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Prise en charge des infections du matériel implantable cardiaque (PM, DEF) : US *vs* EU

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Déclaration de liens d'intérêt avec les industries de santé en rapport avec le thème de la présentation (loi du 04/03/2002) :

Intervenant : Bonnet Eric

Titre : Prise en charge des infections de matériel implantable

- L'orateur ne souhaite pas répondre ☐

Consultant ou membre d'un conseil scientifique	☐ OUI	☑ NON
Conférencier ou auteur/rédacteur rémunéré d'articles ou documents	☐ OUI	☑ NON
Prise en charge de frais de voyage, d'hébergement ou d'inscription à des congrès ou autres manifestations	☑ OUI	☐ NON
Investigateur principal d'une recherche ou d'une étude clinique	☐ OUI	☑ NON

Introduction

- Fréquence relativement faible des infections de dispositif électronique cardiaque implantable (DECI) : 0,6-1,3%.
- Nombreuses situations de gravité variable : => diversité des entités cliniques individualisées selon les « guidelines »
- Nécessité d'une prise en charge pluridisciplinaire.

Entités cliniques

- **Extériorisation du matériel** : effraction cutanée avec exposition à la vue du boitier et/ou des sondes, sans signes d'inflammation

- **Infection du site d'implantation = signes locaux d'inflammation**
  - **superficielle** : dans les 30 jours suivant l'implantation, sans fièvre et sans autres signes généraux, limitée à la peau et au tissu sous-cutané de la zone d'incision et n'atteignant pas le fascia et/ou les muscles
  - **profonde** : toute collection au contact du matériel avec ou sans fièvre

- **Infection de sonde(s) = « endocardite » sur sonde(s) :** végétation visualisée par échocardiographie et/ou hyperfixation sur le trajet d'une sonde (Pet scan/ scintigraphie aux leucocytes marqués)

Endocardite définie selon les guidelines de l'ESC 2015

Quels guidelines ?

- **Non spécifiques**
  - Endocardites
    - AHA 2015
    - ESC 2015
  - Gestion des complications associées aux DECI, incluant les infections
    - **HRS 2017** → 1 infectiologue (IDSA)
2 cardiologues européens
(dont un français)

- **Spécifiques**
  - AHA 2010
  - BSAC 2015
  - **EHRA 2019** → 2 infectiologues (ECCMID)
1 auteur français (cardiologue)

2017 HRS expert consensus statement on cardiovascular implantable electronic device lead management and extraction

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ESC European Society of Cardiology

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EHRA CONSENSUS PAPER

European Heart Rhythm Association (EHRA) international consensus document on how to prevent, diagnose, and treat cardiac implantable electronic device infections—endorsed by the Heart Rhythm Society (HRS), the Asia Pacific Heart Rhythm Society (APHRS), the Latin American Heart Rhythm Society (LAHRS), International Society for Cardiovascular Infectious Diseases (ISCVID) and the European Society of Clinical Microbiology and Infectious Diseases (ESCMID) in collaboration with the European Association for Cardio-Thoracic Surgery (EACTS)

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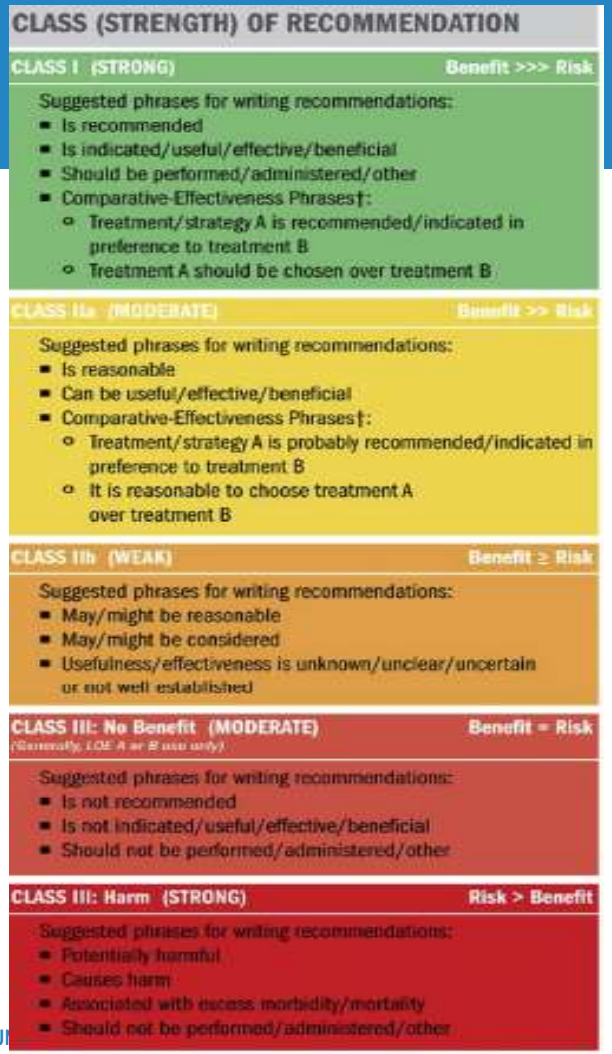
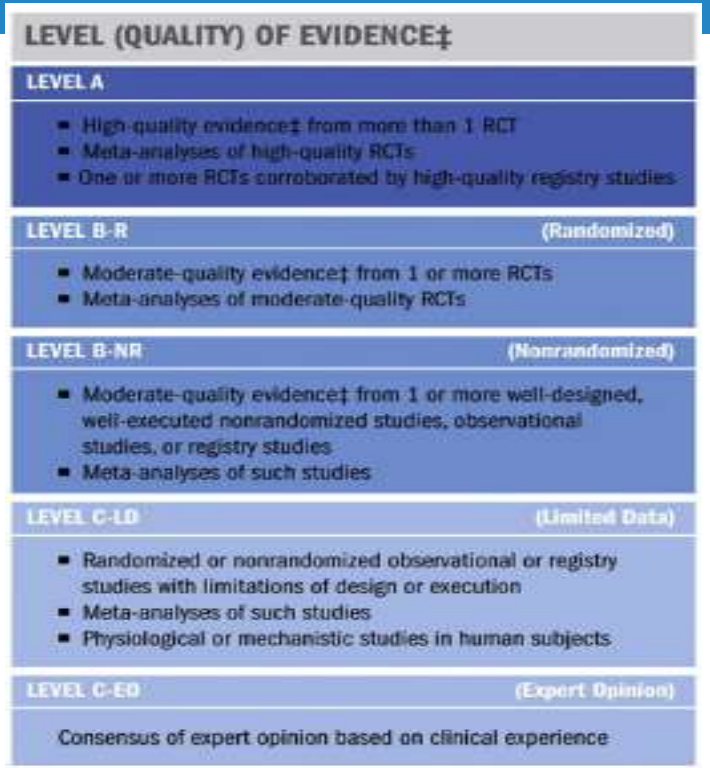
Méthodologie - HRS 2017





Méthodologie -EHRA 2019

Table I Scientific rationale of recommendations

Consensus statement related to a treatment or procedure	Definitions of consensus statement	Statement class	Scientific evidence coding (SEC)	Ref.
Recommended/indicated or 'should do this'	Scientific evidence that a treatment or procedure is beneficial and effective. Requires at least one randomized trial, or is supported by large observational studies and authors' consensus		R	
May be used or recommended	General agreement and/or scientific evidence favour the usefulness/efficacy of a treatment or procedure. May be supported by randomized trials based on small number of patients or not widely applicable		O	
Should NOT be used or recommended	Scientific evidence or general agreement not to use or recommend a treatment or procedure		E	

This categorization for the consensus document should not be considered as being directly similar to that used for official society guideline recommendations which apply a classification (I–III) and level of evidence (A, B, and C) to recommendations.
The 'ROME' coding was applied for each consensus statement, defining existing scientific evidence.
E, expert opinion; M, meta-analyses; O, observational studies; R, randomized trials.

