Advances in Cardiac Arrhythmias and Great Innovations in Cardiology"
Turin, October 13-15, 2016

COMPLEXITIES IN APPROACHING INFECTIONS IN PATIENTS WEARING DEVICES

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Turin, Italy

Autunno, canoe sul Po al Valentino

Epidemiologia delle infezioni dei dispositivi per il controllo del ritmo cardiaco (CDI, Cardiac Device Infections)

PM: infezioni tra 0.13% (*) e 19.9% (+) (anni 1975-1999)

- ✓ Molte infezioni localizzate nella tasca.
- ✓ Endocardite su cateteri di PM meno frequente (intorno al 10% delle infezioni associate ai PM);(°) 550 casi/milione di pazienti con PM-anno(“)

(*) Conklin, J Thorac Cardiovasc Surg 1975; 69: 1
(+) Bluhm, Acta Med Scand 1985; 699:S1
(°) Arber, Medicine 1994; 73: 299
(“) Duval, Clin Infec Dis 2004; 39:68-74

Epidemiologia delle infezioni dei dispositivi per il controllo del ritmo cardiaco (CDI, Cardiac Device Infections)

- ICD: infezioni tra lo 0-0.8% [@, #] ed il 3.2 % [§] (anni 2000-2002)
  - ✓ Incidenza più bassa negli impianti prepettorali rispetto agli addominali (0.5 vs 3.2%)[§].

(@) Eggiman, ASM Press 2000; 247
(#) Moss, N Engl J Med 2002; 346: 877
(§) Mela, Am J Cardiol 2001; 88: 750

Epidemiologia delle infezioni dei dispositivi per il controllo del ritmo cardiaco (CDI, Cardiac Device Infections)

PM/ICD: in anni più recenti (2007-2014)

incidenze di 0.2%–1.6%, (^,?, ‘) fino al 6.8%, (@)

o di 1.9 per 1,000 device-anno,(=)

con mortalità tra 10% e 21%.(ò,à,ù)

^) Sohail MR.Clin Infect Dis 2007;45:166-73
?) Catanchin A, Heart Lung Circul 2007; 16: 434-9
(‘) Tsai TS; Am J Ther 2009; E-pub 6/03/2009
(@) Cengiz M. Clin Cardiol 2010;33:406-11.
(=) Uslan DZ, Arch Intern med 2007; 167: 669-75
(ò) Bracke FA; Europace 2004; 6: 243-7
(à) Massoure PL, PACE 2007; 30: 12-9
(ù) Victor F, Heart 1999; 81: 82-7

Infection rates in studies of Cardiac Device Infections (CDI)

Year	Author	Study design	Study size	DRI rate
1994	Chauhan[60]	Case control	2019	0.8%
1994	Mounsey[63]	Open, RCT	656	2%
1998	Smith[112]	Case control	1821	1.2%
1998	Spinler[46]	Case control	202	4.5%
2001	Mela[113]	Case control	1700	1.7%
2006	Bloom[43]	Case control	4856	1.5%
2007	Sohail[22]	Nested case control	12770 (58)	0.2%
2007	Klug[33]	Case control	6319	0.6%
2009	Lekkerkerker[36]	Case control	3410	2.2%
2009	de Oliveira[55]	Blinded RPCT	649	2%
2009	Margey[114]	Case control	3105	1.26%
2010	Nery[35]	Nested case control	2417 (75)	0.99%
2010	Romeyer-Bouchard[44]	Case control	290	4.48%
2010	Cengiz[50]	Case control	833	6.84%
2010	Johansen[13]	Case control	46299	0.70%
2012	Raad[56]	Nested case control	NR (53)	NA
2014	Mittal[45]	Case control	1651	1.51%

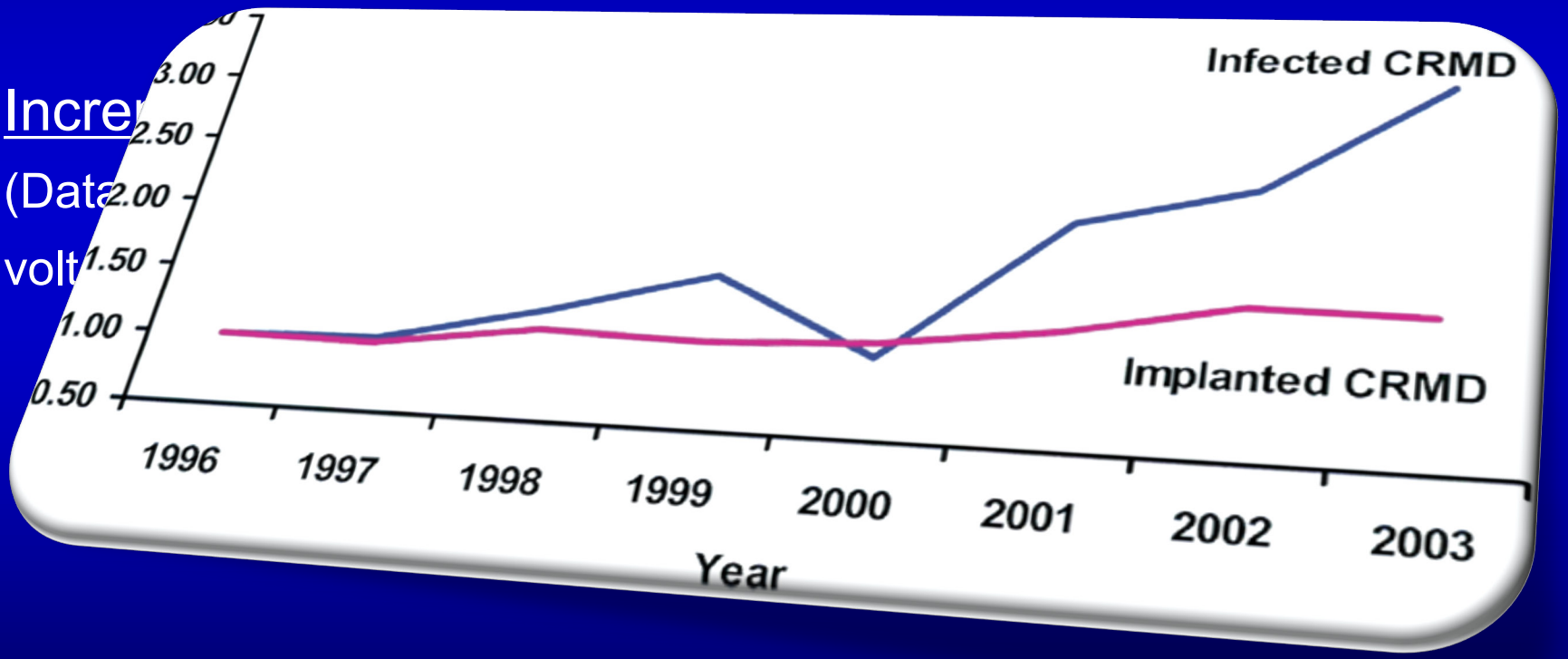
Padfield GJ et alHeart Rhythm2015;12:2344–2356 .

Incremento della incidenza delle CDI

Increm

(Data

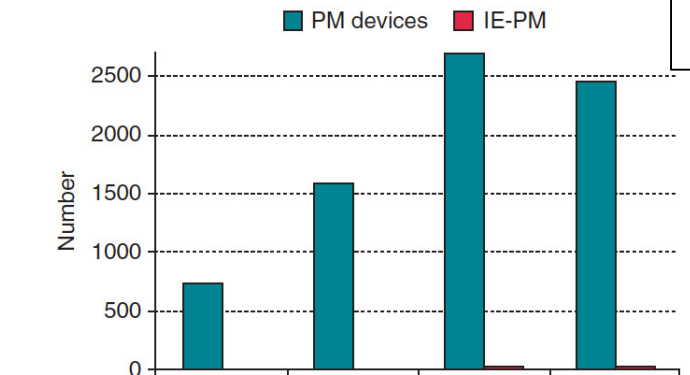
volt



(^) Voigt A, Shalaby A, Saba S et al. JACC 2006; 48: 596-7
(♀) Trohman, Lancet 2004; 364: 1701-19

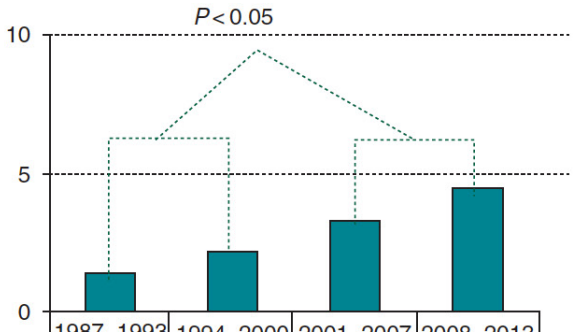
Absolute and relative increase of IE-PM

PM vs IE-PM



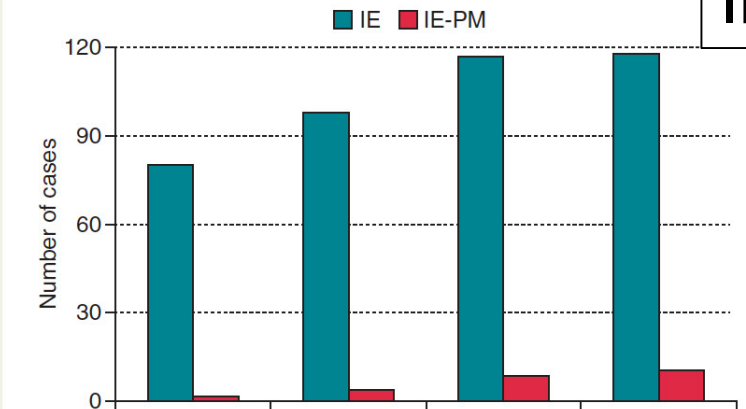
	1987–1993	1994–2000	2001–2007	2008–2013
PM devices	718	1574	2688	2444
IE-PM	1	4	9	11

n/1000



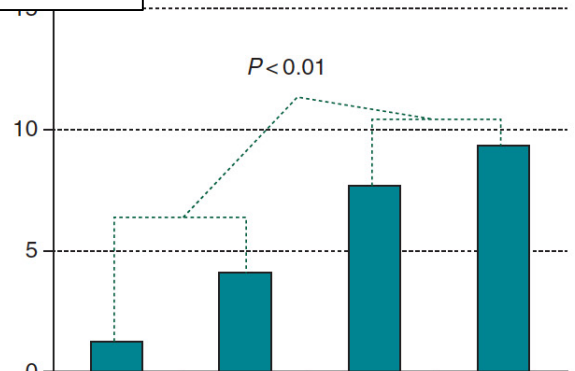
	1987–1993	1994–2000	2001–2007	2008–2013
IE-PM incidence on implanted devices	1.4	2.2	3.3	4.5

IE vs IE-PM



	1987–1993	1994–2000	2001–2007	2008–2013
IE	80	98	117	118
IE-PM	1	4	9	11

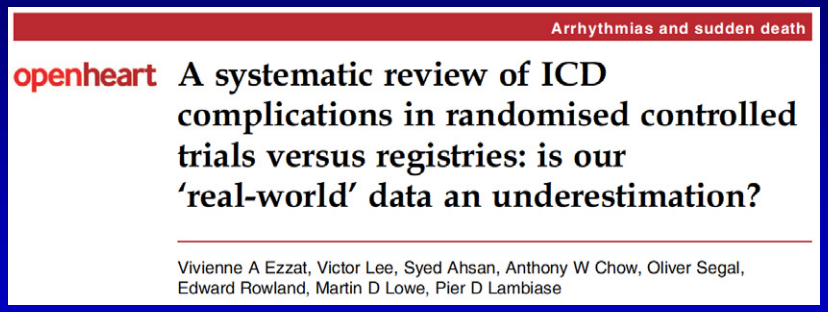
%



	1987–1993	1994–2000	2001–2007	2008–2013
IE-PM incidence on all IE	1.25	4.08	7.69	9.32

Carrasco F et al. *Europace* 2016;18: 836–841

Infection rates underestimated?


Arrhythmias and sudden death

openheart

A systematic review of ICD complications in randomised controlled trials versus registries: is our 'real-world' data an underestimation?

Vivienne A Ezzat, Victor Lee, Syed Ahsan, Anthony W Chow, Oliver Segal, Edward Rowland, Martin D Lowe, Pier D Lambiase

Total pooled complication rate from the RCTs (excluding inappropriate shocks) was **9.1%**, including displacement 3.1%, haematoma 1.2% and pneumothorax 1.1%.

NCDR ICD,
Years 2006-2010,
356 515 implants, statistically significant threefold lower total major complication rate of **3.08**% with lead displacement 1.02%, haematoma 0.86% and pneumothorax 0.44%.

Incidence of infections in RCTs: 1.5%
Years 1999-2013; 18 RCTs, 6433 patients, mean follow-up 3 months-5.6 years.

	Patients, n	All events, n (%)	Infection, n (%)
Calkins *et al*[23]	71	2 (2.8)	0
Deisenhofer *et al*[24]	92	10 (10.9)	0
Kron *et al*[8]	539	68 (12.6)	14 (2.6)
Bänsch *et al*[25]	50	14 (28)	2 (4.0)
Moss *et al*[26]	742	18 (2.4)	5 (0.7)
Vollman *et al*[27]	542	64 (11.8)	–
Bänsch *et al*[28]	102	20 (19.6)	–
Bokhari *et al*[29]	60	21 (35)	3 (5.0)
Hohnloser *et al*[30]	310	25 (8.1)	–
Kadish *et al*[11]	229	13 (5.7)	1 (0.4)
Bänsch *et al*[31]	190	3 (1.6)	–
Reddy *et al*[32]	128	0	0
Almendral *et al*[10]	334	30 (9.0)	4 (1.2)
Russo *et al*[33]	1530	71 (4.6)	–
Steinbeck *et al*[7]	415	76 (18.3)	–
Kuck *et al*[34]	107	15 (14.0)	1 (0.9)
Varma *et al*[35]	1339	81 (6.0)	–
Cheng *et al*[36]	16	1 (6.3)	–
Event rate, % (95% CI)		**9.1** (6.4 to 12.6)	**1.5** (0.8 to 2.6)

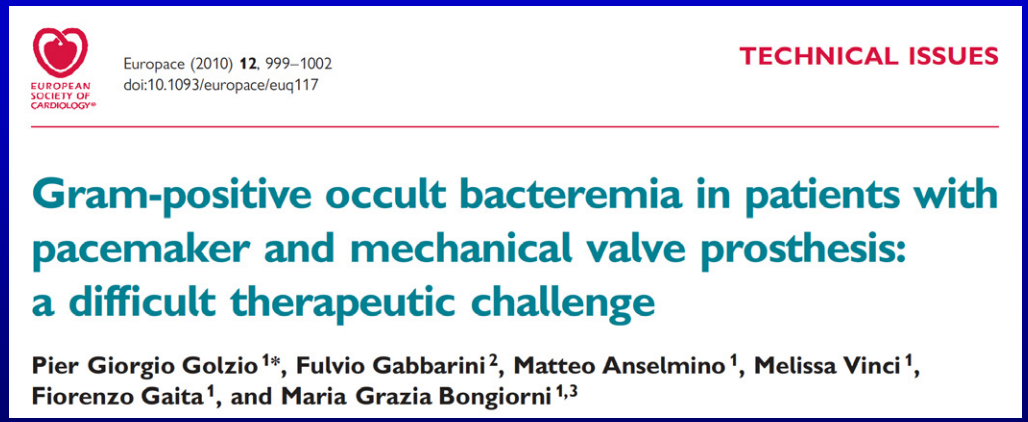
Ezzat VA et al. Open Heart. 2015;2:e000198. doi:10.1136/openhrt-2014-000198

DIAGNOSTIC TOOLS

“All diagnostic tools are sometimes equivocal or inconclusive for accurate diagnosis…”

Blood samples

- Gram positive occult bacteraemia in CIED patients



Europace (2010) **12**, 999–1002
doi:10.1093/europace/euq117

TECHNICAL ISSUES

Gram-positive occult bacteremia in patients with pacemaker and mechanical valve prosthesis: a difficult therapeutic challenge

Pier Giorgio Golzio [1]*, Fulvio Gabbarini [2], Matteo Anselmino [1], Melissa Vinci [1], Fiorenzo Gaita [1], and Maria Grazia Bongiorni [1,3]

Golzio, PG et a. *Europace* 2010; 12: 999-1002

Patient B.R.

