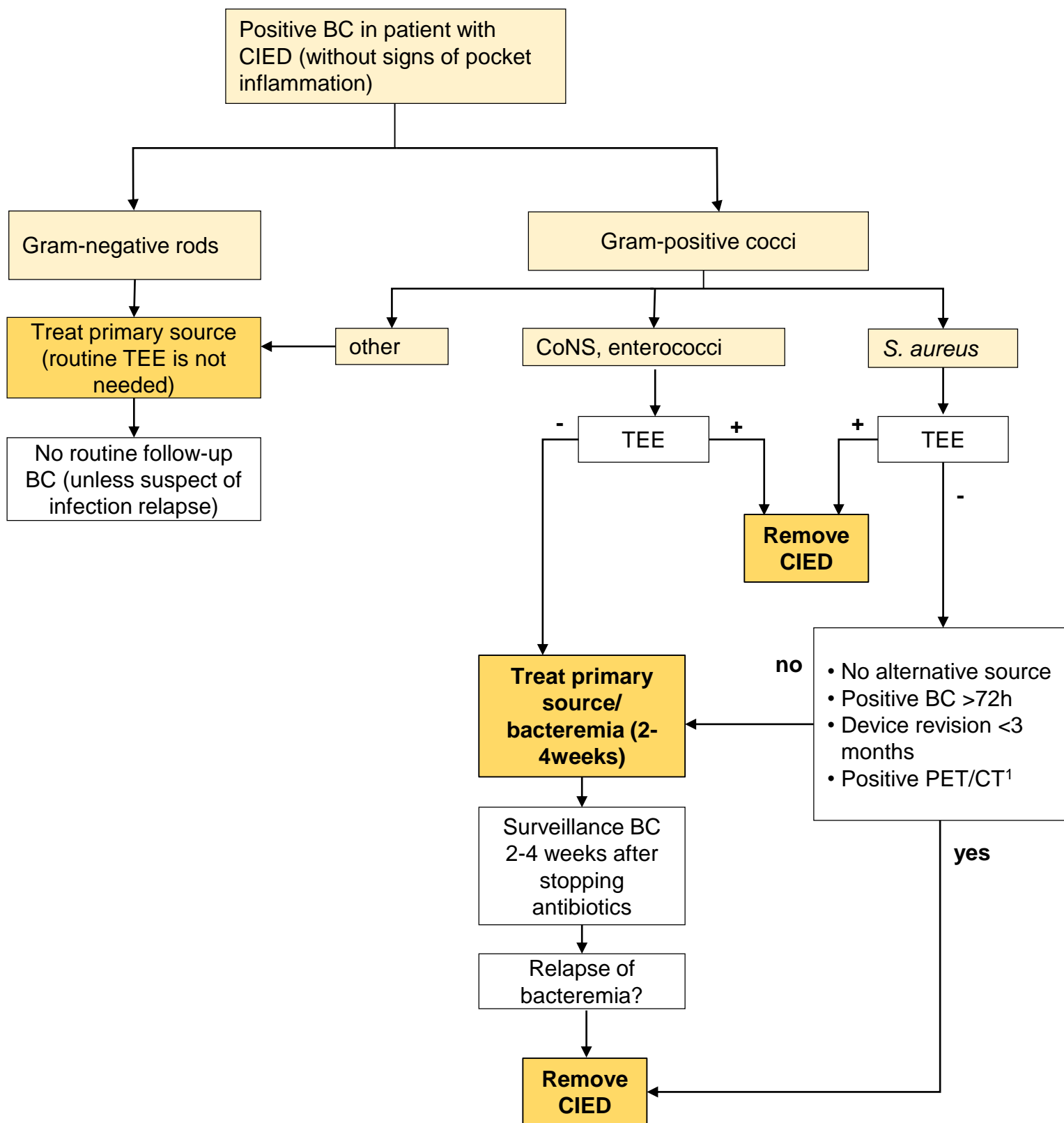
<sup>1</sup> In MRSA according to MIC for vancomycin: if ≤0.5mg/L: vancomycin, if ≥1mg/l: daptomycin

<sup>2</sup> Adjustment according to through level: gentamicin: target <1 mg/l; vancomycin: target 15-20mg/l)

<sup>3</sup> or ampicillin 6x2g i.v.

# MANAGEMENT OF BACTEREMIA IN CIED-CARRIERS

(modified after DeSimone et al. Heart Rhythm 2016)



<sup>1</sup> Accuracy of PET/CT for pocket infection: sensitivity 96%, specificity 97%; for systemic infection: sensitivity 76%, specificity 83% (Mahmood M., J Nucl Cardiol 2017)