Table 13 Recommendations/guidelines published by different societies on management of cardiac implantable electronic device infections

Guidelines content	Recommendations	AHA[65] 2010	BHRS[19] 2015	ESC[59] 2015	AHA[199] 2015	HRS[81] 2017	EHRA 2019[a]
Diagnosis							
Transoesophageal echocardiography	TEE should be used for diagnosis since it has higher sensitivity in establishing intravascular related CIED infection than TTE	✓	✓	✓	✓	✓	7
[^{18}F]FDG PET/CT/scintigraphy with radiolabelled WBC	[^{18}F]-FDG PET/CT/scintigraphy with radiolabelled WBC should be used as an additive diagnostic tool	NA	Only for research	✓	NA	✓	7
Blood cultures	Blood cultures should be taken 48–72 h after removal of infected CIED	NA	✓	NA	NA	NA	6
Generator pocket tissue/lead	Percutaneous aspiration of generator pocket should not be performed	✓	NA	NA	NA	NA	6
Generator pocket tissue/lead	Tissue should be excised from pocket site and sent for culture	NA	✓	NA	NA	NA	6
Radiography	Chest X-ray should be performed if suspected CIED infection	NA	✓	NA	NA	NA	7
ceCT/CT pulmonary angiography	ceCT or CT pulmonary angiography should be considered when CIED infection is suspected and echocardiography is non-diagnostic	NA	✓	NA	NA	NA	7

Treatment—CIED management							
Early post-implantation inflammation	In superficial or early inflammation, the CIED can initially be left *in situ*.	✓	✓	NA	NA	NA	**8**
Isolated pocket infection/erosion	The CIED must be removed completely within 2 weeks after diagnosis	✓	✓	NA	NA	NA	**8**
CIED lead infection	Complete device system must be removed in CIED lead infection.	✓	✓	NA	NA	✓	**8**
CIED infective endocarditis	Complete removal is mandatory in CIED infective endocarditis	✓	✓	✓	✓	✓	**8**
Occult bacteraemia	Complete device removal is recommended in occult bacteraemia	✓	NA	NA	NA	✓	**8**
Device reimplantation	New transvenous lead implant should be postponed if possible, to allow a few days or weeks of antibiotic therapy	✓	✓	✓	NA	✓	**10**
Device reimplantation	The replacement device implantation should not be ipsilateral to extraction site. Preferred locations are contralateral side, iliac vein, or epicardial	✓	✓	NA	NA	✓	**10**

Treatment—antibiotic strategy							
Early post-implantation inflammation	In early post-implantation inflammation, the use of antibiotic therapy should be determined on a case by case basis	NA	✓	NA	NA	NA	9
Uncomplicated pocket infection	In uncomplicated pocket infection, empirical antibiotic therapy can be used	NA	✓	NA	NA	NA	9
Complicated pocket infection	Duration of antibiotic therapy should be 10–14 days after CIED removal for pocket-site infection	✓	NA	NA	NA	NA	9

Guidelines content	Recommendations	AHA[65] 2010	BHRS[19] 2015	ESC[59] 2015	AHA[199] 2015	HRS[81] 2017	EHRA 2019[a]
~~Diagnosis~~ Traitement							
Complicated pocket infection	Antibiotic treatment options and duration depend on echo findings; if no native valve involvement, treat as uncomplicated generator pocket infection	NA	✓	NA	NA	NA	9
CIED lead infection	Duration of antibiotic therapy should be at least 14 days after CIED removal for bloodstream infection	✓	NA	NA	NA	NA	9
CIED infective endocarditis	The duration of antibiotic therapy should be at least 4–6 weeks for complicated infection	✓	✓	NA	✓	NA	9
Antibiotic prophylaxis	Systemic antibiotic prophylaxis should be used prior to CIED implantation	✓	✓	NA	NA	NA	4
Team/reference centre	Complicated infective endocarditis should be referred early and managed in a reference centre with immediate surgical facilities ('Endocarditis Team')	NA	NA	✓	NA	NA	7

^{18}F-FDG PET/CT, fluorine-18-fludeoxyglucose ([^{18}F]FDG) positron emission tomography-computerized tomography (PET/CT) scanning; CIED, cardiac implantable electronic device; NA, not available; TEE, transoesophageal echocardiography; TTE, transthoracic echocardiography; ✓, agreed recommendation.
[a]The number refers to the table for the recommendation in the present document where the particular subject was addressed.

Pathogénèse (HRS 2017. EHRA 2019)

- **Trois origines possibles aux infections de DECI**
  - Mise en place ou remplacement du dispositif
  - Erosion secondaire (traumatisme local) de la loge du boitier => colonisation → infection du site → infection de sonde(s), partie proximale puis distale (= « endocardite sur sonde »)
  - Bactériémie → localisation secondaire sur le boitier et/ou sonde(s)

Facteurs de risque (HRS 2017)

Risk Factors for Cardiovascular Implantable Electronic Device Infection

Patient-related factors	Procedure-related factors	Microbe-related factors
Age	Pocket reintervention (generator change, upgrade, lead or pocket revision)	Highly virulent microbes (eg, staphylococci)
Chronic kidney disease		
Hemodialysis		
Diabetes mellitus	Pocket hematoma	
Heart failure	Longer procedure duration	
Chronic obstructive pulmonary disease	Inexperienced operator	
	ICD (compared with PM)	
Preprocedure fever	Lack of use of prophylactic antibiotics	
Malignancy		
Skin disorder		
Immunosuppressive drug		
Prior CIED infection		
Anticoagulation		

CIED = cardiovascular implantable electronic device; ICD = implantable cardioverter defibrillator; PM = pacemaker.

Facteurs de risque spécifiques (SFC, SPILF)

- **Liés à la procédure :**
  - Réintervention sur le site d'implantation du boitier (changement de générateur, rajout d'une sonde, révision du site d'implantation)
  - Hématome de la loge
  - Durée longue de procédure
  - Défibrillateur (*vs* stimulateur)
  - Absence d'antibioprophylaxie
- **Liés à l'hôte :**
  - Anticoagulation
  - ATCD d'infection de DECI

Facteurs de risque (EHRA 2019)

Table 4 List of recommended preventive measures for CIED infections

Consensus statement	Statement class	Scientific evidence coding
Pre-procedural measures		
Confirm indication for CIED		E
Delay CIED implantation in patients with infection		E
Avoid temporary transvenous pacing and central venous lines, which should ideally be removed prior to introducing new hardware, wherever possible		O, M
Measures to avoid pocket haematoma are recommended (avoid heparin bridging, discontinue antiplatelets if possible)		R
Periprocedural use of therapeutic low-molecular-weight-heparin		R, M, O
Perform the CIED procedure in an operating room/suite with complete sterile environment as required for other surgical implant procedures		E
Procedure should be performed or supervised by an operator with sufficient training and experience (*Table 12*)		O
Topical *S. aureus* decolonization may be performed		E
Pre-procedural skin wash may be performed		E
Hair removal with electric clippers (not razors) is recommended		O
Antibiotic prophylaxis is recommended within 1 h of incision for cefazolin and flucloxacilline, within 90-120 min for vancomycin		R, M
A continuous surveillance program of infection rates and associated microbiology should be set-up at the level of each implanting centre		E

Facteurs de risque (EHRA 2019)

Peri-procedural measures		
Surgical preparation with alcoholic chlorhexidine should be used rather than povidone-iodine		R
Allow sufficient time for the antiseptic preparation to dry		E
Adhesive iodophor-impregnated incise drapes may be used		E
Perform the procedure with adequate surgical technique—minimize tissue damage, haemostasis, adequate wound closure		E
Antibiotic envelope in high-risk situations is recommended[a]		R
If the operator performs the prepping and draping, glove change/re-scrub or remove outer glove of a double-glove before incision		E
Using local instillation of antiseptic and antibiotics in the pocket		R, E
Use of braided sutures for final skin closure		E
Post-procedural measures		
Use of postoperative antibiotic therapy		R
Adequate dressing for 2–10 days is recommended		E
Patient instructions on wound care should be provided		E
Delay or reconsider indication for re-intervention if possible		E
Haematoma drainage or evacuation (unless tense, wound dehiscence is present or pain is severe)		O