A young patient at 6 years of age underwent dual-chamber pacemaker implantation due to complete atrioventricular block after mitral valve replacement. He felt well until November 2008, when he suffered from febrile illness with blood cultures disclosing methicillin-resistant staphylococcus aureus strain. Repeated antibiotic courses were effective only in obtaining temporary remissions. Consecutive transoesophageal echocardiography examinations were inconclusive. A labelled leucocyte scintigraphy, showing increased captation along leads, was very helpful and critical in guiding our decision to extract leads.

Patient B.R.

* 589.2009.8

To

92.19.7 SCINT.SEGM.GRANUL.(HMPAO)

89.01 ANAMNESI E VALUTAZIONE DEFINITE BREVI

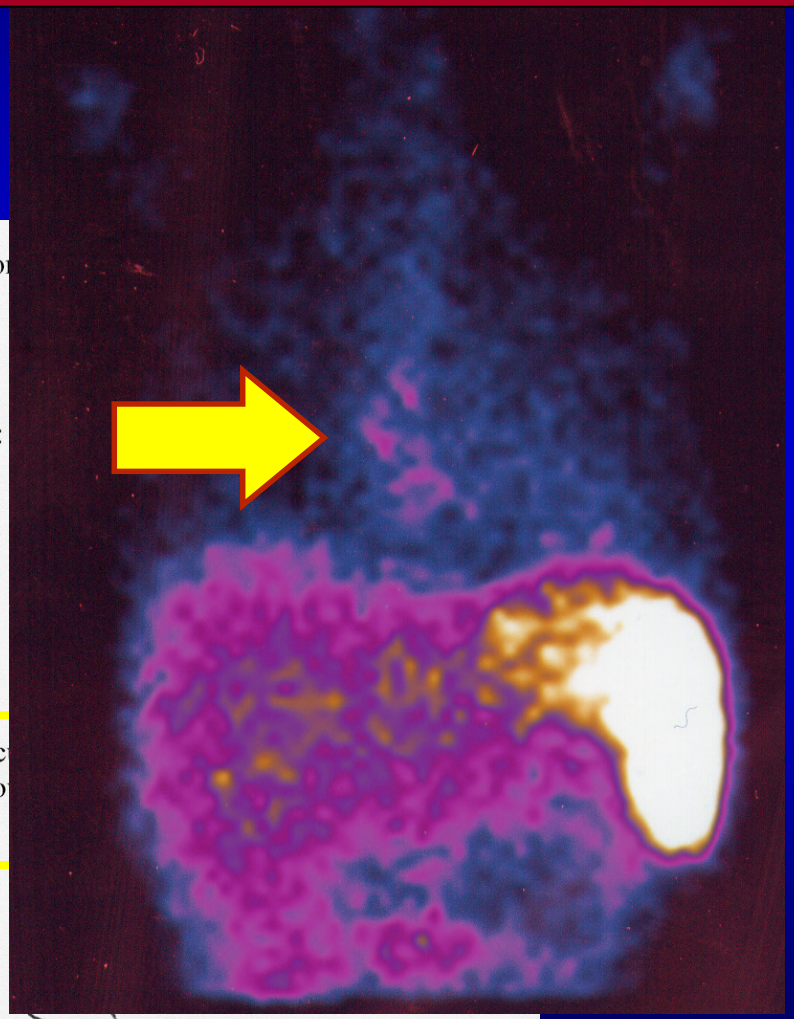
Radiofarmaco: 99mTc-HMPAO Leucociti Attività Somministrata:

INDAGINE FINALIZZATA ALLA VALUTAZIONE DEL TORACE, IN PAZIENTE CON SOSPETTO DI ENDO-CARDITE IN TERAPIA ANTIBIOTICA.
PRESENZA DI PROTESI MITRALICA MECCANICA.

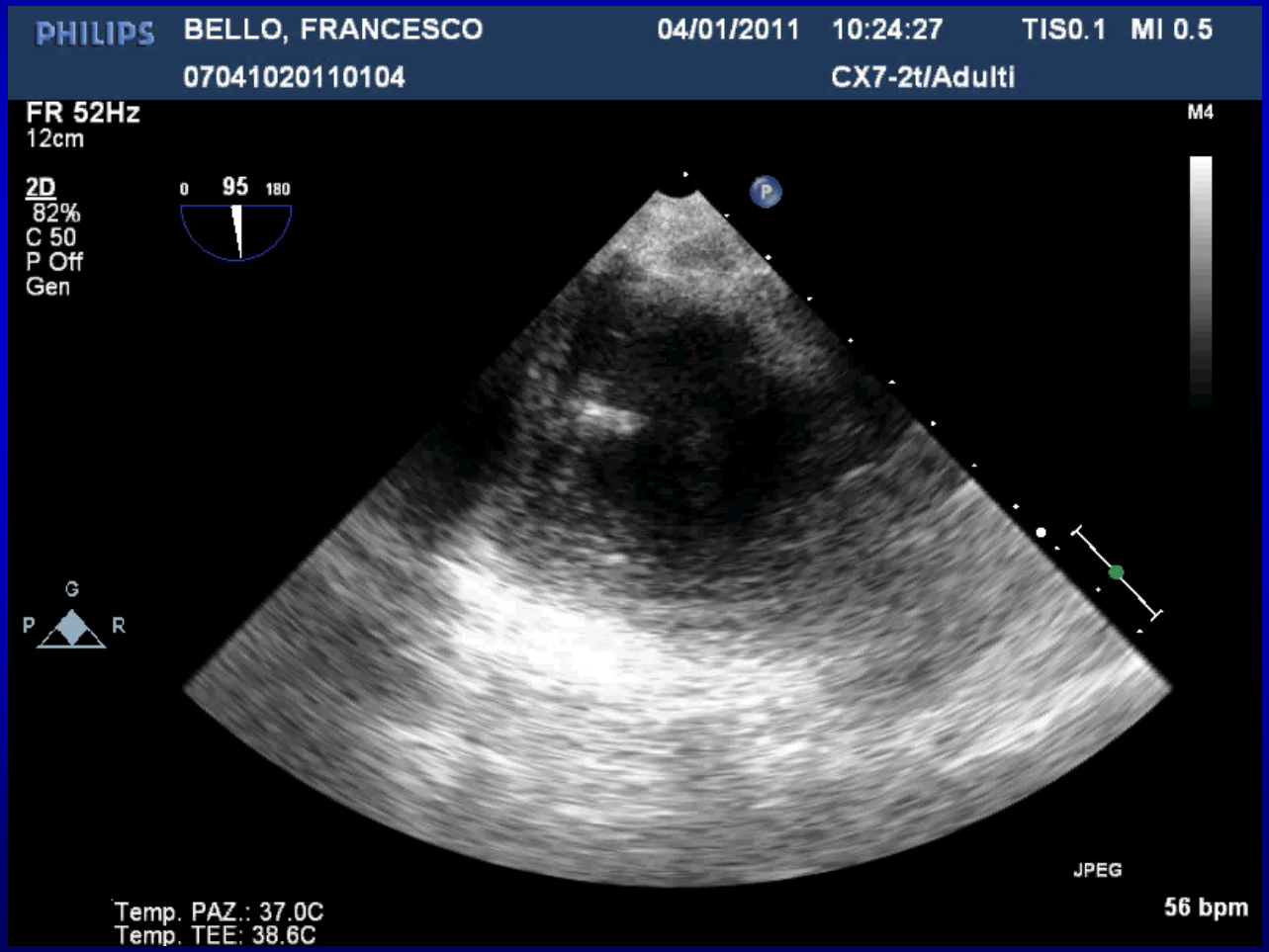
A partire dall'immagine relativa alla terza ora si osserva modesto acc
aspetto lineare, in corrispondenza del decorso dell'elettrocatetere endo
con l'ipotesi dell'infezione.

04746A

Il Dirigente Biologo
Dott. Giovanni CACACE



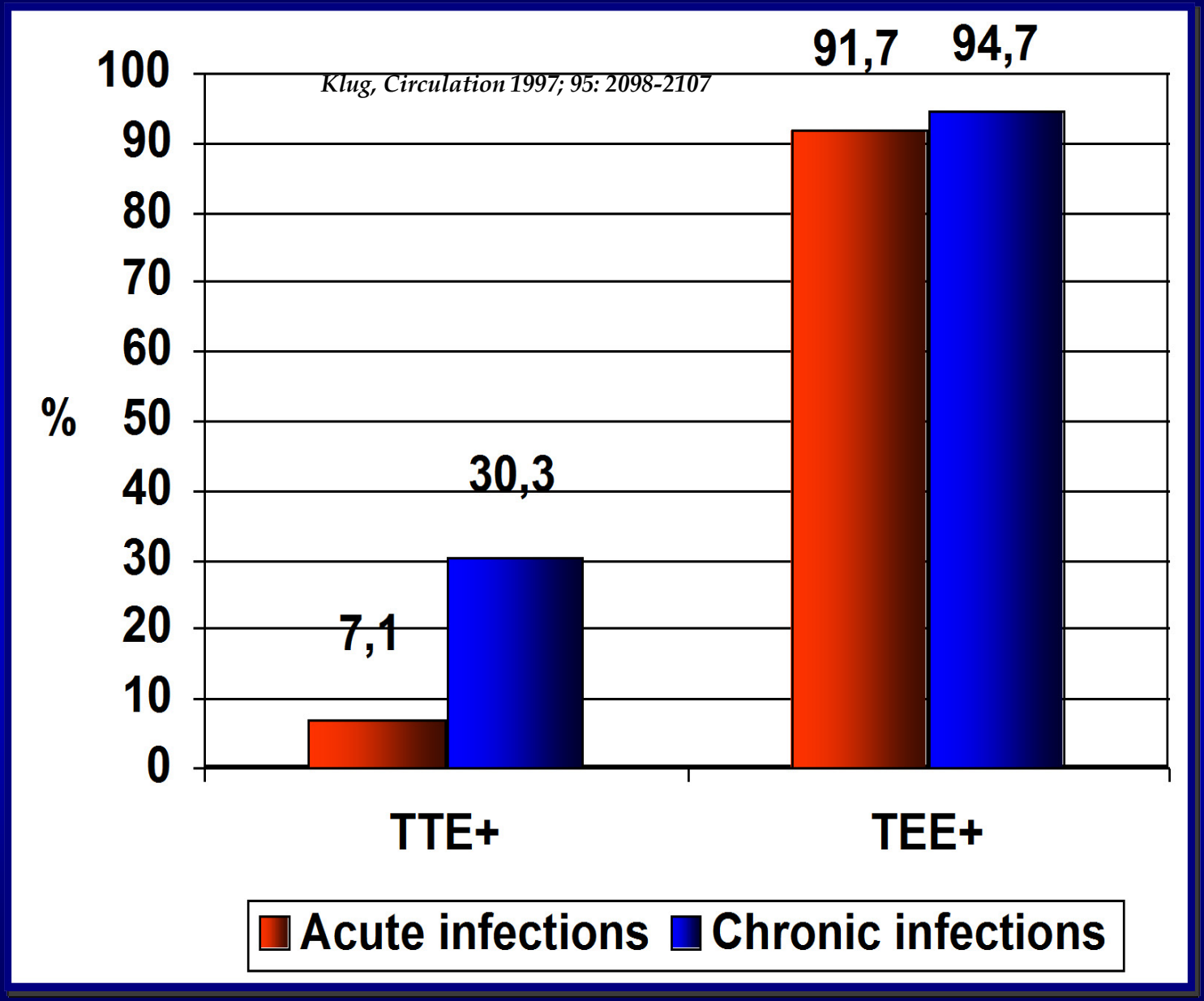
Lead vegetations at echocardiography



Lead vegetations

- TT Echo: abnormal images along leads 8(#) → 18(§) → 20-23%(+,*)
- TE Echo: abnormal images 67(§) → 80(#) →90-96%(+,*)
- Different sensitivity in acute and chronic infections(*)

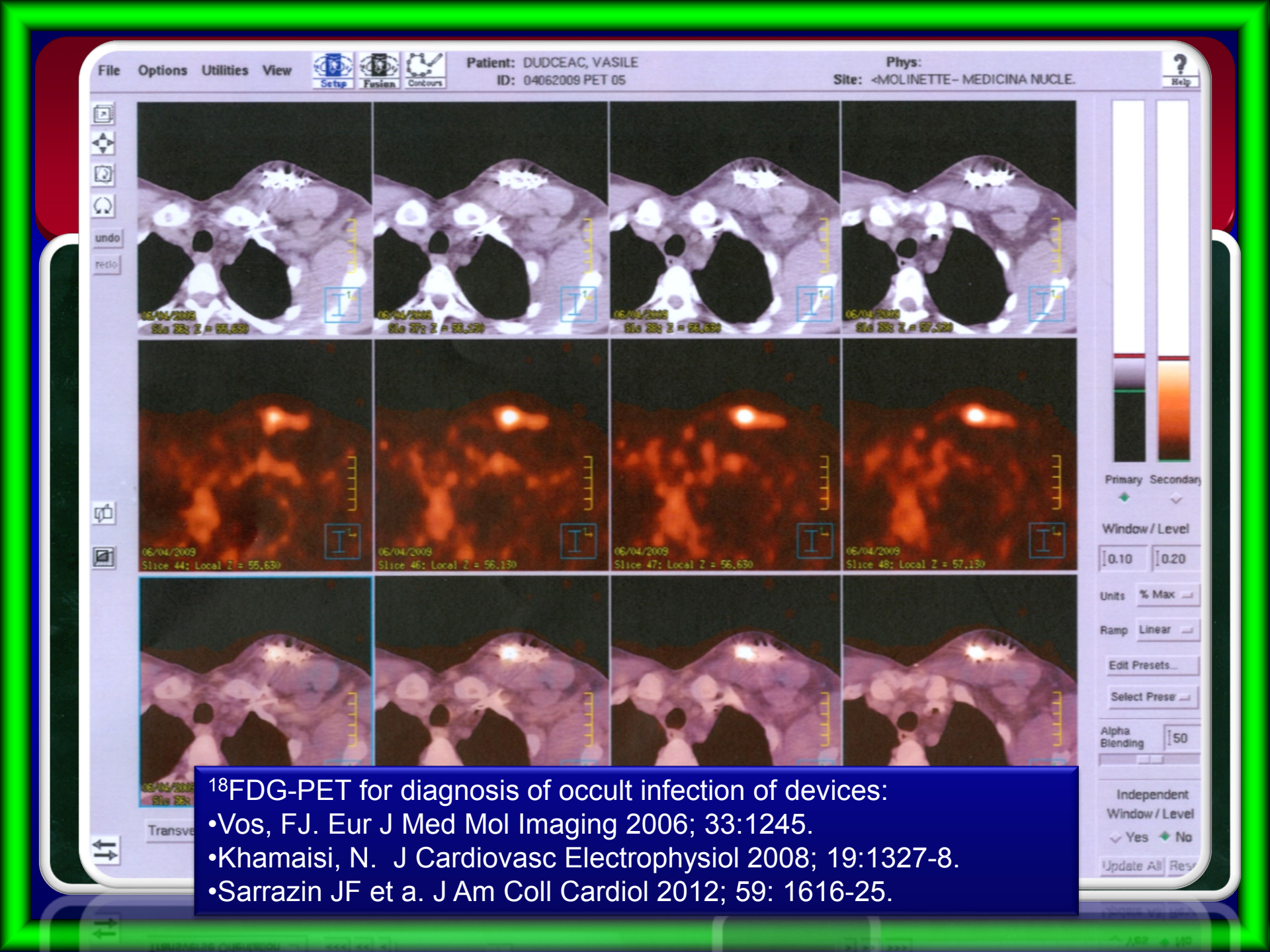
(§)Kennergren, Scand J Infect Dis 2004; 36:674-9
(#) Sohail, Mayo Clin Proc 2008; 83:46-53
(+)Cacoub, Am J Cardiol 1998; 82: 480-4;
(*)Klug, Circulation 1997; 95: 2098-2107
(°)Chamis, Circulation 2001; 104: 1029-33