Facteurs de risque (EHRA 2019)

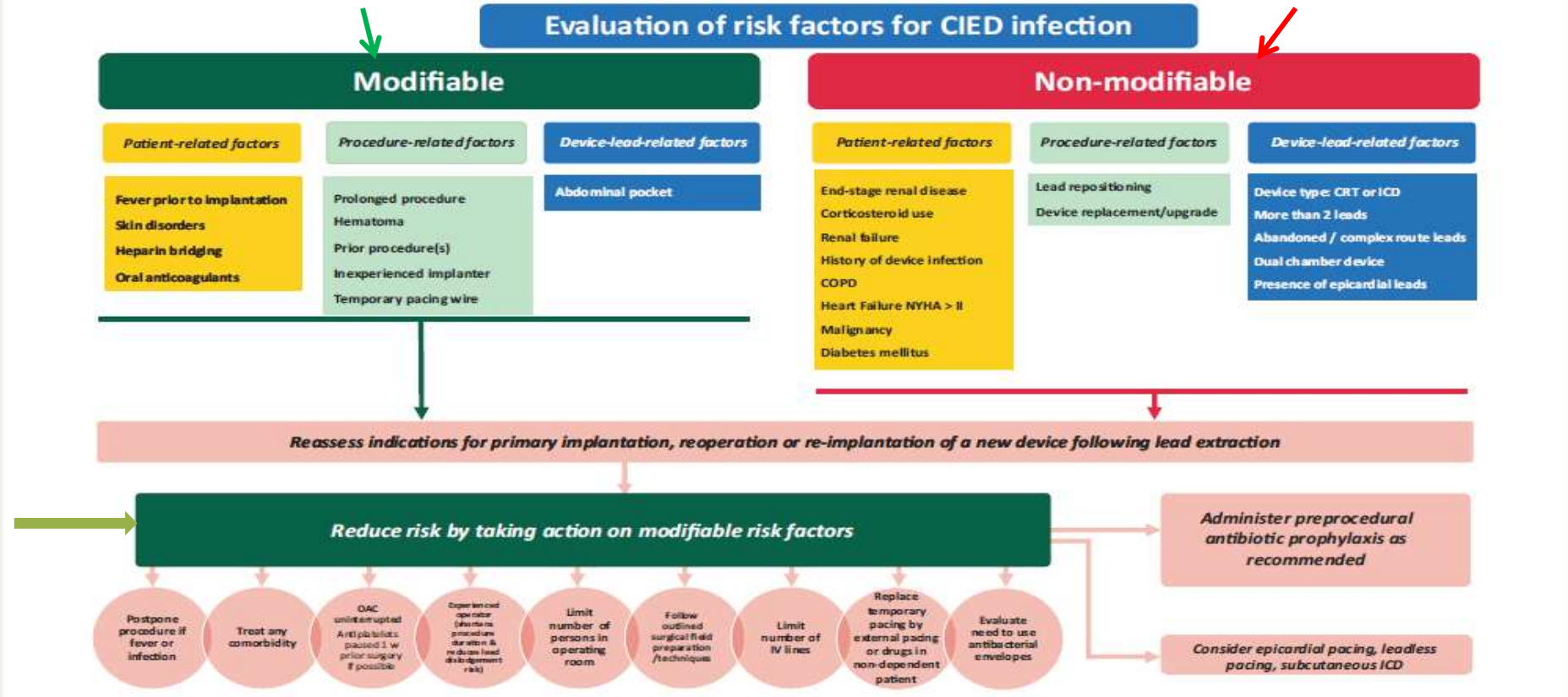


Figure 1 A flowchart indicating how device-related infections can be minimized by targeting modifiable risk factors on various levels. Risk factors ranked in order of strength from top to bottom. CIED, cardiac implantable electronic device; COPD, chronic obstructive pulmonary disease; CRT, cardiac resynchronization therapy; ICD, implantable cardiac defibrillator; NYHA, New York Heart Association; OAC, oral anticoagulation; w, week.

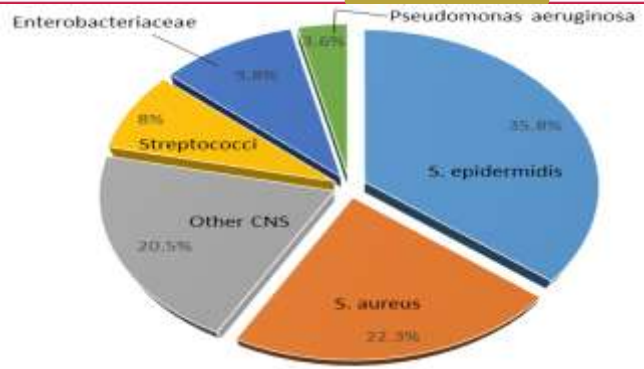
Table 2 Pathogens isolated in patients undergoing interventions for device infection from three large patient cohorts in North America, Europe, and Asia

Pathogen	Percentage of isolates		
	North America[16]	Europe[17]	Asia[18]
Coagulase-negative staphylococci		69	45.2
Methicillin-*resistant*	18.8		
Methicillin-*sensitive*	18.8		
S. aureus		13.8	4.1
Methicillin-*sensitive*	15.8		
Methicillin-*resistant*	15.0		
Streptococcus spp.	2.5		
Enterococcus spp.			
Vancomycin-sensitive	2.8		
Vancomycin-resistant	1.4		
Cutibacterium spp. (previously *Propionibacterium* spp.)		2.5	
Corynebacterium		5	
Gram-negative bacteria	8.9	6.1	9.1
Enterobacteriaceae		3	3.2
Non-fermentative bacilli, incl. *Pseudomonas* spp.		1.5	5.9
Anaerobes	1.6		
Fungi	0.9	1	0.9
Mycobacteria	0.2		

Microbiologie

Bactéries isolées de culture de la partie distale des sondes (123 souches)

Eric Bonnet et al. ENDO 06
Journées Nationales d'Infectiologie.
Lyon. 2019



Diagnostic microbiologique (HRS 2017)

If antibiotics are going to be prescribed, drawing at least 2 sets of blood cultures before starting antibiotic therapy is recommended for all patients with suspected CIED infection to improve the precision and minimize the duration of antibiotic therapy. (COR I; LOE C-LD)

Gram stain and culture of generator pocket tissue and the explanted lead(s) are recommended at the time of CIED removal to improve the precision and minimize the duration of antibiotic therapy. (COR I; LOE C-LD)

Diagnostic microbiologique (EHRA 2019)

Table 6 Recommendations for diagnosis of CIED infections by clinical findings and microbiology

Consensus statement	Statement class	Scientific evidence coding
At least three sets of blood cultures should be acquired in case of clinically suspected CIED endocarditis		E, O
Samples from the pocket should be cultured but only if acquired during removal and not passing through the sinus		E, O
Suspect CIED infections in case of vertebral osteomyelitis and/or embolic pneumonia (clinical signs and symptoms of CIED systemic infections may be difficult to recognize as only fever may be present)		E, O
Cultures of extracted CIED should be performed		E, O
PCT may be useful in case of infective endocarditis and embolism and/or in case of *S. aureus* CIED-related infective endocarditis		E, O
Increased incubation time (10–14 days) for slowly-growing microorganism may be considered in case of CIED-related infective endocarditis and persistent negative blood cultures		E
The usefulness of sonication of CIED to enhance microbial detection during removal/extraction is still under evaluation but may be used with caution when interpreting results		E, O
Cultures from the sinus of the CIED pocket or from parts of the device exposed		E

CIED, cardiac implantable electronic device; E, expert opinion; M, meta-analysis; O, observational studies; PCT, procalcitonin; R, randomized trials.

Diagnostic microbiologique

Table 13 Recommendations/guidelines published by different societies on management of cardiac implantable electronic device infections

Guidelines content	Recommendations	AHA[65] 2010	BHRS[19] 2015	ESC[59] 2015	AHA[199] 2015	HRS[81] 2017	EHRA 2019[a]
Diagnosis							
Transoesophageal echocardiography	TEE should be used for diagnosis since it has higher sensitivity in establishing intravascular related CIED infection than TTE	✓	✓	✓	✓	✓	7
[^{18}F]FDG PET/CT/scintigraphy with radiolabelled WBC	[^{18}F]-FDG PET/CT/scintigraphy with radiolabelled WBC should be used as an additive diagnostic tool	NA	Only for research	✓	NA	✓	7
Blood cultures	Blood cultures should be taken 48–72 h after removal of infected CIED	NA	✓	NA	NA	NA	6
Generator pocket tissue/lead	Percutaneous aspiration of generator pocket should not be performed	✓	NA	NA	NA	NA	6
Generator pocket tissue/lead	Tissue should be excised from pocket site and sent for culture	NA	✓	NA	NA	NA	6
Radiography	Chest X-ray should be performed if suspected CIED infection	NA	✓	NA	NA	NA	7
ceCT/CT pulmonary angiography	ceCT or CT pulmonary angiography should be considered when CIED infection is suspected and echocardiography is non-diagnostic	NA	✓	NA	NA	NA	7

Diagnostic par l'imagerie. HRS 2017

Preprocedural transesophageal echocardiography (TEE) is recommended for patients with suspected systemic CIED infection to evaluate the absence or size, character, and potential embolic risk of identified vegetations. (COR I; LOE B-NR)

TEE can be useful for patients with CIED pocket infection with and without positive blood cultures to evaluate the absence or size, character, and potential embolic risk of identified vegetations. (COR IIa; LOE B-NR)

Additional imaging may be considered to facilitate the diagnosis of CIED pocket or lead infection when it cannot be confirmed by other methods. (COR IIb; LOE C-LD)

Diagnostic par l'imagerie. EHRA 2019

Table 7 Recommendations for diagnosis of CIED infections by imaging[59]

Consensus statement	Statement class	Scientific evidence coding
TTE is recommended as the first-line imaging modality in patients with suspected CIED-related IE	❤	O
A chest X-ray should be performed in all patients with suspected CIED infection	❤	E
TEE is recommended in suspected CIED infection with positive or negative blood cultures, independent of TTE results before an extraction, to evaluate CIED infection and IE	❤	O
Repeat TTE and/or TEE within 5–7 days is recommended in case of initially negative examination when clinical suspicion of CIED-related IE remains high	❤	O
TEE should be performed in CIED patients with *S. aureus* bacteraemia	❤	O
ICE may be considered if suspected CIED-related IE, with positive blood cultures and negative TTE and TEE results	❤	O, E
[^{18}F]FDG PET/CT scanning or radiolabelled WBC scintigraphy or contrast enhanced CT are recommended if suspected CIED-related IE, positive blood cultures, and negative echocardiography (attention in imaging interpretation early after device implant)	❤	O, M
[^{18}F]FDG PET/CT should be performed in case of *S. aureus* bacteremia in CIED patients	❤	O, E
[^{18}F]FDG PET/CT, radiolabelled WBC scintigraphy and/or contrast enhanced CT is recommended for identification of unexpected embolic localizations (i.e. lung embolism) and metastatic infections	❤	O, M

Diagnostic par l'imagerie. EHRA 2019

The identification of the infection portal of entry may be considered by [^{18}F]FDG PET/CT and WBC imaging in order to prevent IE relapse		O, E
Pulmonary CT angiography is recommended in patients with recurrent pneumonia		O, E
In patients with CIED infection treated with percutaneous lead extraction, TTE/TEE before hospital discharge are recommended to detect presence of retained segments of pacemaker lead, and to assess tricuspid valve function, RV function, and pulmonary hypertension		O
In case of persistent sepsis after device extraction: - TEE is recommended to identify residual insulation material and local complications - [^{18}F]FDG PET/CT, radiolabelled WBC scintigraphy and/or contrast enhanced CT for better assessment of local extension of the infection and whole body assessment		O, M
A multidisciplinary team (the Endocarditis Team) is recommended for evaluation of imaging results		E

[^{18}F]FDG PET/CT, fluorine-18-fludeoxyglucose positron emission tomography/computerized tomography scanning; CIED, cardiac implantable electronic device; E, expert opinion; ICE, intracardiac echocardiography; IE, infective endocarditis; M, meta-analysis; O, observational studies; R, randomized trials; RV, right ventricular; TEE, transoesophageal echocardiography; TTE, transthoracic echocardiography; WBC, white blood cell count.

Diagnostic par l'imagerie

- **Echographie transoesophagienne (ETO) devant toute suspicion d'infection de DECI avant l'extraction**
- **ETO post extraction de materiel nécessaire, afin de vérifier l'absence de végétation résiduelle**
- **Imagerie proposée quand le diagnostic d'infection du site d'implantation ou de la (des) sonde(s) n'a pu être affirmé par d'autres moyens :**
  - TEP-TDM au 18 FDG
  - scintigraphie aux leucocytes marqués (sensibilité de 94% pour la détection et la localisation des infections de DECI)

Traitement [Antibiothérapie (1)]. HRS 2017

- **Choix des molécules**
  - Si bactériémie, antibiothérapie empirique à large spectre couvrant CGP et BGN.
  - Autres situations, antibiothérapie empirique à débuter après ablation du matériel, en attendant les résultats microbiologiques = Vancomycine
  - Après identification
    - Si staphylo méti-S, céfazoline, péni-M
    - Si staphylo méti-R, poursuite vancomycine

Traitement [Antibiothérapie (2)]. HRS 2017

- **Durée de traitement**
  - Erosion de boitier : 10 jours
  - Infection de loge : 2 semaines après extraction
  - Bactériémie sans atteinte valvulaire : 2 semaines après extraction
  - Infection compliquée (endocardite, thrombophlébite suppurée, ostéomyélite, bactériémie persistante après ablation du matériel et malgré une antibiothérapie initiale appropriée) : 4 à 6 semaines
  - En cas d'impossibilité d'enlever le matériel, antibiothérapie suppressive.

Traitement [Antibiothérapie (1)]. EHRA 2019

Superficial incisional infection

Empirical treatment:

Oral antibiotic treatment covering *S. aureus*

Flucloxacillin oral (amoxicillin-clavulanate is an alternative)	Flucloxacillin p.o. 1 g every 6–8 h	♥	O, R
If high MRSA prevalence: Trimethoprim-sulfamethoxazole, Clindamycin, Doxycyclin, Linezolid	(amoxicillin-clavulanate standard dose)		

To be adjusted after culture result

Duration: 7–10 days

Traitement [Antibiothérapie (2)]. EHRA 2019

Isolated pocket infection (negative blood cultures)	
Empirical treatment:	
Directed at methicillin-resistant coagulase-negative staphylococci (CoNS) and *S. aureus*:	
Vancomycin (Daptomycin is an alternative)	Vancomycin: 30–60 mg/kg/d i.v. in 2–3 doses (Daptomycin 8–10 mg/kg i.v. od)
If systemic symptoms:	+/-
For additional Gram-negative coverage, combine with 3rd generation Cephalosporin (or a broader betalactam antibiotic) or Gentamicin	Cephalosporin: standard dose Gentamicin 5–7 mg/kg i.v od**
To be adjusted after culture result	
If sensitive staphylococcus: Flucloxacillin (1st generation cephalosporin as an alternative)	Flucloxacillin: 8 g/d i.v. in 4 doses or (1st generation cephalosporin standard dose)
Partial oral treatment often used	
Duration post-extraction: 10–14 days	