Klug, Circulation 1997; 95: 2098-2107
100
90
80
70
60
%
50
40
30
20
10
0
91,7
94,7
30,3
7,1
TTE+
TEE+
Acute infections
Chronic infections

Lead vegetations

- A normal TT Echo can not rule out an infection: up to 17% of Staph. aureus isolates from generator pocket in patients with clinical infection and negative TT Echo)(˚)

(˚)Chamis, Circulation 2001; 104: 1029-33



[18]FDG-PET for diagnosis of occult infection of devices:

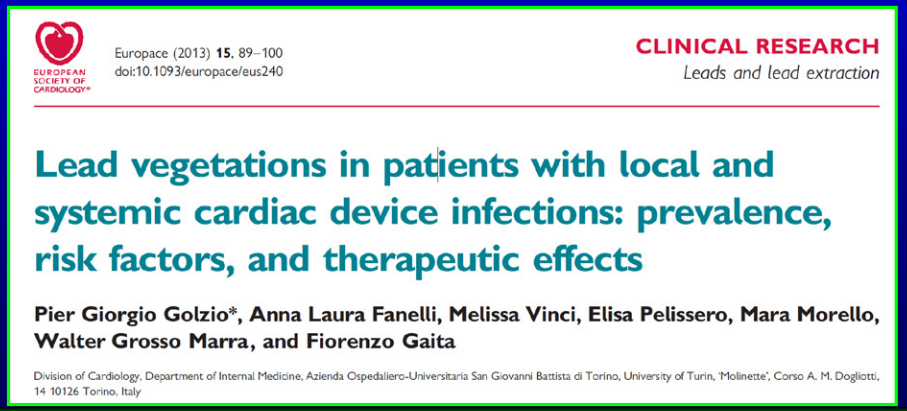
- Vos, FJ. Eur J Med Mol Imaging 2006; 33:1245.
- Khamaisi, N. J Cardiovasc Electrophysiol 2008; 19:1327-8.
- Sarrazin JF et a. J Am Coll Cardiol 2012; 59: 1616-25.

Lead vegetations: frequently observed in patients with only local symptoms

- Between 2003 and 2011, 293 leads were extracted from 136 patients (age 70.5+14.5 years, 109 male) with infective indications: 39.2% chronic draining sinus, 20.9% pocket infections, and 28.8% systemic infections/sepsis.
- All patients underwent transesophageal echocardiography (TEE) before LE.

Lead vegetation prevalence was 40.4%:(§)

- 62.2% in systemic infection,
- 21.9% in local infection,
- 36.4% in chronic draining sinus.



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doi:10.1093/europace/eus240

CLINICAL RESEARCH
Leads and lead extraction

Lead vegetations in patients with local and systemic cardiac device infections: prevalence, risk factors, and therapeutic effects

Pier Giorgio Golzio*, Anna Laura Fanelli, Melissa Vinci, Elisa Pelissero, Mara Morello, Walter Grosso Marra, and Fiorenzo Gaita

Division of Cardiology, Department of Internal Medicine, Azienda Ospedaliero-Universitaria San Giovanni Battista di Torino, University of Turin, 'Molinette', Corso A. M. Dogliotti, 14 10126 Torino, Italy

(§) Golzio, *Europace* 2013;15:89-100

MEDICAL THERAPY?

Conservative approaches

- Conservative approaches:
  - systemic administration of antibiotics,(1,2)
  - limited debridement, irrigation,(3)
  - aspiration of the infected site,
  - closed-suction drainage with flap coverage for tension-free closure.(1)
- → High recurrences (up to 97%),
- →often only “time-wasting” procedures.[4, 5]

1. Kolker AR et al. *Ann Plast Surg*. 2007;59(1):26-9; discussion 30.
2. Turkisher V et al. *PACE* 1997;20:268-2270.
3. Yamada M et al. Ann Thorac Surg. 2002;74(5):1494-9; discussion
4. Lewis A et al. *J Thorac Cardiovasc Surg.* 1985;89:758-63.
5. Molina JE et al. *Ann Thorac Surg.* 1997;63(2):504-9.

Conservative approaches

- Lead preservation with pulse generator change, relocation in a new distant pocket →20-80% recurrence of infection.(1, 2)
- Partial catheter removal and several local lead-preserving surgical procedures →seldom effective (3-7)

1. Vogt PR. Et al. *J Card Surg.* 1996;11:180-6.
2. Parry G et al., *Pacing Clin Eletrophysiol.* 1991;14:1251-7.
3. Siu C et al. *Int J Cardiol. 2007*;114(2):E40-1.
4. Tsai V et al. *J Interv Card Electrophysiol.* 2007;19(2):133-7.
5. Kaur MR et al. *J Eur Acad Dermatol Venereol.* 2006;20(4):466-7.
6. Nandyala R et al. , Parsonnet V. *Pacing Clin Electrophysiol.* 2006;29(4):393-6.
7. Tascini C et al. , *J Chemother.* 2006;18(2):157-63.

Antibiotic therapy: microbiology of CDIs

Europace (2013) **15**, 89–100
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CLINICAL RESEARCH
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Europace (2013) 15, 89–100

Europace
doi:10.1093/europace/eus044

Microbiology of cardiac implantable electronic device infections

Maria Grazia Bongiorni[1], Carlo Tascini[2], Enrico Tagliaferri[2]*, Andrea Di Cori[1], Ezio Soldati[1], Alessandro Leonildi[2], Giulio Zucchelli[1], Ilaria Ciullo[2], and Francesco Menichetti[2]

[1]Second Division of Cardiovascular Diseases, Cardiac and Thoracic Department, New Santa Chiara Hospital, University Hospital of Pisa, Via paradisa 2, 56124 Pisa, Italy; and [2]Infectious Diseases Unit, New Santa Chiara Hospital, University Hospital of Pisa, Via paradisa 2, 56124 Pisa, Italy

Europace (2012) 14, 1334–1339

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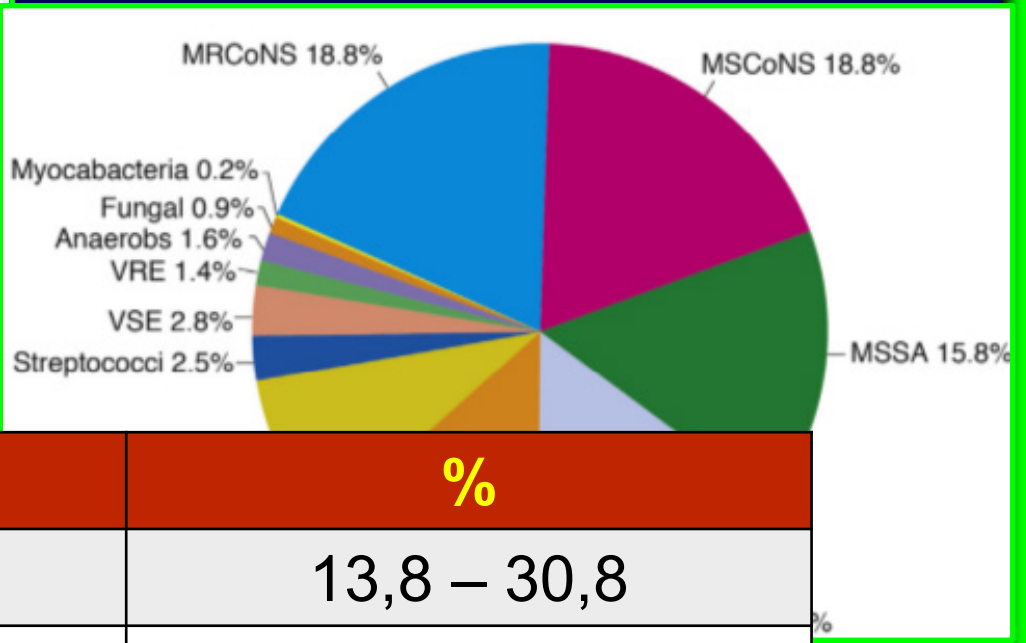
Microbiology of Cardiac Implantable Electronic Device Infections

Ayman A. Hussein, MD, Yacoub Baghdy, MD, Oussama M. Wazni, MD, Michael P. Brunner, MD, Ghazal Kabbach, MD, Mingyuan Shao, MS, Steven Gordon, MD, Walid I. Saliba, MD, Bruce L. Wilkoff, MD, Khaldoun G. Tarakji, MD, MPH

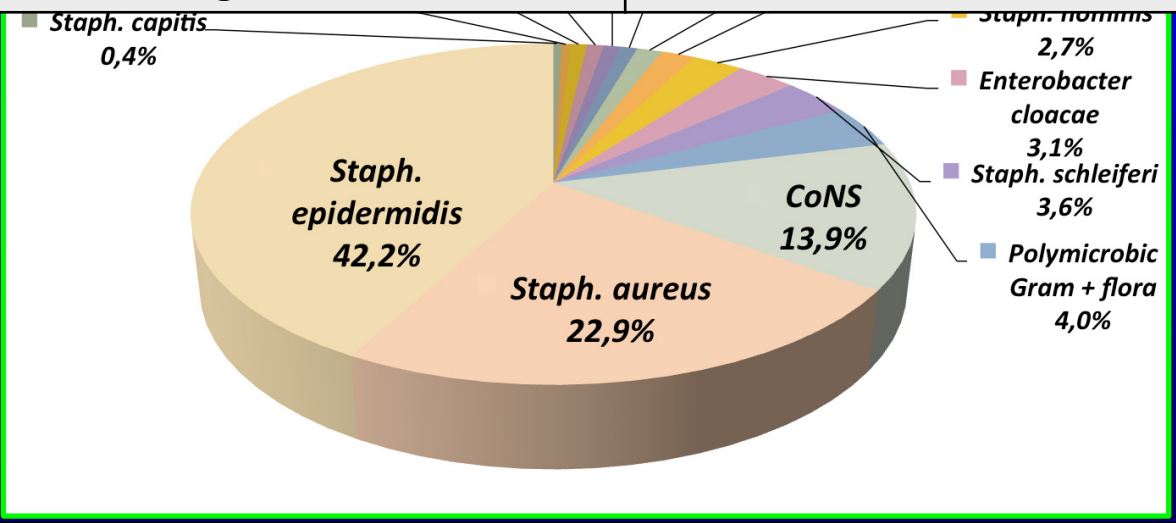
	N	%
Total infected leads	1204	
Total isolates	1068	100.0
Gram positive	988	92.5
CoNS	737	69.0
Staphylococcus aureus	147	13.8
Corynebacterium spp.	53	5.0
Propionibacterium spp.	27	2.5
Gram negative	65	6.1
Enterobacteriaceae[3]		
Pseudomonas spp.		
Candida spp.		
Candida albicans		
Molds		



Bacteria	%
Staph aureus	13,8 – 30,8
CoNS	37,8 – 69,0
Gram negative	6,1 – 8,9

Pisa, 2000–2011, 1204 Pts

Turin, 2003–2011, 136 Pts



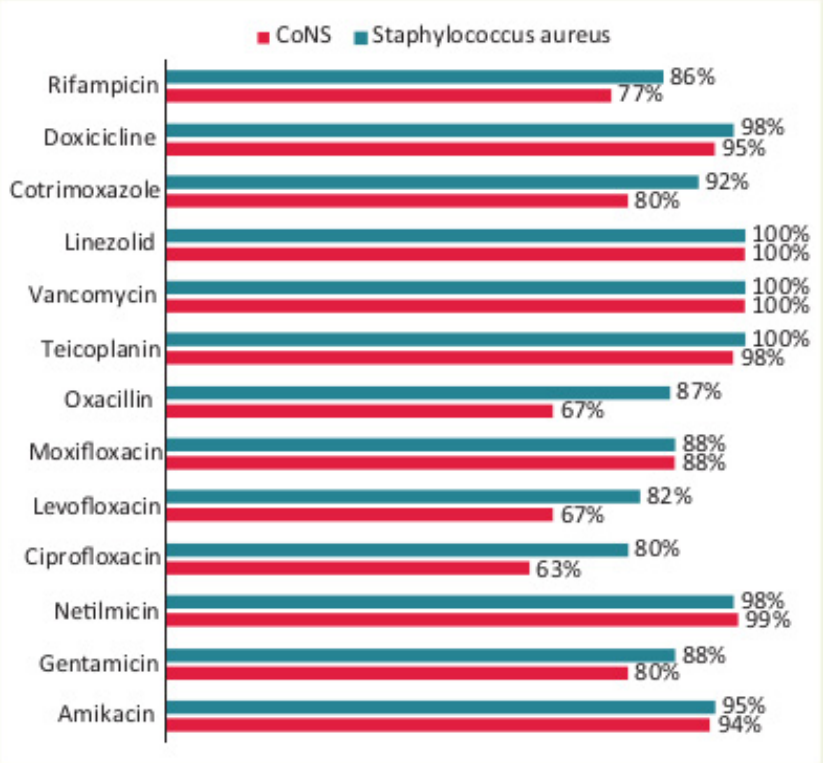


Figure 1 Antimicrobial susceptibility of staphylococci isolated from electrodes of CIEDs (Pisa, 2000–2011).