O, R

Traitement [Antibiothérapie (3)]. EHRA 2019

Systemic infections		
Without vegetation on leads or valves ± pocket infection		
Empirical treatment (directed at methicillin-resistant staphylococci and Gram-negative bacteria):		O, R
Vancomycin (Daptomycin is an alternative)	Vancomycin: 30–60 mg/kg/d i.v. in 2–3 doses (Daptomycin 8–10 mg/kg od)	
+ 3rd generation Cephalosporin (or a broader betalactam antibiotic) or Gentamicin	+ Cephalosporin: standard dose i.v or Gentamicin 5–7 mg/kg i.v. od[b]	
To be adjusted after culture result		
If sensitive staphylococcus: Flucloxacillin i.v. (1st generation cephalosporin i.v. as an alternative)	Flucloxacillin i.v. dosages as above. (1st generation cephalosporin standard dose i.v.)	
Duration post-extraction: 4 weeks (2 weeks if negative blood culture, see text)		

Traitement [Antibiothérapie (4)] EHRA 2019

CIED endocarditis with vegetation on leads and/or valves ± embolism		
Empirical treatment:		
Vancomycin (Daptomycin is an alternative)	Vancomycin; 30–60 mg/kg/d i.v. in 2–3 doses (Daptomycin 8–10 mg/kg od)	O, R
+	+	
+ 3rd generation Cephalosporin (or a broader betalactam antibiotic) or Gentamicin	Cephalosporin; standard dose or Gentamicin 5–7 mg/kg i.v. od[b]	
Adjust to culture result according to ESC endocarditis guidelines 2015		
If prosthetic valve and staphylococcal infection: Rifampicin to be added after 5–7 days	Rifampicin: 900–1200 mg/day orally (or i.v.) in 2 doses	
Duration for native valve infective endocarditis: 4 weeks post extraction, for prosthetic valve endocarditis: (4-) 6 weeks, for isolated lead vegetation: 2 weeks therapy after extraction may be sufficient (in total 4 weeks) except for *S. aureus* infection, see text		

Traitement [Antibiothérapie (5)]. EHRA 2019

Bacteraemia in a CIED patient without signs of pocket infection or echocardiographic evidence of lead or valve involvement		
According to pathogen specific treatment guidelines, see text		O, R

Traitement [Antibiothérapie (6)]. EHRA 2019

Attempted salvage therapy and long-term suppressive therapy

I.v. antibiotics as in prosthetic valve endocarditis for 4–6 weeks

Stop antibiotic therapy under close follow-up or continue individualized long-term suppressive oral therapy, see text

E

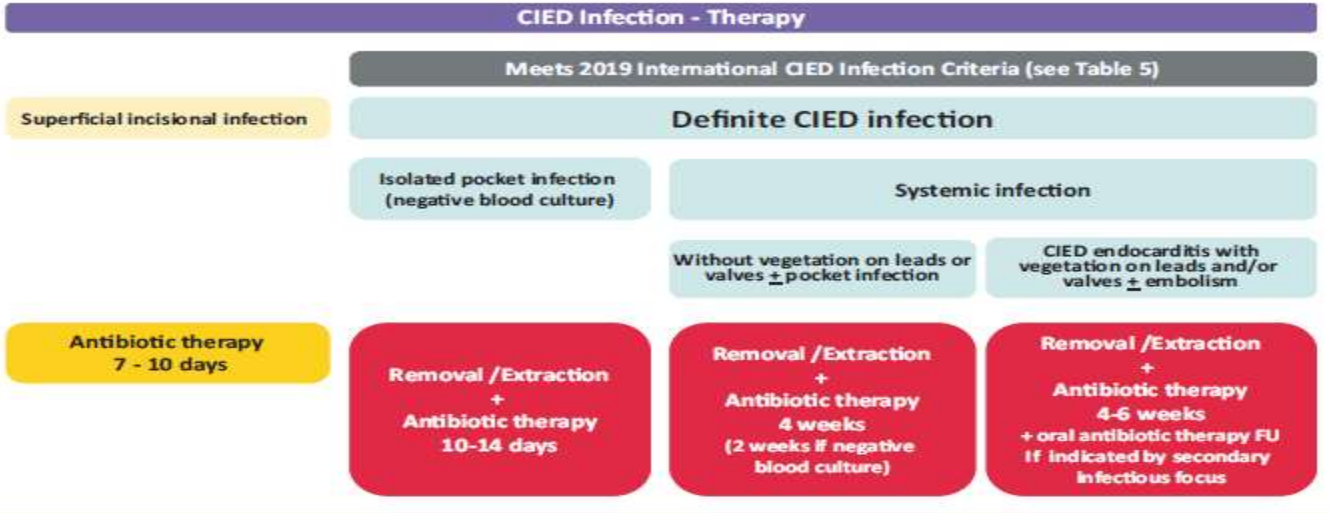


Figure 3 Therapeutic strategies for patients with CIED infections. CIED, cardiac implantable electronic device; FU, follow-up; IE, infective endocarditis.

Antibiothérapie probabiliste

Antibiotique	Dosage et voie	Durée	Commentaires
Infection précoce superficielle			
Pristinamycine	1gx3/j PO	7 jours	si poids > 100kg: Clindamycine 600 mgx4/j PO
Suspicion d'infection de DECI			
***Sepsis** (Quick sofa≥ 2): traitement sans délai*			
Daptomycine Avec Cefotaxime Ou Ceftriaxone	10 mg/kg/j, IVL 150 mg/kg/j en 4 à 6 perfusions ou en perfusion prolongée ou continue après 2 g de dose de charge 50 mg//kg/j	Jusqu'au résultat des cultures	Second choix: Vancomycine 40 mg/kg/j IV, en perfusion continue après dose de charge de 30mg/kg IVL sur 2h00 Allergie aux Bêtalactamines: Aztreonam 100 mg/kg/j en 3 à 4 perfusions de 30' ou en continue après dose de charge de 2 g
Absence de sepsis: traitement probabiliste initié au bloc opératoire après extraction et prélèvements			
Daptomycine	10 mg/kg/j, IVL	Jusqu'au résultat des cultures	Second choix Vancomycine 40 mg/kg/j IV, en perfusion continue après dose de charge de 30mg/kg IVL sur 2h00

Antibiothérapie documentée sur antibiogramme

Antibiotique	Dosage	Durée
Infection du boîtier sans bactériémie : traitement oral après ablation du matériel et documentation		
Staphylococcus spp.		7 j
Pristinamycine ou Clindamycine	1gx3/j 1,8 g/jour en 3 prises et jusqu'à 2,4 g/jour si poids > 100 kg	
Streptococcus spp		
Amoxicilline	50 mg/kg/j en 3 prises par jour	
Streptococcus spp et allergie pénicilline		
Pristinamycine	1gx3/j	
Enterococcus spp.		
Amoxicilline	50 mg/kg/j en 3 prises par jour	
***Enterococcus spp.* résistant à l'amoxicilline ou allergique**		
Linezolide	600 mgx2/j	

Antibiothérapie documentée sur antibiogramme

Antibiotique	Dosage et voie	Durée (semaines)	Commentaires
Bactériémie sans endocardite après ablation complète			
Staphylocoque sensible à méticilline			
(cl)Oxacilline ou Céfazoline	150 mg/kg/j en 4 à 6 perfusions par jour 100mg/kg en perfusion continue	2	
Staphylocoque spp. sensible à la méticilline et allergie à la pénicilline			
Céfazoline	100mg/kg en perfusion continue	2	
Allergie à la pénicilline avec réaction anaphylactique ou allergie aux céphalosporines ou staphylocoque résistant à la méticilline			
Daptomycine	10 mg/kg/j, IV, une fois par jour	2	Second choix Vancomycine 40 mg/kg/j IV, en perfusion continue après dose de charge de 30mg/kg IVL sur 2h00

Antibiothérapie documentée sur antibiogramme

Antibiotique	Dosage et voie	Durée (semaines)	Commentaires
Bactériémie sans endocardite, après ablation complète du matériel			
Streptococcus spp			
Amoxicilline	100 mg/kg/j en 4 perfusion par jour	2	si poids> 100kg: Clindamycine 600 mgx4/j
Streptococcus spp et allergie vraie à la pénicilline sans réaction anaphylactique			
Ceftriaxone ou Cefotaxime	2g/j IV 100 mg/kg/j	2	
Streptococcus spp et allergie à la pénicilline avec réaction anaphylactique ou allergie aux céphalosporines			
Vancomycine	40 mg/kg/j IV, en perfusion continue après dose de charge de 30mg/kg IVL sur 2h00	2	Adapter la posologie aux dosages (concentration à l'équilibre = 15-20 mg/l)
Enterococcus spp.			
Amoxicilline	200 mg/kg/j en 6 injections ou en perfusion continue	2	
Enterococcus spp. Résistant à l'amoxicilline ou allergique			
Vancomycine	40 mg/kg/j IV, en perfusion continue après dose de charge de 30mg/kg IVL sur 2h00	2	Adapter la posologie aux dosages (concentration à l'équilibre = 15-20 mg/l)

Antibiothérapie suppressive

- Indication : infection de DECI documentée en l'absence d'extraction complète, devant le risque élevé de rechute
- Décision prise après concertation multidisciplinaire
- **Modalités:**
  - après 6 semaines d'antibiothérapie curative
  - monothérapie PO bien toléré: C1G, cotrimoxazole, doxycycline
  - suivi à M2 et M3 puis tous les 6 mois

Extraction du matériel- HRS 2017

Complete device and lead removal is recommended for all patients with definite CIED system infection. (COR I; LOE B-NR)

Complete removal of epicardial leads and patches is recommended for all patients with confirmed infected fluid (purulence) surrounding the intrathoracic portion of the lead. (COR I; LOE C-EO)

Complete device and lead removal is recommended for all patients with valvular endocarditis without definite involvement of the lead(s) and/or device. (COR I; LOE B-NR)

Complete device and lead removal is recommended for patients with persistent or recurrent bacteremia or fungemia, despite appropriate antibiotic therapy and no other identifiable source for relapse or continued infection. (COR I; LOE B-NR)

Careful consideration of the implications of other implanted devices and hardware is recommended when deciding on the appropriateness of CIED removal and for planning treatment strategy and goals. (COR I; LOE C-EO)

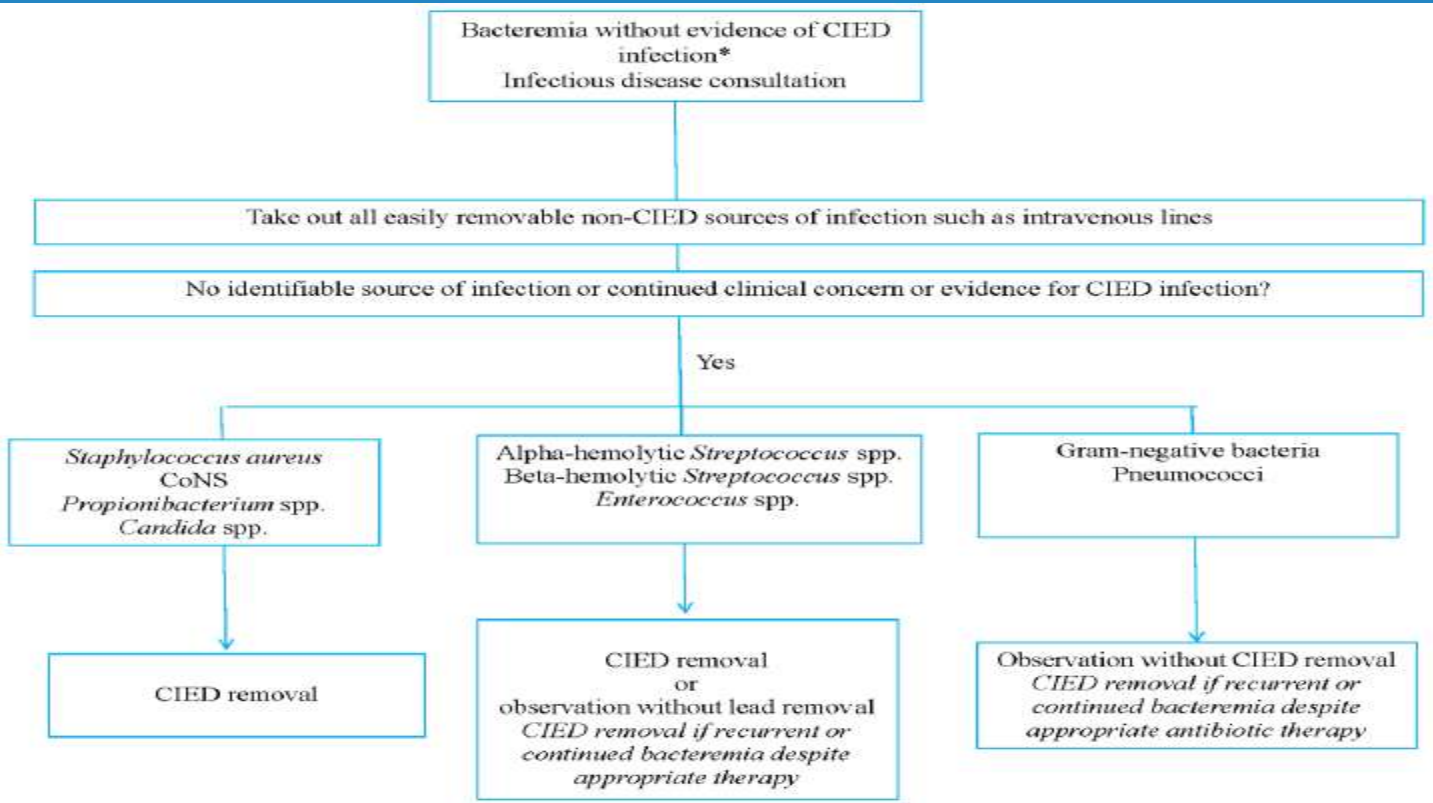


Figure 3 Management of bacteremia without evidence of CIED infection

*Important to distinguish between blood stream infection and contamination in bacteremia involving skin flora.

Extraction du matériel-EHRA 2019

- In patients with definite CIED infection (systemic and local), complete device removal is recommended (including abandoned leads, epicardial leads, and lead fragments)
- After diagnosis of CIED infection, the device removal procedure should be performed without unnecessary delay (ideally within 3 days)
- The recommended technique for device system removal is percutaneous, transvenous extraction technique. Epicardial leads require surgical removal.
- In patients with systemic infection and lead vegetations of approximately >20 mm, percutaneous aspiration of vegetations prior to and during transvenous lead extraction or alternatively surgical extraction may be considered

Extraction du matériel-EHRA 2019

After device removal, meticulous debridement of the generator pocket (complete excision of the fibrotic capsule and complete removal of all non-absorbable suture material) and subsequent wound irrigation with sterile normal saline solution is recommended

Extraction du matériel-EHRA 2019

Complete CIED removal is indicated in bacteraemia or fungaemia with **S. aureus, CoNS, Cutibacterium spp., and Candida** spp

In bacteraemia with **alpha- or beta-haemolytic Streptococcus** spp. and **Enterococcus** spp., a complete CIED removal may be performed as first-line treatment or in case of recurrent/continued bacteraemia despite appropriate antibiotic therapy as a second step therapy

In case of bacteraemia with **non-pseudomonal/Serratia Gram-negative bacteria or Pneumococcus spp.**, CIED removal should be performed in the case of recurrent/continued bacteraemia despite appropriate antibiotic therapy when there is no other identifiable source for recurrence or continued infection