TABLE 2 Microbiology of Early Versus Late Cardiac Implantable Electronic Device Pocket or Endovascular Infections

Variable	Early Infection (%)	Late Infection (%)	p Value
Pocket infections, n	217	213	
Bacterial type			<0.001
Staphylococcus aureus	30.2	16.3	
Coagulase-negative *Staphylococcus*	40.0	53.6	
Enterococcus	0.5	0.0	
Negative cultures	16.7	23.9	
Others	12.6	6.2	
Staphylococcal resistance			0.04
Methicillin resistant	29.8	34.4	
Methicillin sensitive	40.5	35.4	
Endovascular infections, n	115	213	
Bacterial type			0.6
Staphylococcus aureus	51.7	44.5	
Coagulase-negative *Staphylococcus*	27.6	26.1	
Enterococcus	5.7	8.1	
Negative cultures	3.4	7.1	
Others	11.5	14.2	
Staphylococcal resistance			0.6
Methicillin resistant	42.5	39.8	
Methicillin sensitive	36.8	30.8	

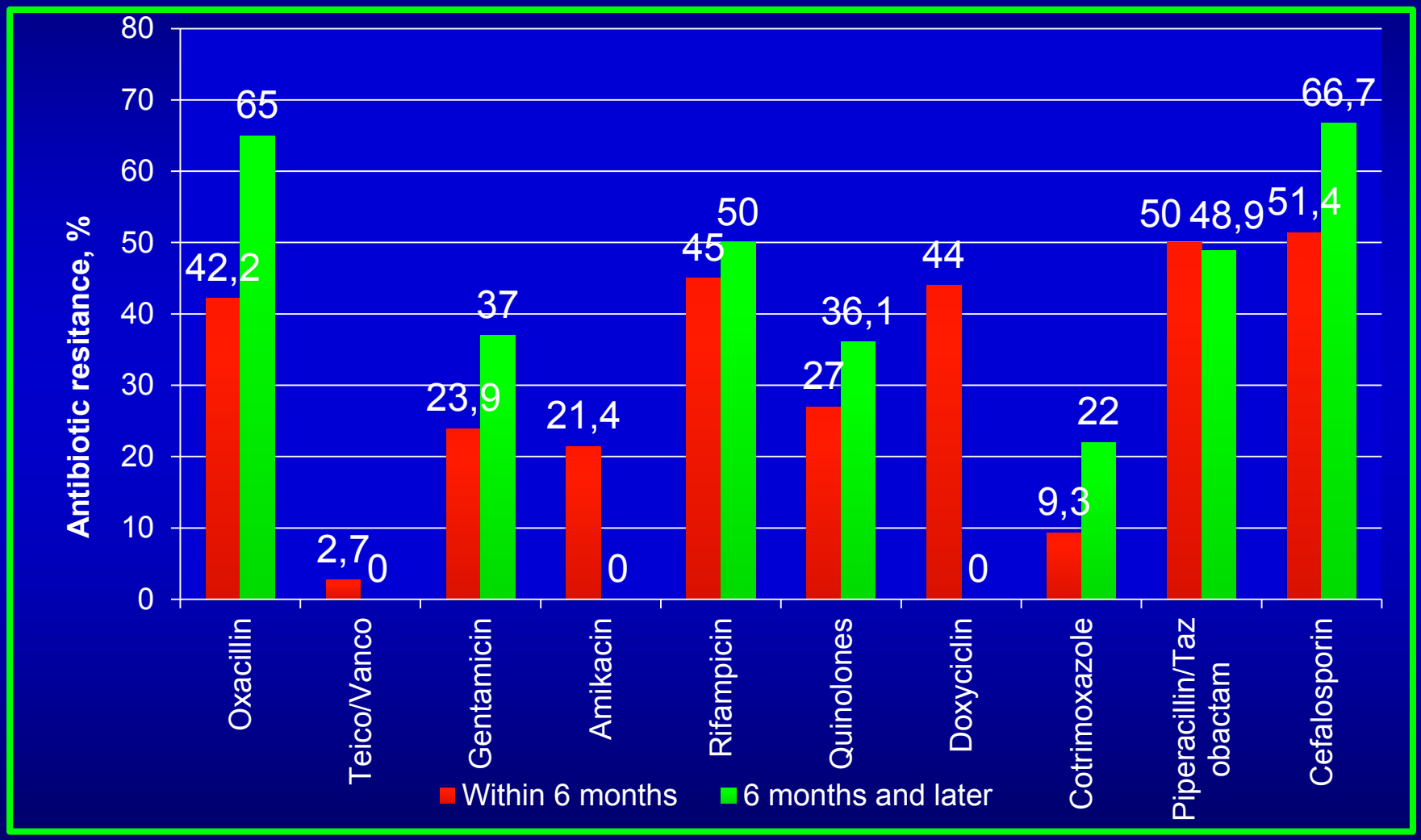
Antibiotics	% Resistant
Oxacillin	69
Teicoplanin/Vancomycin	0
Amikacin	6
Doxicyclin	4
Piperacillin-tazobactam	31
Co-trimoxazole	18
Gentamicin	31
Quinolones	44
Rifampicin	47
Cephalosporins	61

Methicillin-resistant Staph aureus species (MRSA)

Reference	Years	MRSA%
Golzio (*)	2003 - 2009	75
Greenspon (§)	1999 - 2007	67
Uslan (°)	1991 - 2003	4

(*) Golzio, J Cardiovasc Med 2009; 10:693-8
(§) Greenspon, Pacing Clin Electrophysiol 2008; 31:548-53
(°) Uslan, J Am Coll Cardiol 2007; 49:1851-9

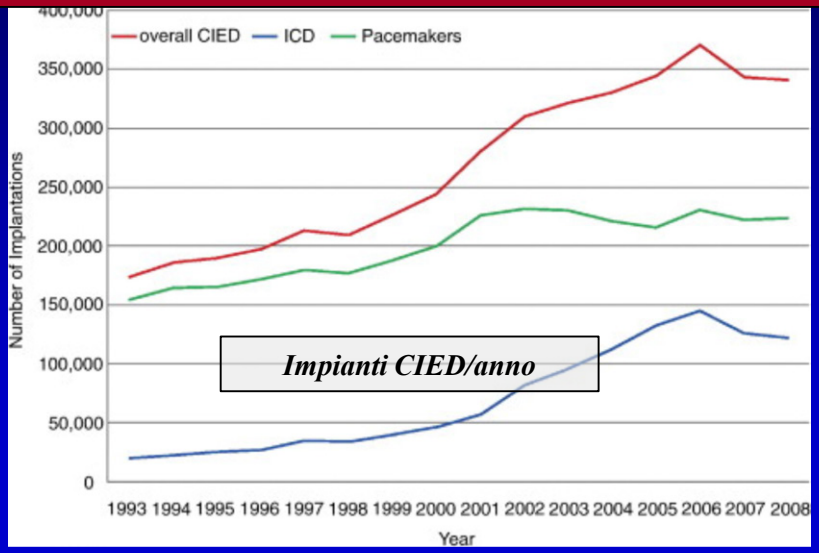
Antibiotic resistance increases with duration of therapy

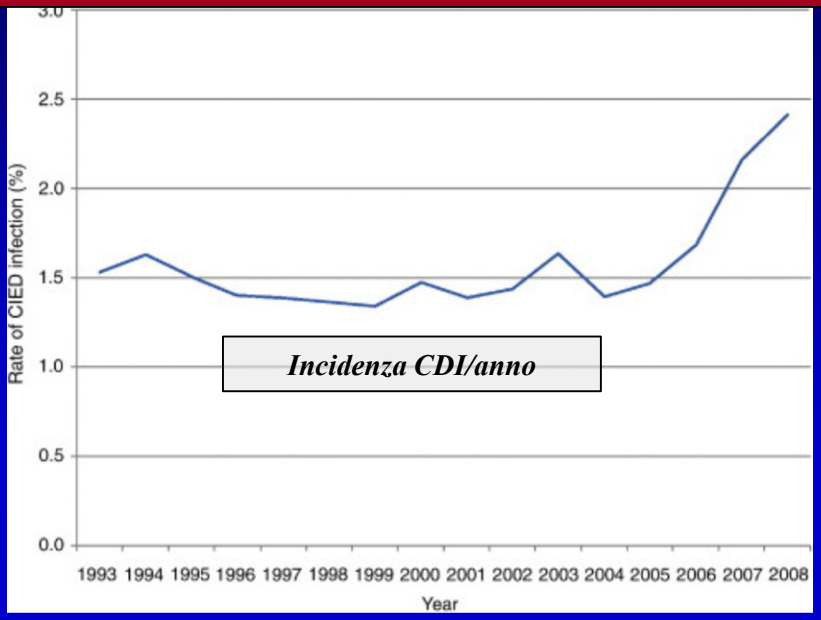


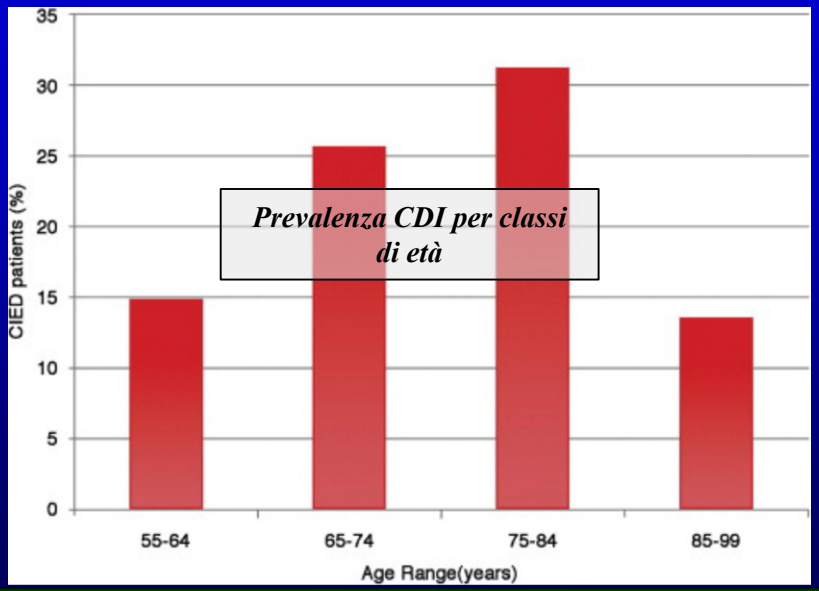
AOU Molinette, 2003-2016, 210 TLE Patients, age 69.6±14,3 years, 153 M

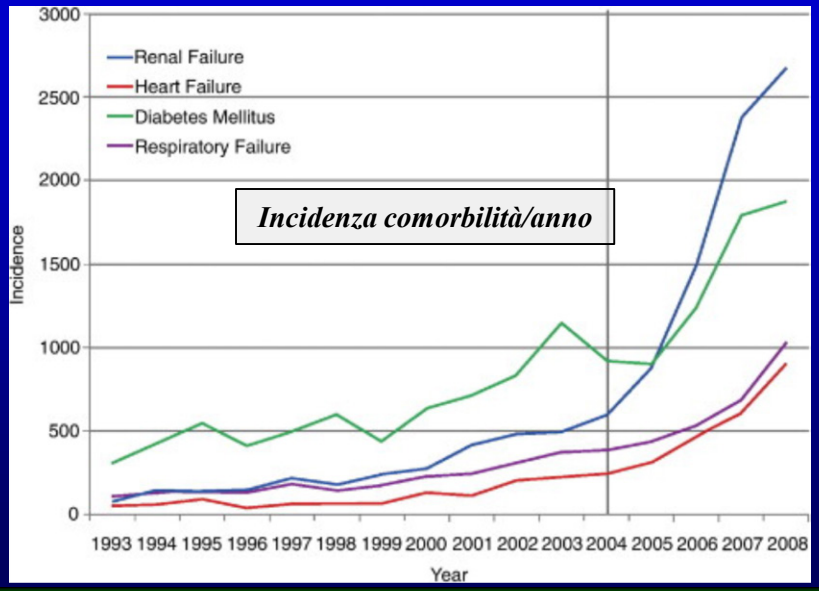
Increase of age and comorbidities

Greenspon, JACC 2011;58:1001-6

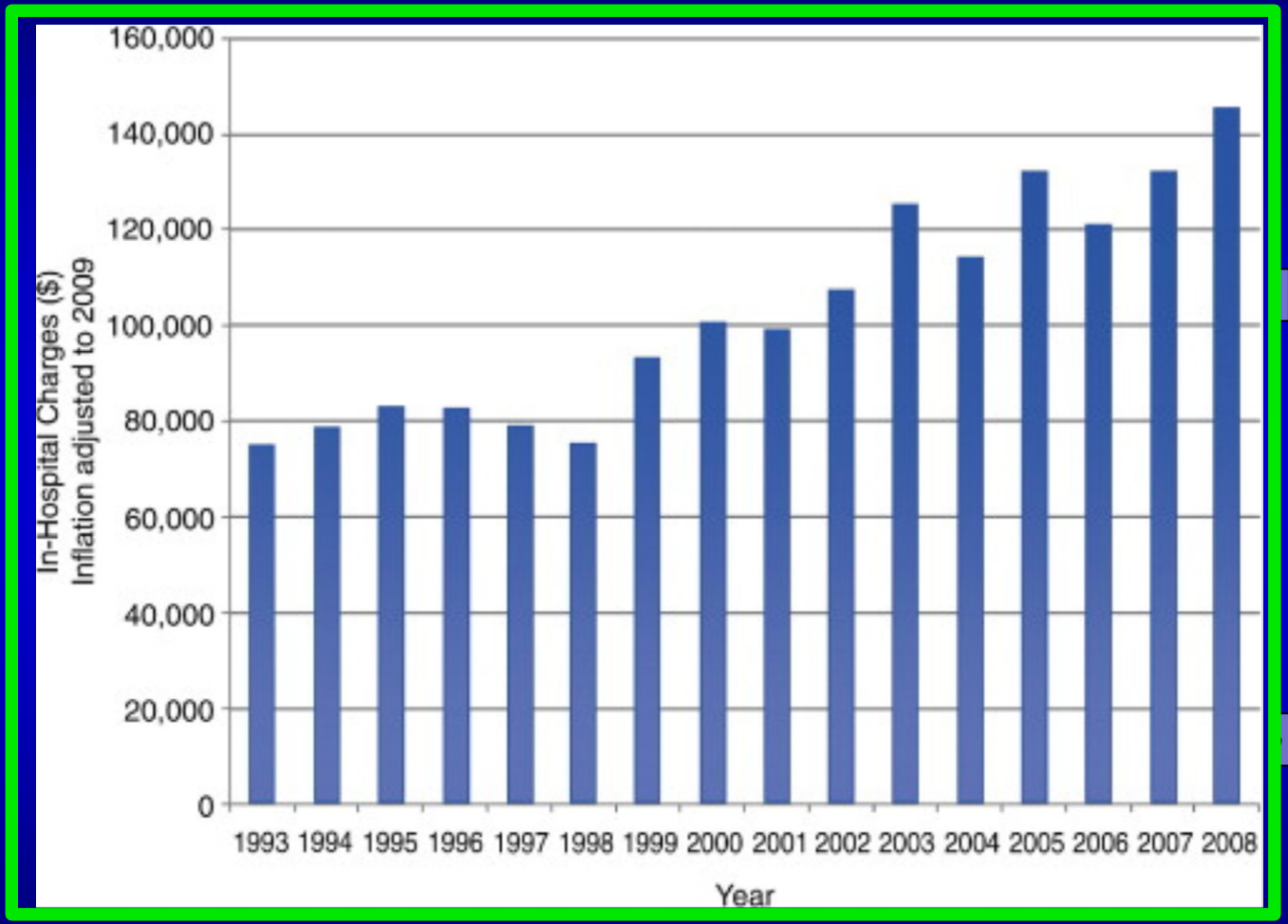






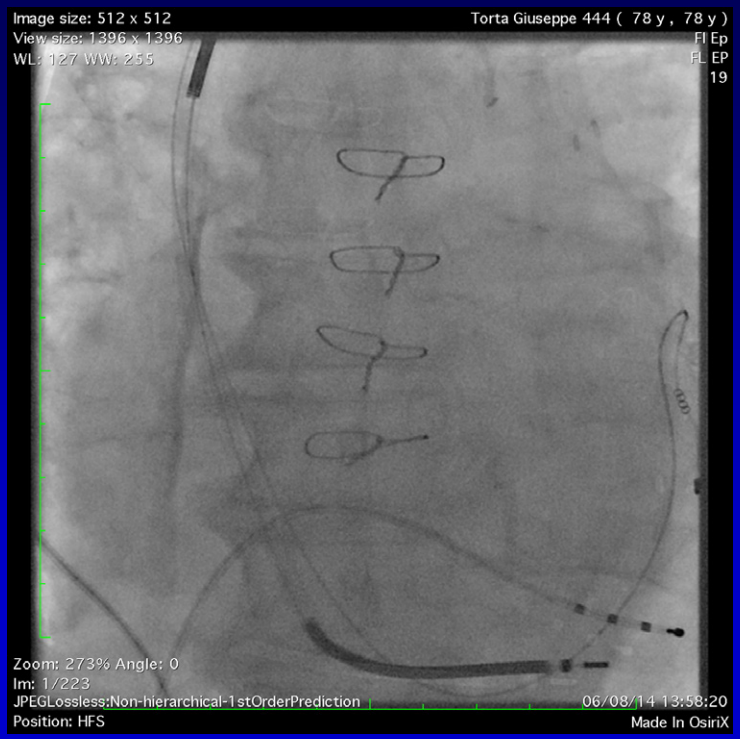


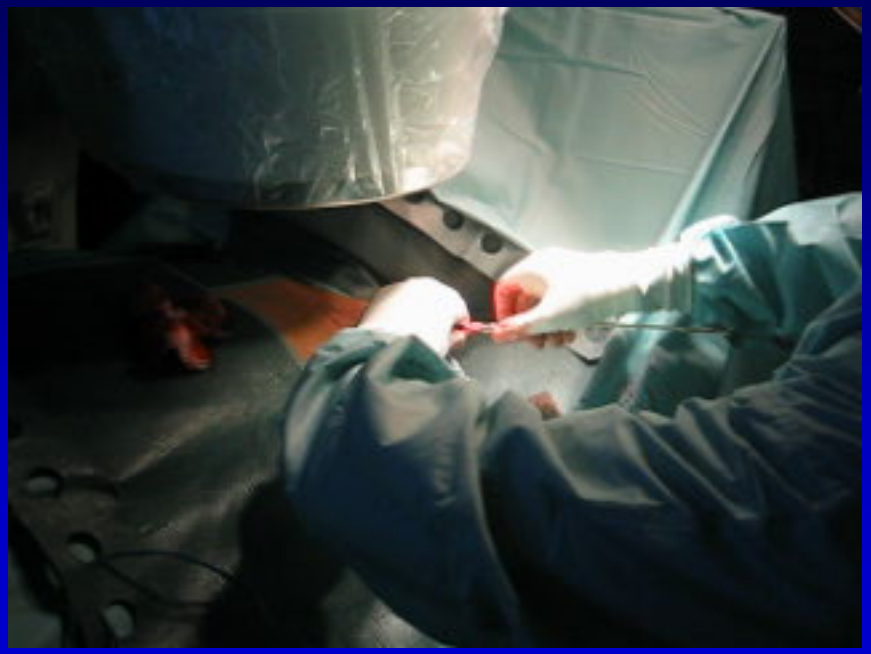
Increase of In-Hospital Charges Associated With CIED Infection



In 1993, in-hospital charges for CIED infection were approximately $75,000 and increased to over $146,000 by 2008, an increase of 47% per decade

Greenspon, JACC 2011;58:1001-6



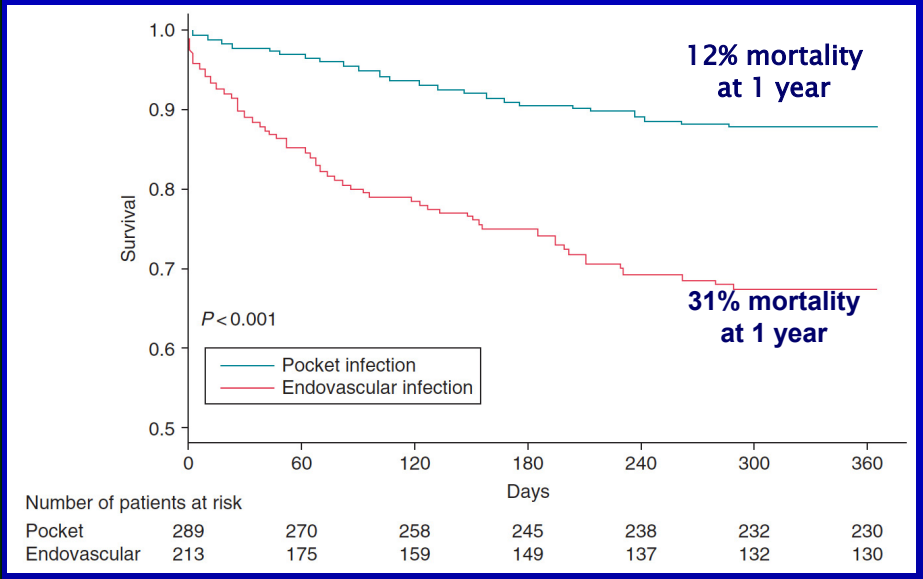


TRANSVENOUS LEAD EXTRACTION (TLE)

"…however, TLE is the mainstay in CDI therapy"

Infection after TLE: rise in Cumulative Mortality

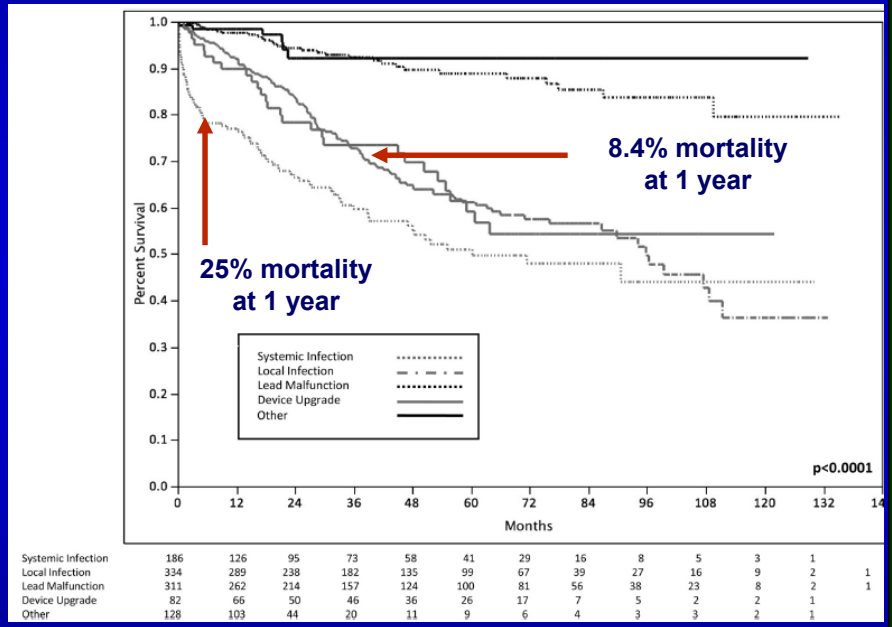
Kaplan–Meier survival curves over 1 year among TV-ICD patients with pocket infection and endovascular infection following TV-ICD system removal



Analysis from Cleveland Clinic evaluated survival in patients who developed a CIED infection and found a 3-fold higher risk of death in those who had an endovascular infection compared to a pocket infection

Tarakji et al; Europace, 2014;16:1490-1495

Kaplan–Meier survival curves according to TV-ICD lead extraction indication



Analysis from Maytin et al demonstrates that in patients referred for lead extraction due to systemic CIED-associated infection, the unadjusted mortality rate approaches 25% within 1 year

Maytin et al; Circ Arrhythm Electrophysiol. 2012;5:252-257

REIMPLANTATION AFTER TLE FOR INFECTION

Why?

What?

When?

Where?

Timing del reimpianto

Principles for CIED Replacement following Infected Removal

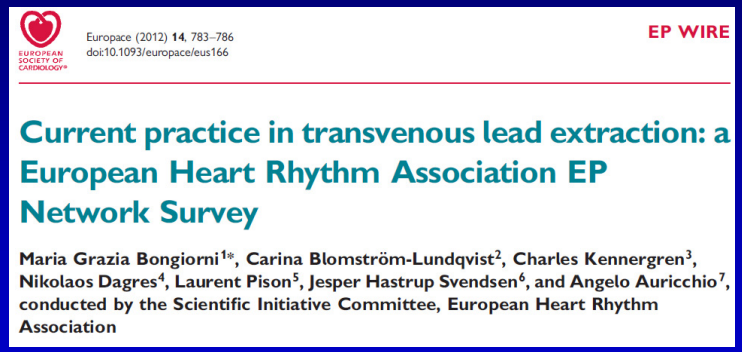
Class IIa

1. A new CIED system can be implanted into patients who have no valvular or lead associated vegetations but preoperative positive blood cultures, when there is no further clinical evidence of systemic infection and the blood cultures drawn within 24 hours of CIED system removal remain negative for at least 72 hours (Level of evidence: C)
2. A new CIED system can be implanted into patients who have no valvular or lead associated vegetations but positive lead tip cultures, when there is no further clinical evidence of systemic infection and the blood cultures drawn within 24 hours of CIED system removal remain negative for at least 72 hours (Level of evidence: C)
3. A new CIED system can be implanted into patients who have no valvular or lead associated vegetations but preoperative sepsis and positive blood cultures, when there is no further clinical evidence of systemic infection and the blood cultures drawn within 24 hours of CIED system removal remain negative for at least 72 hours (Level of evidence: C)
4. It is reasonable to delay transvenous reimplantation of a new CIED system into patients with valvular or lead associated vegetations for at least 14 days after CIED system removal. However there are options to reduce this delay including debridement of the vegetations and epicardial lead implantation. (Level of Evidence: C)

Cleveland Clinic

HRS Lead Extraction Consensus - 2009

Reimplantation after TLE: EHRA Survey



Europace (2012) 14, 783–786
doi:10.1093/europace/eus166

EP WIRE

Current practice in transvenous lead extraction: a European Heart Rhythm Association EP Network Survey

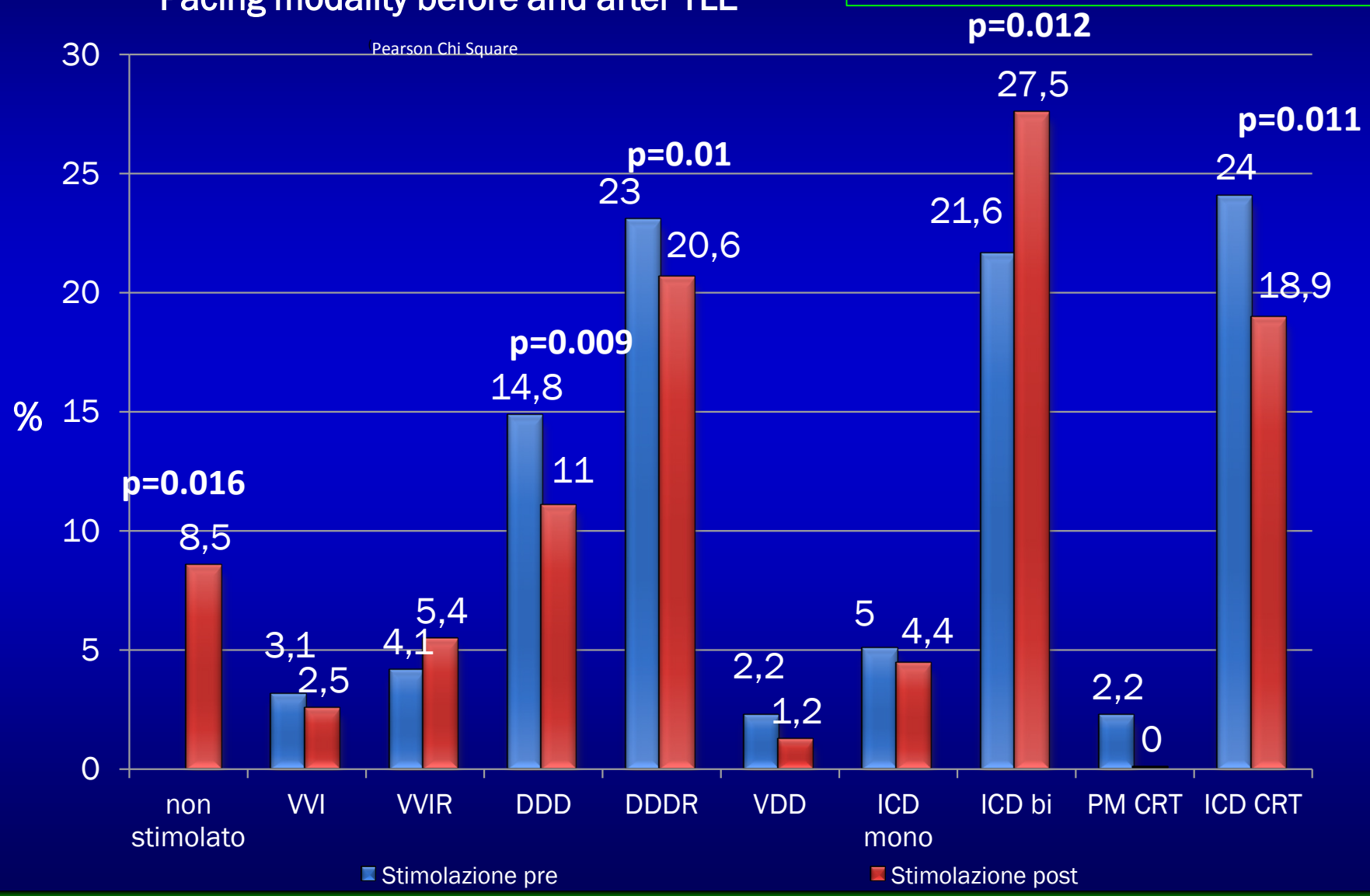
Maria Grazia Bongiorni[1]*, Carina Blomström-Lundqvist[2], Charles Kennergren[3], Nikolaos Dagres[4], Laurent Pison[5], Jesper Hastrup Svendsen[6], and Angelo Auricchio[7], conducted by the Scientific Initiative Committee, European Heart Rhythm Association

- Per i PM:
  - Reimpianto < 85% → 12% dei centri
  - Reimpianto 85 – 94% → 20%
  - Reimpianto > 95% → 68%
- Per gli ICD:
  - Reimpianto > 97% → 60% dei centri
  - Reimpianto 100% → 40%