HRS 2017

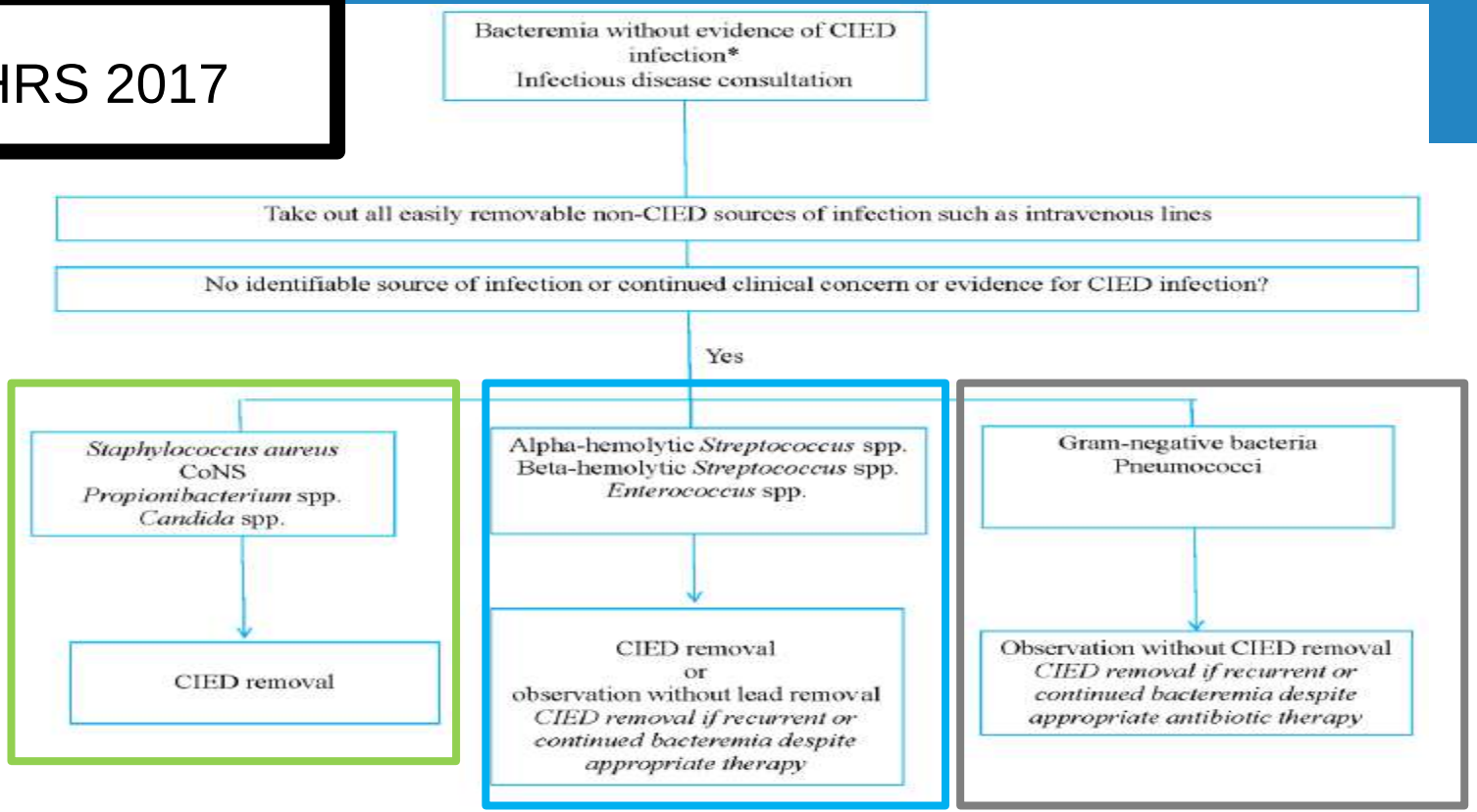


Figure 3 Management of bacteremia without evidence of CIED infection.
*Important to distinguish between blood stream infection and contamination in bacteremia involving skin flora.

Extraction du matériel-EHRA 2019

Complete CIED removal is recommended in patients with infective endocarditis with or without definite involvement of the CIED system

Complete device and lead removal is recommended for all patients with valvular endocarditis without definite involvement of the lead(s) and/or device. (COR I; LOE B-NR)

HRS 2017

Extraction de matériel

- **Extraction complète (boitier et sondes) si infection de DECI certaine.**
  A réaliser le plus précocement possible :
  - idéalement dans les 3 jours suivant le diagnostic
  - indépendamment de la durée du traitement antibiotique préalable
- **Extraction percutanée :**
  - si végétations < 2 cm
  - à discuter au cas par cas si végétations > 2 cm
- Extraction à discuter en RCP si :
  - endocardite valvulaire sans implication identifiée des sondes et/ou du boitier
  - Isolement, dans les hémocultures, d'une bactérie à fort pouvoir pathogène sur les DECI (staphylocoques >> streptocoques >> BGN)

Réimplantation du matériel-HRS 2017-EHRA 2019

- **Délai de réimplantation**
  - Réévaluer pour chaque patient, l'utilité, l'indication du DECI
  - Le délai idéal avant la repose du matériel n'est pas connu
  - Une nouvelle implantation peut raisonnablement être réalisée 72 heures après la première hémoculture négative (=> nécessité de prélever des hémocultures quotidiennement en cas de bactériémie).
  - Mais ce délai peut être prolongé si le patient a une autre source d'infection non maitrisée comme un abcès du psoas
  - Réimplantation possible le jour même (dans un autre site) si infection localisée au site d'implantation

Réimplantation du matériel-HRS 2017-EHRA 2019

- **Site de réimplantation**
  - Choisir un site de réimplantation différent du site initial
    - Controlatéral
    - Veine iliaque (exceptionnelle)
    - Epicardique
    - Sous-cutané

Réimplantation du matériel-HRS 20176EHRA 2019

- **Alternatives au PM et DAI « traditionnel » (permanent)**
  - PM semi-permanent
  - PM sans fil
  - Life vest →

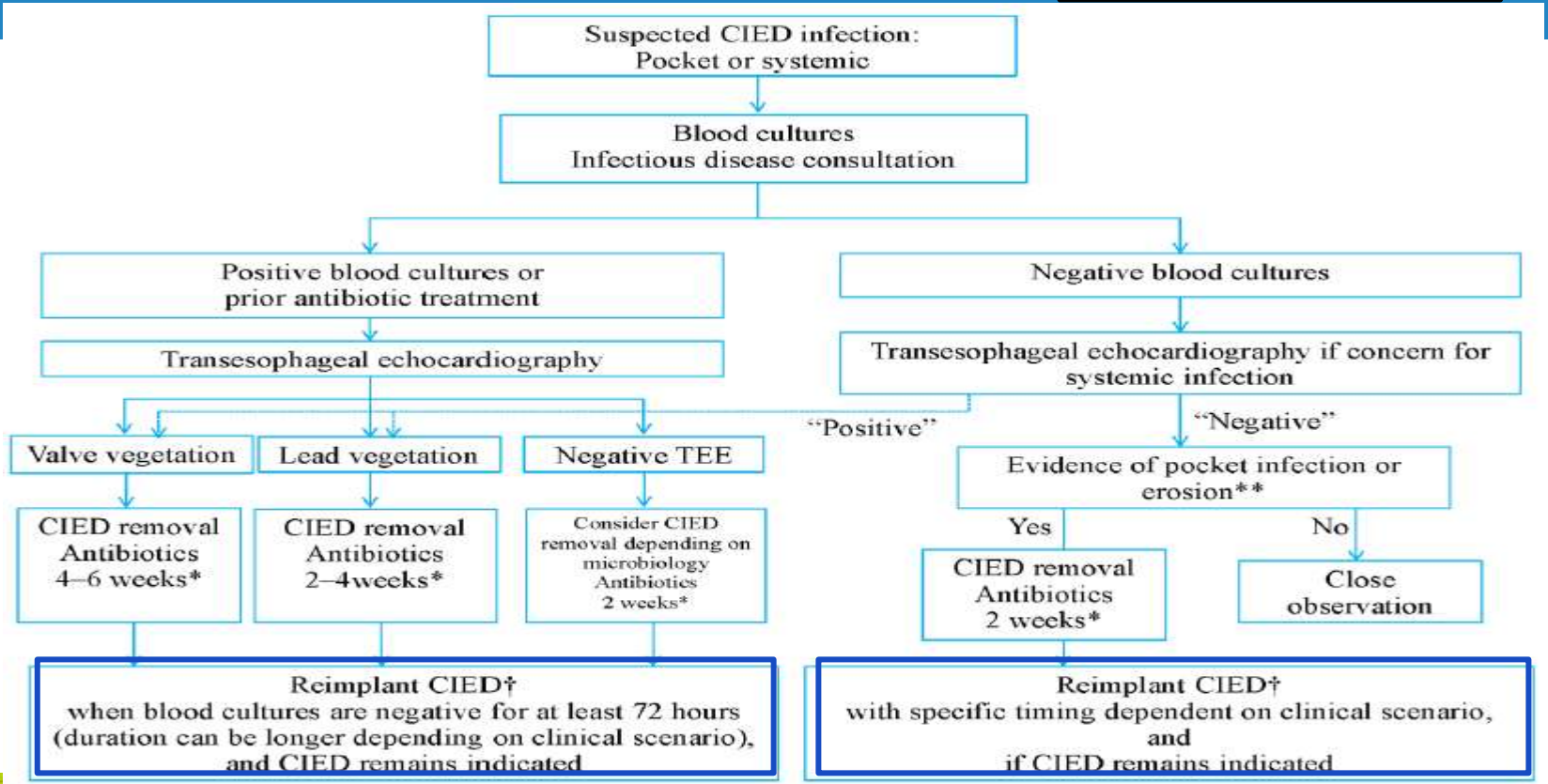


Figure 1 Management of suspected CIED infection.

Réimplantation du matériel-EHRA 2019

Table 10 Recommendations for preventive strategies after device implantation and for new re-implantations including alternative novel devices

Consensus statement	Statement class	Scientific evidence coding	References
After device extraction, re-assessment of the indication for re-implantation is recommended		O	38,122
Whenever possible, re-implantation may be avoided or delayed until symptoms and signs of systemic and local infection have resolved		O	38,123
A temporary pacemaker with ipsilateral active fixation strategy may be considered in pacemaker-dependent patients requiring appropriate antibiotic treatment before re-implantation		O	124–127
Preferred access sites for replacement device are the contralateral side, the femoral vein, or epicardially		E, O	38,128,129
Temporary pacing in patients who are not pacemaker dependent		O	28
Replacement device implantation ipsilateral to the extraction site		E	38
Alternative novel devices as LPM and S-ICD may be considered in selected patients with high infective risk or in patients in whom these devices are considered better options after an CIED infection		O	129–133

CIED, cardiac implantable electronic device; E, expert opinion; LPM, leadless pacemaker; M, meta-analysis; O, observational studies; R, randomized trials; S-ICD, subcutaneous implantable cardiac defibrillator.

Prévention des infections de DECI - HRS 2017

- **Différer implantation si infection en cours**
- **Antibioprophylaxie pré-implantation (CIG, Vanco)**
- **Préparation cutanée du site+++**
- **Ne pas :**
  - Utiliser de solution antibiotique pour irriguer la zone d'implantation du boitier
  - Prolonger les antibiotiques en post-opératoire
  - Prescrire d'antibiotiques avant soins dentaires

Prévention des infections de DECI - EHRA 2019

Table 4 List of recommended preventive measures for CIED infections

Consensus statement	Statement class	Scientific evidence coding
Pre-procedural measures		
Confirm indication for CIED		E
Delay CIED implantation in patients with infection		E
Avoid temporary transvenous pacing and central venous lines, which should ideally be removed prior to introducing new hardware, whenever possible		O, M
Measures to avoid pocket haematoma are recommended (avoid heparin bridging, discontinue antiplatelets if possible)		R
Periprocedural use of therapeutic low-molecular-weight-heparin		R, M, O
Perform the CIED procedure in an operating room/suite with complete sterile environment as required for other surgical implant procedures		E
Procedure should be performed or supervised by an operator with sufficient training and experience (*Table 12*)		O
Topical *S. aureus* decolonization may be performed		E
Pre-procedural skin wash may be performed		E
Hair removal with electric clippers (not razors) is recommended		O

Prévention des infections de DECI - EHRA 2019

Antibiotic prophylaxis is recommended within 1 h of incision for cefazolin and flucloxacilline, within 90-120 min for vancomycin		R, M
A continuous surveillance program of infection rates and associated microbiology should be set-up at the level of each implanting centre		E
Peri-procedural measures		
Surgical preparation with alcoholic chlorhexidine should be used rather than povidone-iodine		R
Allow sufficient time for the antiseptic preparation to dry		E
Adhesive iodophor-impregnated incise drapes may be used		E
Perform the procedure with adequate surgical technique—minimize tissue damage, haemostasis, adequate wound closure		E
Antibiotic envelope in high-risk situations is recommended[a]		R
If the operator performs the prepping and draping, glove change/re-scrub or remove outer glove of a double-glove before incision		E

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Antibacterial Envelope to Prevent Cardiac Implantable Device Infection

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Prise en charge dans des centres experts- EHRA 2019

Table 12 Recommendations on minimum volume requirements of cardiac implantable electrical device (CIED) procedures for centres and operators

Consensus statement	Statement class	Scientific evidence coding	References
Operators with less than approximately 100 CIED procedures experience should work under close supervision of more experienced operators	❤	O, E	181–184
An annual minimum operator volume of approximately 50 CIED procedures is recommended for all operators	❤	O, E	185–188

CIED, cardiac implantable electrical device; E, expert opinion; M, meta-analysis; O, observational studies; R, randomized trials.

Définition infection de DECI.Consensus EHRA 2019

- ‘Definite’ CIED clinical pocket/generator infection = generator pocket shows swelling, erythema, warmth, pain, and purulent discharge/sinus formation or deformation of pocket, adherence and threatened erosion or exposed generator or proximal leads
- ‘Definite’ CIED/IE = presence of either 2 major criteria or 1 major + 3 minor criteria
- ‘Possible’ CIED/IE = presence of either 1 major + 1 minor criteria or 3 minor criteria
- ‘Rejected’ CIED/IE diagnosis = patients who did not meet the aforementioned criteria for IE

Définition infection de DECI. Consensus EHRA 2019

- **Major criteria** ♥ **E**
  - Microbiology
    - A. Blood cultures positive for typical microorganisms found in CIED infection and/or IE((Coagulase-negative staphylococci, S. aureus)
    - B. Microorganisms consistent with IE from 2 separate blood cultures:
      - a. Viridans streptococci, Streptococcus gallolyticus (S. bovis), HACEK group, S. aureus; or
      - b. Community-acquired enterococci, in the absence of a primary focu
    - C. Microorganisms consistent with IE from persistently positive blood cultures:
      - a. >_2 positive blood cultures of blood samples drawn >12 h apart; or
      - b. All of 3 or a majority of >_4 separate cultures of blood (first and last samples drawn >_1 h apart); or
      - c. Single positive blood culture for Coxiella burnetii or phase I IgG antibody titre >1:800

Définition infection de DECI. Consensus EHRA 2019

- **Major criteria** **E**
  - Imaging positive for CIED infections and/or IE
    - D. Echocardiogram (including ICE) positive for:
      - a. CIED infection:
        - i. Clinical pocket/generator infection
        - ii. Lead-vegetation
      - b. Valve IE
        - i. Vegetations
        - ii. Abscess, pseudoaneurysm, intracardiac fistula
        - iii. Valvular perforation or aneurysm
        - iv. New partial dehiscence of prosthetic valve
    - E. [18F]FDG PET/CT (caution should be taken in case of recent implants) or radiolabelled WBC SPECT/CT detection of abnormal activity at pocket/generator site, along leads or at valve site
    - F. Definite paravalvular leakage by cardiac CT

Points forts

- Pas de discordances notables entre recommandations américaines (HRS 2017) et européennes (EHRA 2019). Recommandations EHRA plus détaillées, mieux présentées
- Diaporama de synthèse des recommandations réalisée par SPILF, SFC, AEPEI accessible sur le site de la SPILF
- Proposition d'une définition d'infection de DECI par l'EHRA
- Nécessité d'une prise en charge pluri-disciplinaire (Endocarditis Team) dans des centres ayant une bonne expertise de ce type d'infection