Bongiorni MG et al. *Europace* 2012; 14, 1666–1669

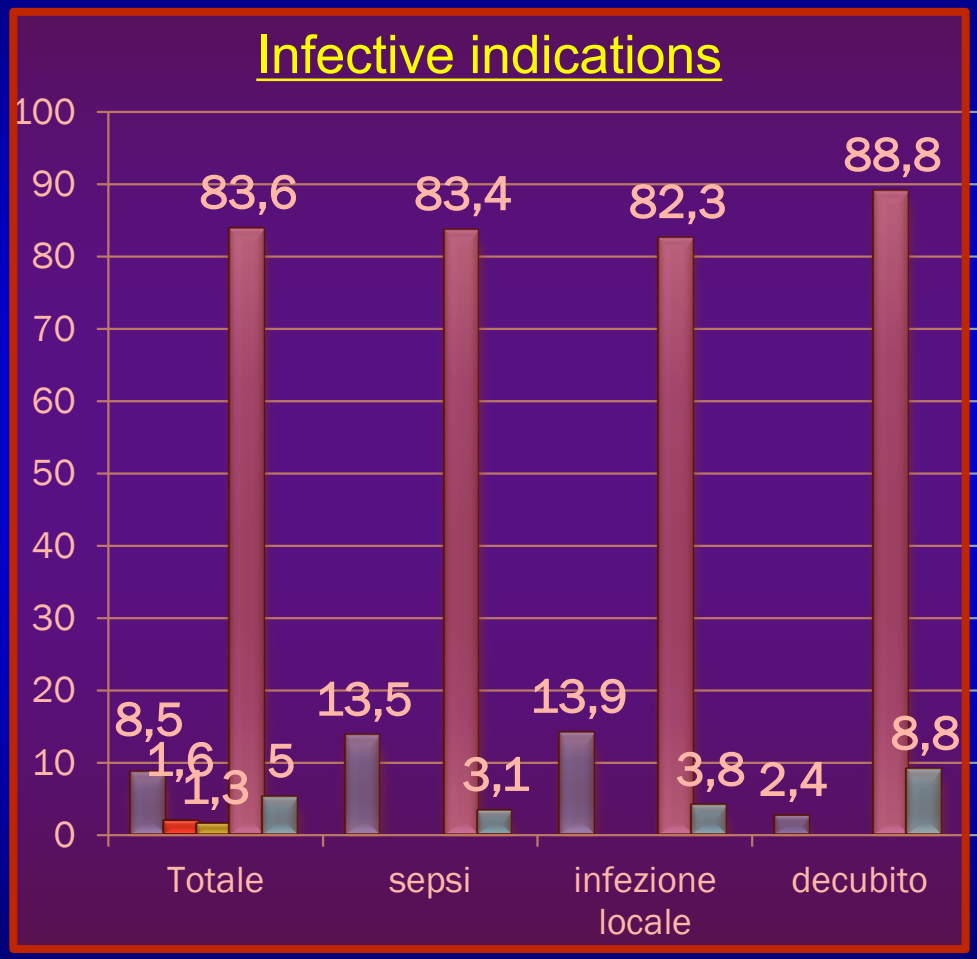
Turin experience

AOU Molinette, 2003-2016, 210 TLE Patients, age 69.6±14,3 years, 153 M,



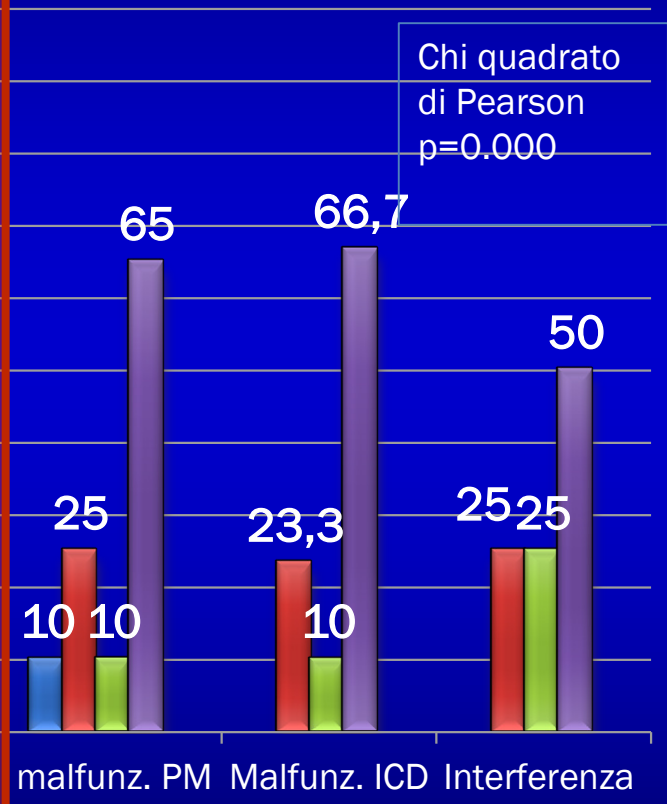
Turin experience

AOU Molinette, 2003-2016,
210 TLE Patients, age
69.6±14,3 years, 153 M,



Momento e sede del reimpianto in rapporto alle indicazioni

Chi quadrato di Pearson p=0.000



non effettuato | contemporaneo, stesso lato | contemporaneo, controlaterale | differito, controlaterale | già reimpiantato

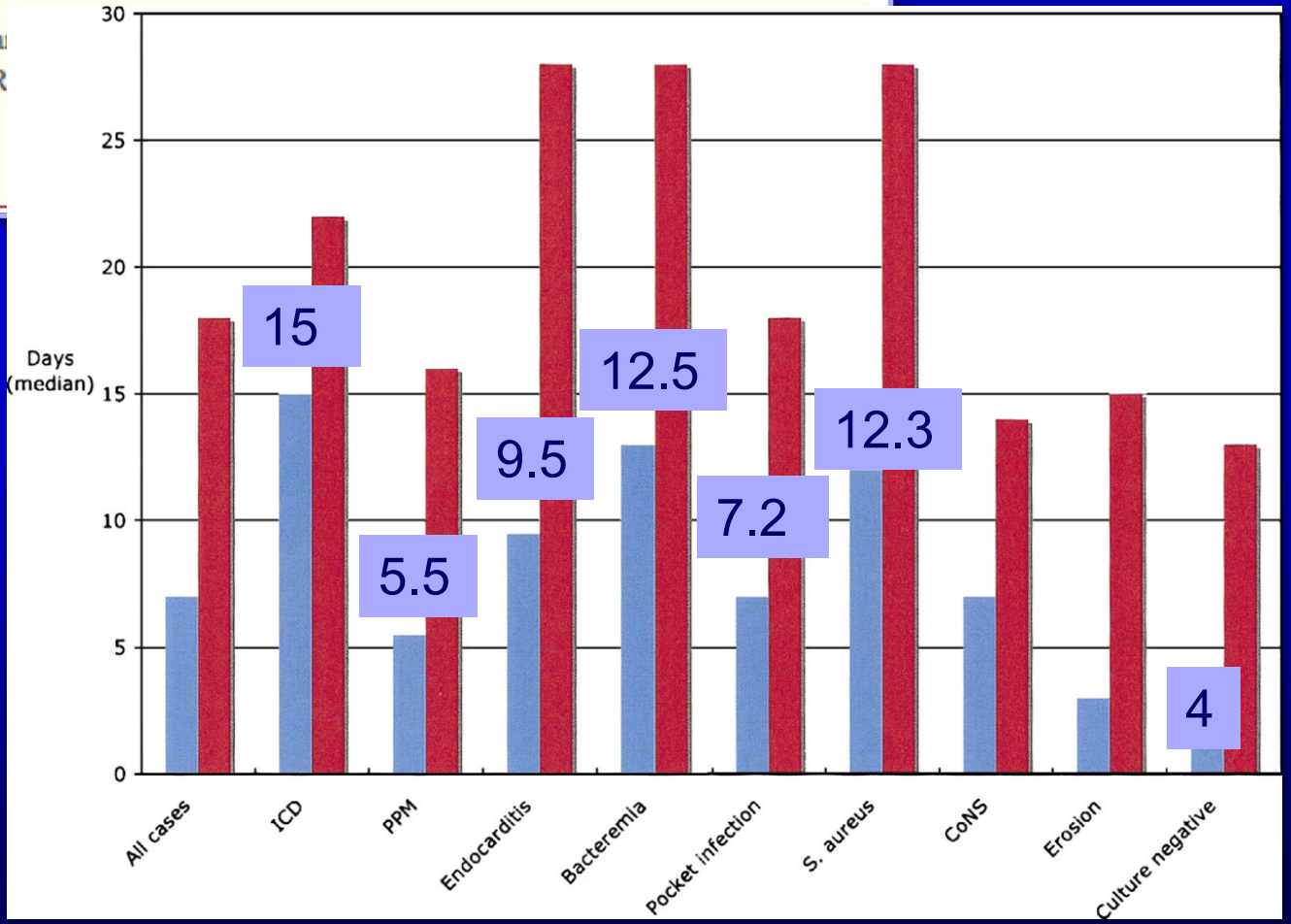
Timing of reimplantation of new cardiac device and duration of post explant antibiotic treatment

Management and Outcome of Permanent Pacemaker and Implantable Cardioverter-Defibrillator Infections

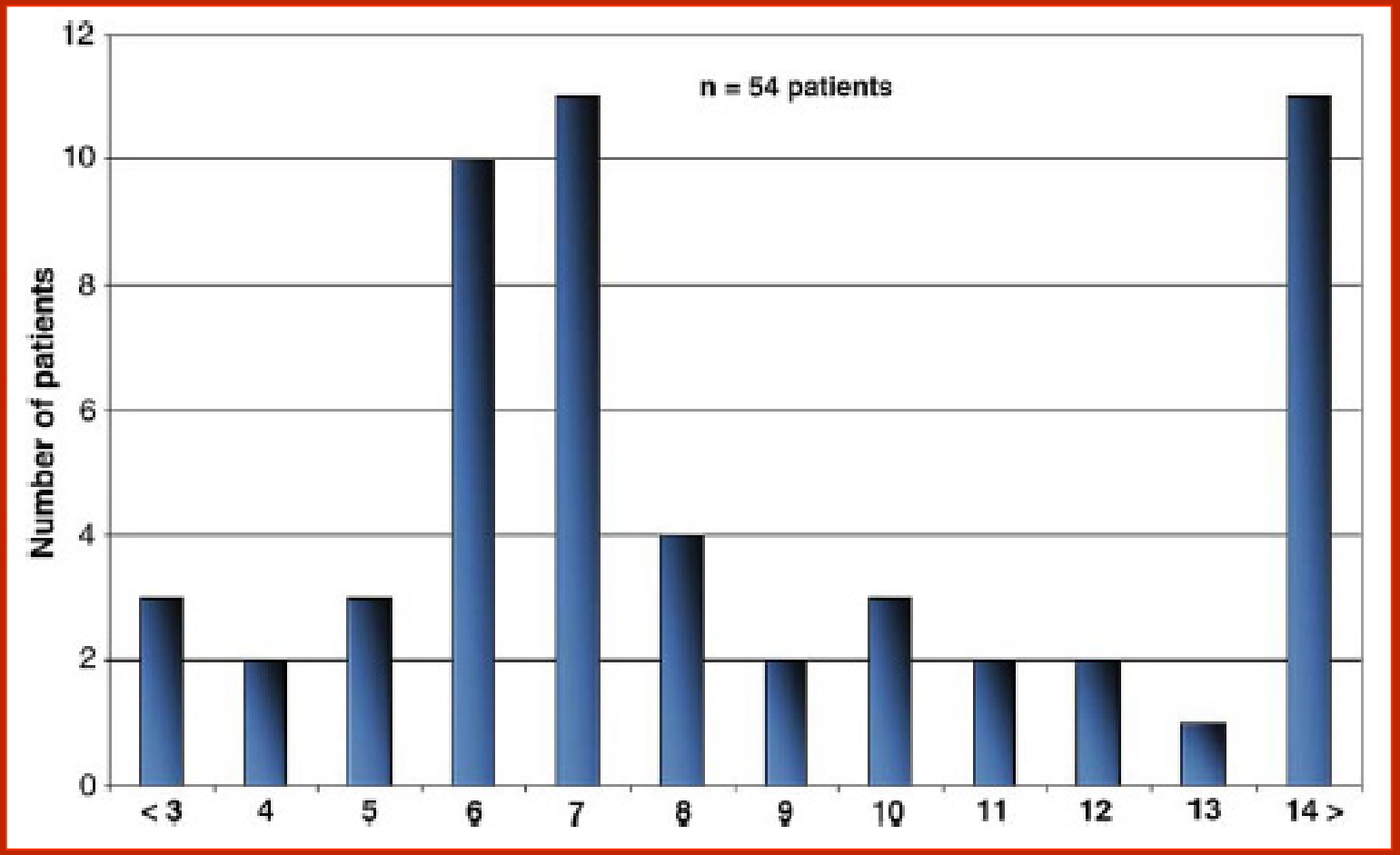
Muhammad R. Sohail, MD,* Da
David L. Hayes, MD,† Walter R
Larry M. Baddour, MD*
Rochester, Minnesota

Sohail MR et al. *J Am Coll Cardiol* 2007;49:1851–9

- Blue bars: time from explant to reimplant
- Red bars: post explant antibiotic duration



Time delay (days) to reimplantation patients with lead vegetations



AOU Città della Salute experience

Infectious patients with and w/out vegetations and time before reimplantation

	Whole population	Vegetations	No vegetations	P value
	N=136	N=55	N=81	
Time before reimplantation (days)	2.6±1.8 (0-8)	4.4±1.6 (1-8)	1.7±0.6 (0-4)	0.000
Duration of hospital stay (days)	12.8±9.1 (6-45)	21.6±8.2 (6-45)	6.8±1.8 (6-14)	0.000
Follow up, months	45.3±27.0 (4-108)	37.7±25.2 (4-104)	50.6±27.1 (6-108)	0.006
Antibiotic therapy, months	0.99±1.01 (0.33-9)	1.6±1.4 (0.5-9)	0.6±0.2 (0.33-2)	0.000

Interim analysis on first 181 patients, 396 leads

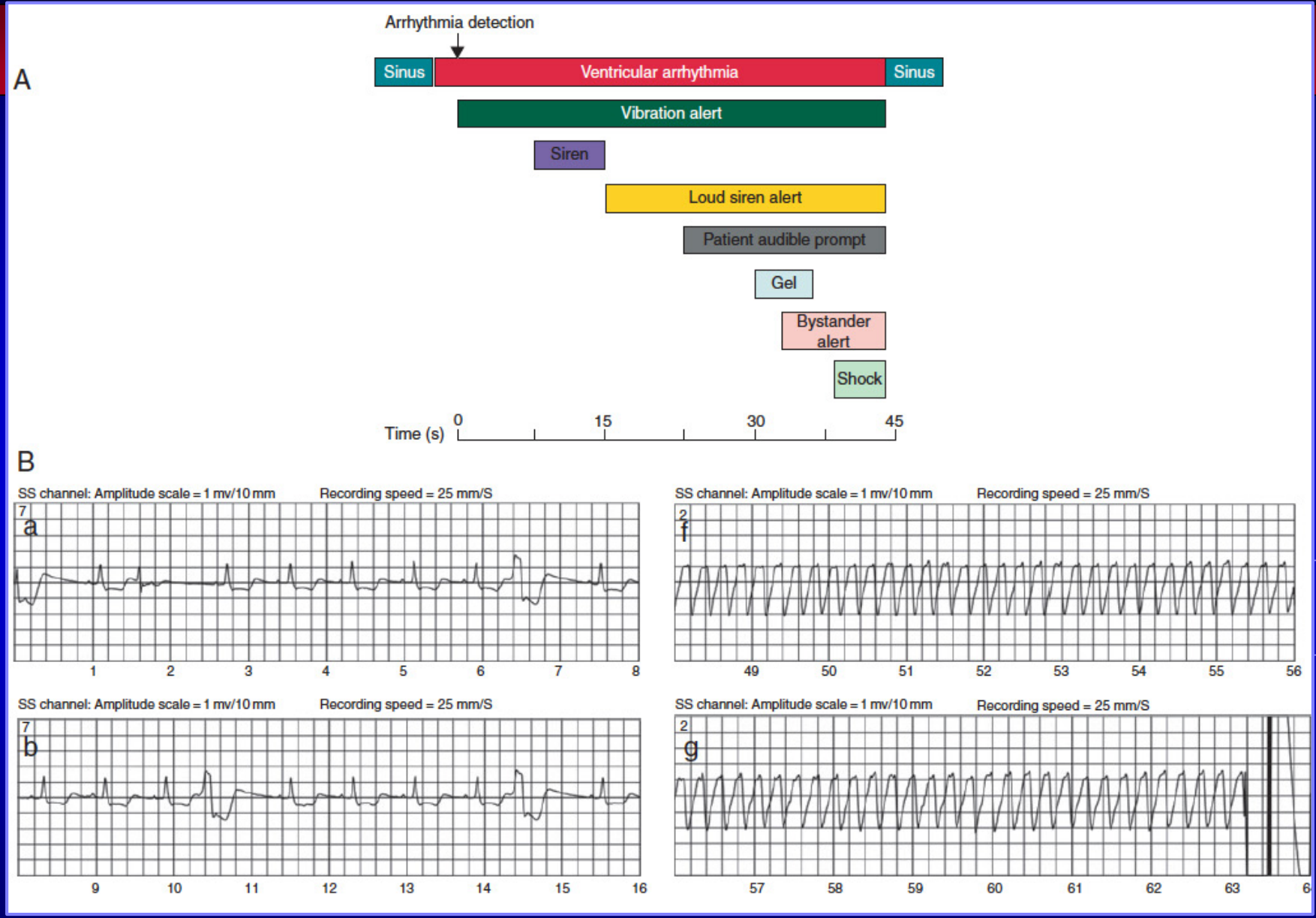
In cases of "continued need" of device reimplantation after TLE…

- Indication to transvenous ICD reimplantation, but impossibility to perform within a short, inhospital period

  → Wearable Cardioverter Defibrillator (WCD)

- High infection risk, young age, primary prevention, venous occlusion, no need for permanent pacing or ATP

  → Subcutaneous Implantable Cardioverter Defibrillator (S-ICD)



Audio alerts after the treatment sequence is initiated

Study	N. pts	Inclusion criteria	Design	Mian findings
Auricchio, 1998	10	EPS for VT/VF	Observational	10/10 episodes of induced VT/VF were successfully terminated with first 230 J monophasic shock i
Reek, 2003	12	EPS for VT/VF	Observational	22/22 episodes of induced VT/VF were successfully erminated with first 70 J or 100 J biphasic shock in12 Pts
Friedman, 2004	289	WEARIT: heart failure NYHA III/IV BIROAD: high risk after MI/CABG	Prospective cohort study	6/8 episodes of spontaneous VT/VF were successfullyterminated during mean FU of up to 4 months
Klein, 2010	354	High risk after MI/CABG, Pts awaiting HTX, ICD explant + delayedimplant, risk stratification	Retrospective, registry data	20/21 VT/VF episodes were successfully terminated by first shock during a mean wear time of 3 months
Chung, 2010	3569	Various indications according to CMS coverage	Retrospective, registry data	Compliance was high, and SCD mortality was low during WCD use comparable to that of ICD Pts; 79/80VT/VF episodes were successfully terminated by first shock during a mean wear time of 53 days
Rao, 2011	162	CSHD, IAS	Prospective observational, registry data	WCD can be safely used in high-risk adults with CSHD and IAS; 3 VT/VF episodes were successfully terminated by the first shock during a mean wear time of 29 days
Saltzberg, 2012	266	PPCM/NICM	Retrospective, registry data	No arrhythmic events and low mortality rate in Pts with PPCM

Study	N. pts	Inclusion criteria	Design	Mian findings
Zishiri, 2012	809	Pts after CABG/PCI with LVEF ≤ 35%	Prospective observational, registry data	WCD use was associated with lower short- and long-term mortality than no WCD use in high-risk Pts after CABG or PCI; 12/18 (1.3% event rate) VT/VF episodes were successfully terminated
Epstein, 2013	845	Recent MI with LVEF ≤ 35%	Retrospective, registry data	22/22 episodes of induced VT/VF were successfully erminated with first 70 J or 100 J biphasic shock in12 Pts
Dunker, 2014		PPCM	Prospective cohort study	Four episodes of VF were successfully terminated by the first WCDshock in 3/7 Pts during mean wear time of 81 days
Kutyifa, 2015	2000	High risk ICM, NICM, CSHD/IAS	Prospective observational, registry data	VT/VF event rates of 3% in ICM and CSHD/IA, respectively, and 1% in NICM during mean wear time of 3 months; 30/30 episodes of spontaneous VT/VF successfully terminated by the first shock
Singh, 2015	525	Newly diagnosed ICM and NICM	Prospective observational, registry data	Very low arrhythmic risk in Pts with NICM, 2.2% of ICM Pts received appropriate shock for VF

WCD, wearable cardioverter-defibrillator; Pts, patients; EPS, electrophysiological study; VT, ventricular tachycardia; VF, ventricular fibrillation; WEARIT,Wearable Cardioverter Defibrillator Investigational Trial; BIROAD, Bridge to ICD in Patients at Risk of Sudden Arrhythmic Death, NYHA, New York Heart Association functional class, MI, myocardial infarction, CABG, coronary artery bypass surgery; HTX, heart transplantation; ICD, implantable cardioverter-defibrillator; CMS, Centers for Medicare & Medicaid Services; SCD, sudden cardiac death; FU, follow-up; CSHD, congenital structural heart disease; IAS, inherent arrhythmia syndromes; PPCM, peripartum cardiomyopathy; NICM, non-ischaemic cardiomyopathy; ICM, ischaemic cardiomyopathy

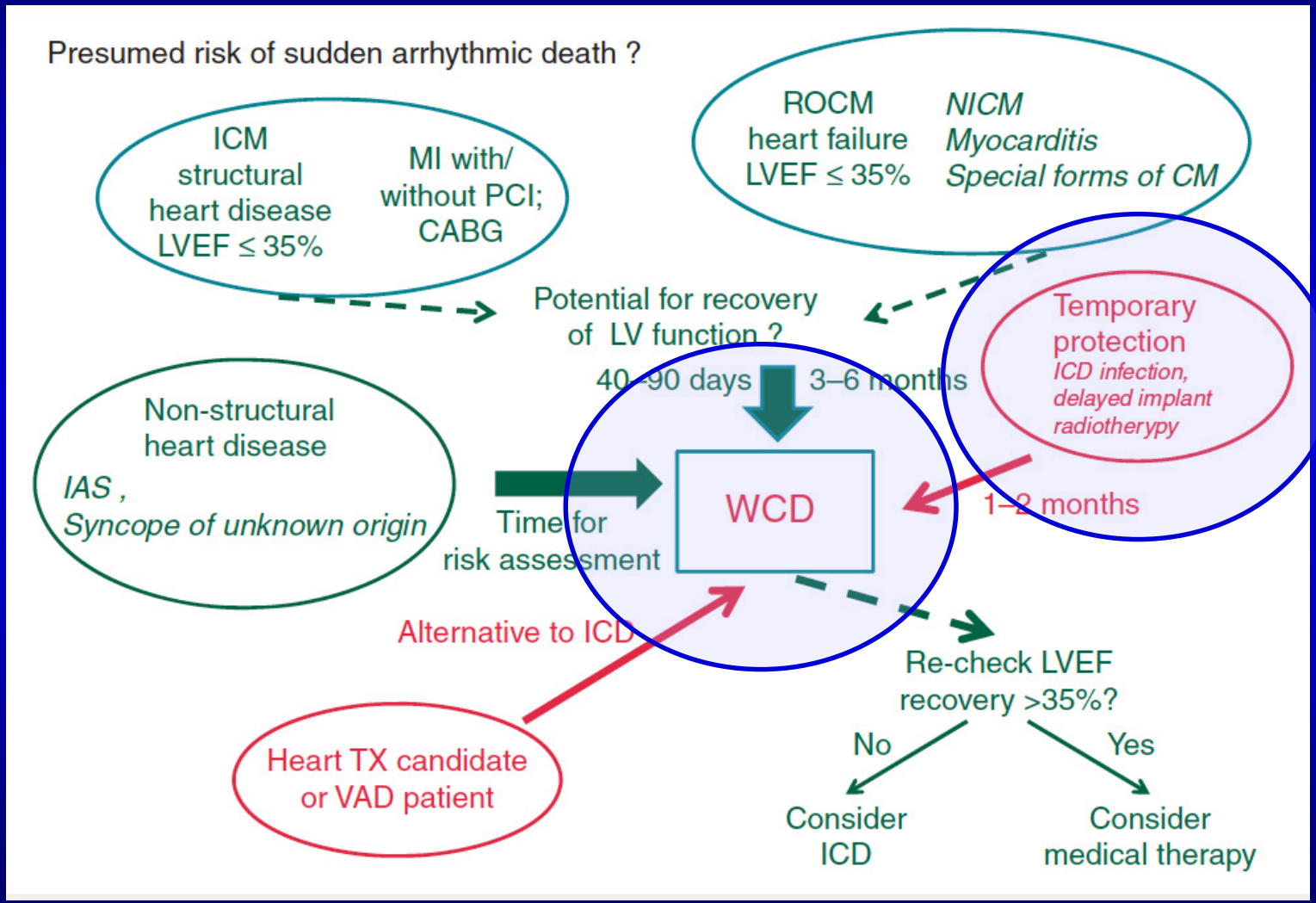
Wearable cardioverter defibrillator according to Guidelines

Wearable cardioverter defibrillator

Recommendation	Class[a]	Level[b]
The WCD may be considered for adult patients with poor LV systolic function who are at risk of sudden arrhythmic death for a limited period, but are not candidates for an implantable defibrillator (e.g. bridge to transplant, bridge to transvenous implant, peripartum cardiomyopathy, active myocarditis and arrhythmias in the early post-myocardial infarction phase).	IIb	C

Priori S et al. *European Heart Journal* 2015; 36, 2793–2867

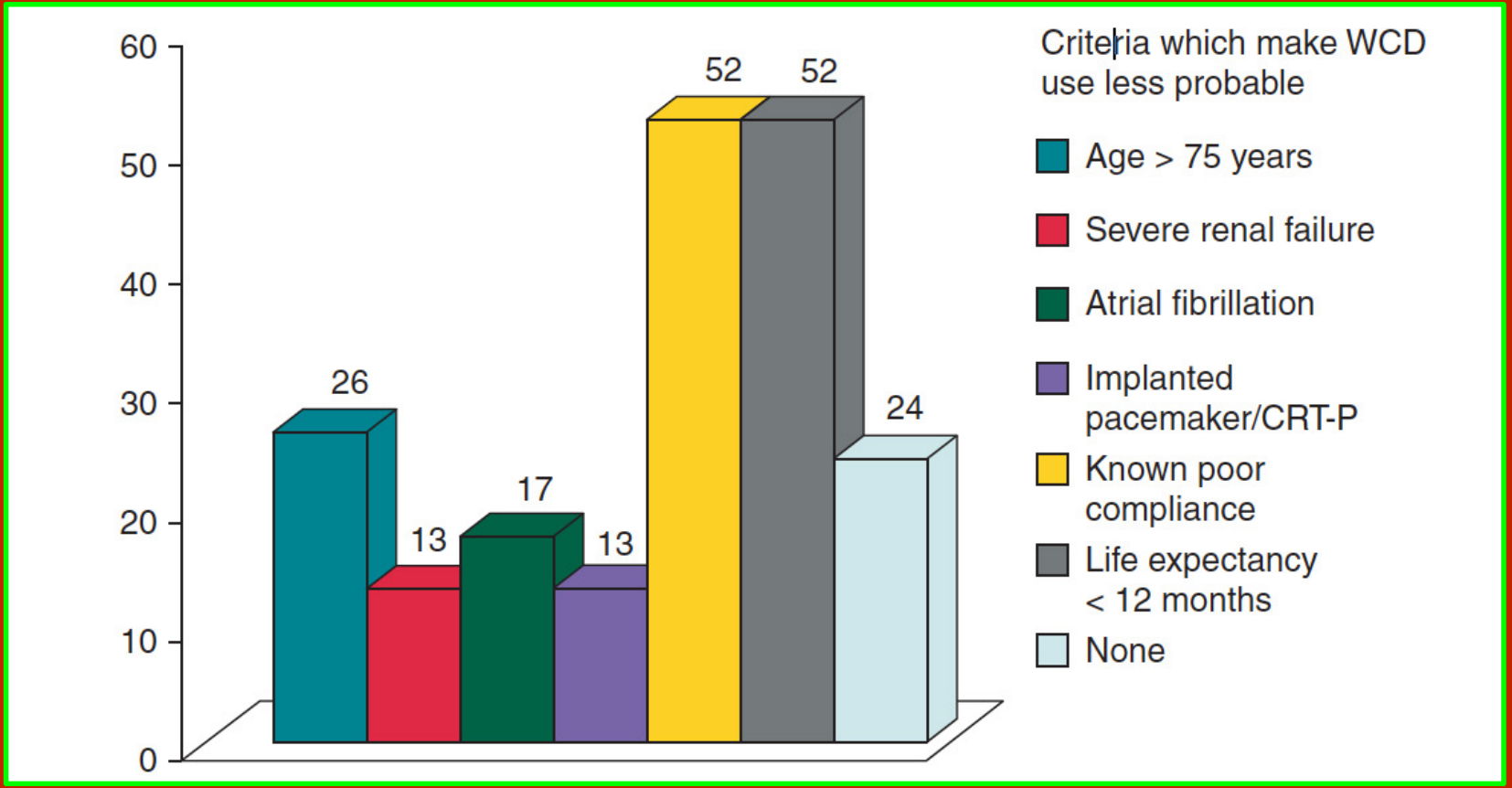
Decision-making algorithm for W-ICD



Reek S et al. Europace Advance Access published October 4, 2016

Wearable cardioverter defibrillator in clinical practice: EHRA Survey 2016

Criteria which made W-ICD use less probable



Lenarczyk R et al. *Europace* 2016; 18, 146–150

WCD after ICD removal for CDI

Compliance of patients (average hours of daily wear)

Mortality: no patient was wearing the WCD

Age/Sex	Days Used/ Average Daily Hour Wear Time	Cause	Location of Death
65/M	88 days/10.6 hours	Septic shock from infection secondary to leg surgery	Hospital
75/F	Prescribed but died before leaving the hospital	Septic shock	Hospital
71/M	Prescribed but died before leaving the hospital	VF	Hospital
60/M	155 days/19.6 hours	Unknown	Home
67/F	47 days/23.1 hours	Bacteremia	Hospital
68/F	Prescribed but died before leaving the hospital	Intracranial bleed	Hospital
64/M	26 days/20.6 hours	Unknown	Home
69/F	8 days/20.6 hours	Unknown	Home

while hospitalized

Cost effectiveness of WCD after TLE for infection

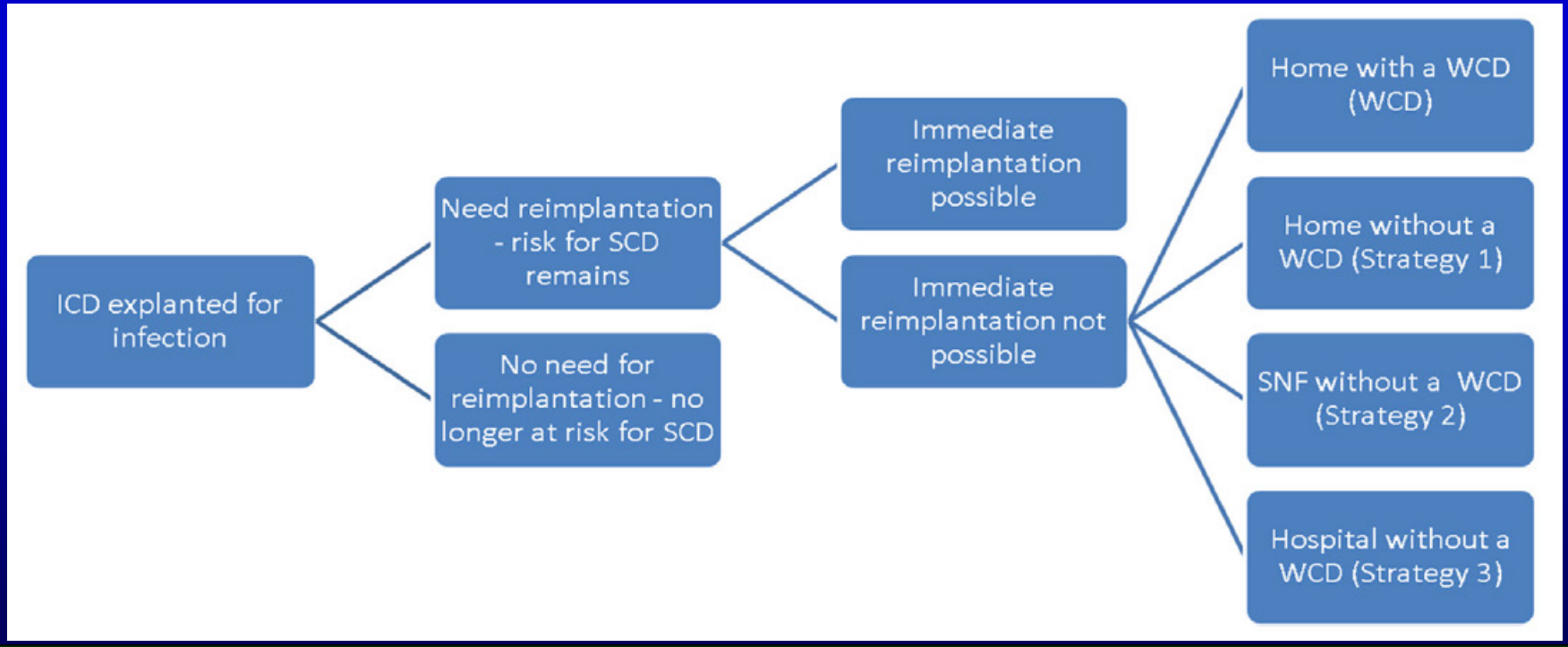
Wearable cardioverter-defibrillator for prevention of sudden cardiac death after infected implantable cardioverter-defibrillator removal: A cost-effectiveness evaluation

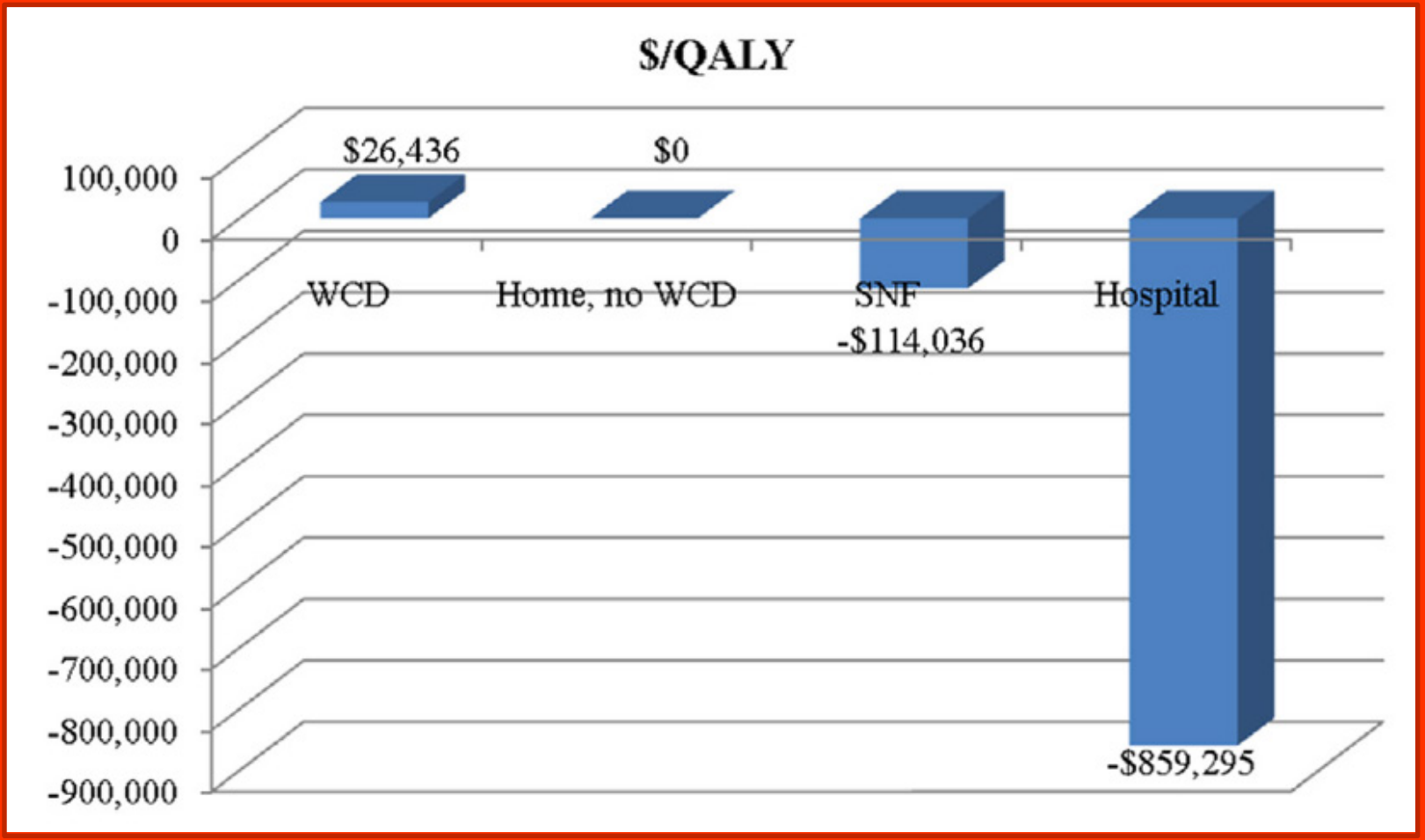
Christopher A. Healy, MD,* Roger G. Carrillo, MD, FHRS†

*From the *Division of Cardiology, University of Miami Miller School of Medicine, Miami, Florida and †Division of Cardiothoracic Surgery, University of Miami Miller School of Medicine, Miami, Florida.*

Healy CA et al. *Heart Rhythm* 2015;12:1565–1573

Treatment strategies after implantable cardioverter-defibrillator (ICD) extraction for infection.





The incremental cost- effectiveness of the WCD strategy was$20,300 pe rlife-year (LY) or $26,436 per quality-adjustedlife-year (QALY) compared to discharge home without a WCD. Discharge to a skilled nursing facility and in-hospital monitoring resulted in higher costs and worse clinical outcome. The WCD strategy remained cost-effective, assuming 5.6% 2-month SCA risk, as long as the time to reimplantation was at least 2 weeks.

WCD - Summary

- The WCD is a useful tool that safely terminates ventricular tachyarrhythmias with high clinical success. Approximately 1–2% patients per month receive an appropriate shock, with <1% of inappropriate shocks due to advanced detection criteria and the alert system that allows patients to withheld therapy.
- The main indication for WCD is as a bridge to ICD implantation (infection, before heart transplantation or LVAD implant) or to manage a temporarily increased risk for SCD until the arrhythmic risk subsides

Reek S et al. *Europace* Advance Access, October 4, 2016
doi:10.1093/europace/euw180

WCD - Summary

- A major limitation is the lack of prospective, randomized trials. Therefore, the guidelines are quite general and mainly based on expert opinion.
- The clinical value of the WCD must be measured not only by the number of terminated arrhythmic events, but also by the number of prevented unnecessary ICD implantations.

Reek S et al. *Europace* Advance Access, October 4, 2016
doi:10.1093/europace/euw180

Subcutaneous implantable cardioverter defibrillator (S-ICD)

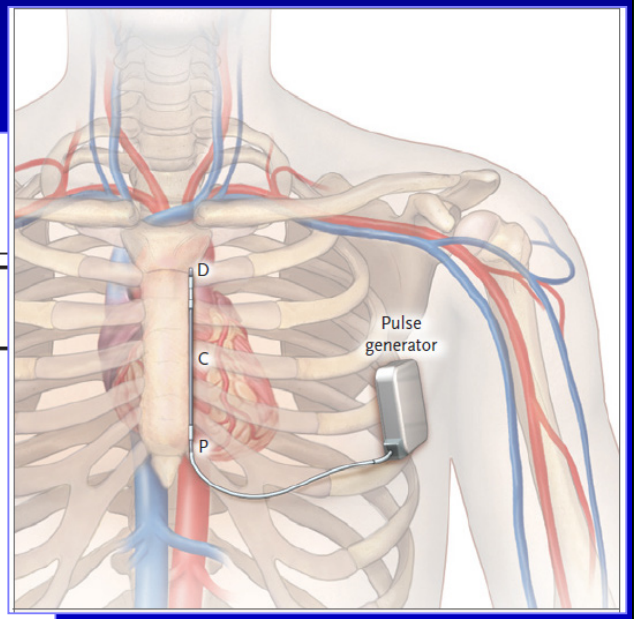
Bardy GH et al. *NEJM* 2010; 363: 36-44

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

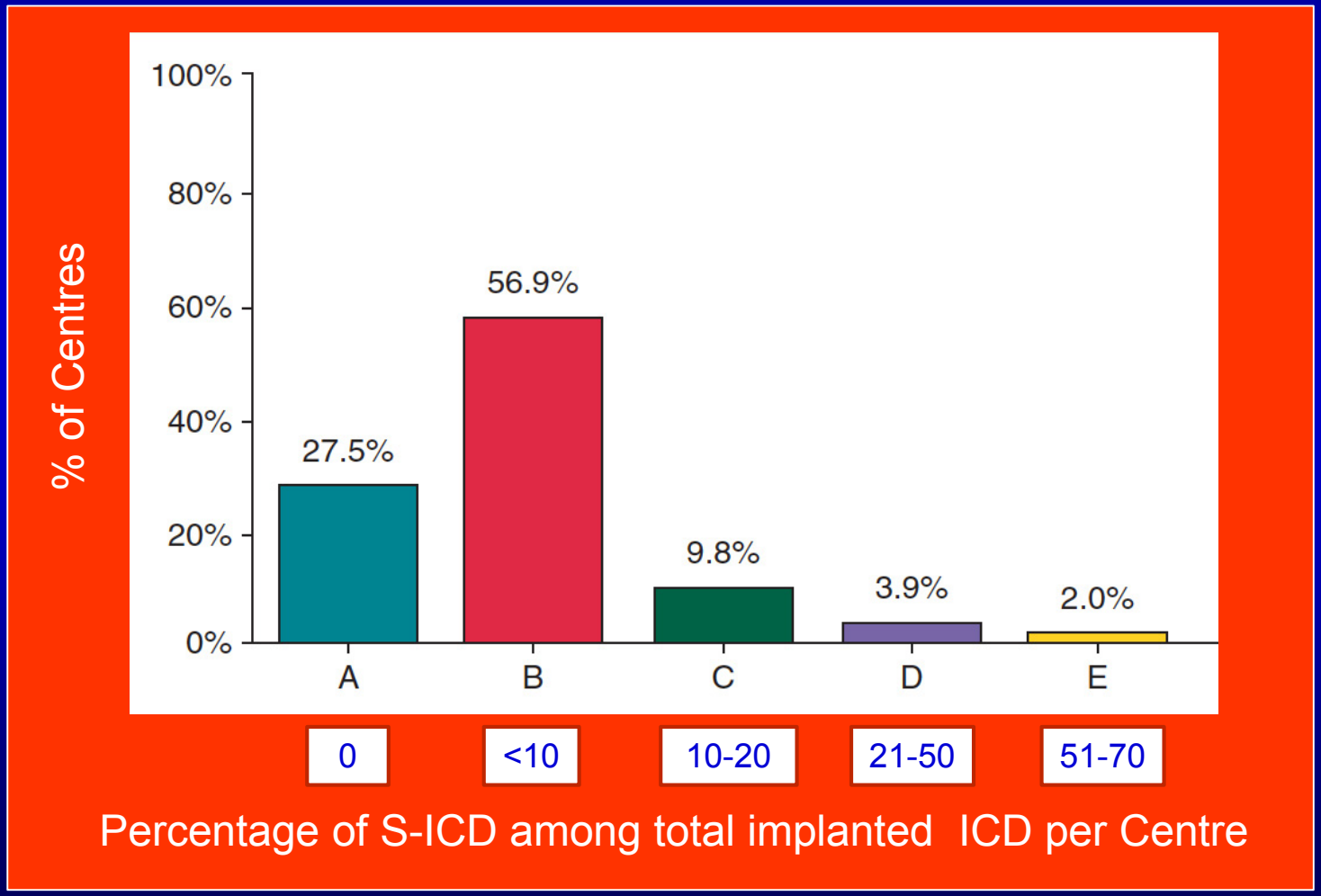
An Entirely Subcutaneous Implantable Cardioverter–Defibrillator

Gust H. Bardy, M.D., Warren M. Smith, M.B., Margaret A. Hood, M.B., Ian G. Crozier, M.B., Iain C. Melton, M.B., Luc Jordaens, M.D., Ph.D., Dominic Theuns, Ph.D., Robert E. Park, M.B., David J. Wright, M.D., Derek T. Connelly, M.D., Simon P. Fynn, M.D., Francis D. Murgatroyd, M.D., Johannes Sperzel, M.D., Jörg Neuzner, M.D., Stefan G. Spitzer, M.D., Andrey V. Ardashev, M.D., Ph.D., Amo Oduro, M.B., B.S., Lucas Boersma, M.D., Ph.D., Alexander H. Maass, M.D., Isabelle C. Van Gelder, M.D., Ph.D., Arthur A. Wilde, M.D., Ph.D., Pascal F. van Dessel, M.D., Reinoud E. Knops, M.D., Craig S. Barr, M.B., Pierpaolo Lupo, M.D., Riccardo Cappato, M.D., and Andrew A. Grace, M.B., Ph.D.



Subcutaneous implantable cardioverter defibrillator (S-ICD): EHRA Survey

Boveda S et al. Europace (2016) 18, 1434–1439



S-ICD in patients explanted for infection

Infection and mortality after implantation of a subcutaneous ICD after transvenous ICD extraction

Lucas Boersma, MD, PhD,[*] Martin C. Burke, DO,[†] Petr Neuzil, MD, PhD,[‡] Pier Lambiase, MD, PhD,[§] Ted Friehling, MD,[‖] Dominic A. Theuns, PhD,[¶] Fermin Garcia, MD,[#] Nathan Carter,[**] Timothy Stivland,[**] Raul Weiss, MD,[††] on behalf of the EFFORTLESS and IDE Study Investigators

Boersma L et al. *Heart Rhythm* 2016;13:157–164

METHODS. Patients in the S-ICD IDE Study and EFFORTLESS Registry with a prior TV-ICD explantation, as well as those with no prior implantable cardioverter-defibrillator (ICD), were included.

- 3 groups:
  - implanted with the S-ICD after TV-ICD extraction for system-related infection (n = 75);
  - implanted after TV-ICD extraction for reasons other than system-related infection (n = 44);
  - and patients with no prior ICD (de novo implantations, n = 747).

S-ICD in patients explanted for infection

Boersma L et al. *Heart Rhythm* 2016;13:157–164

Reasons for TV-ICD explantation N(%)

Primary indication for TV-ICD explantation	S-ICD reimplantation after TV-ICD extraction
Infection	75 (63.0)
End of battery life	5 (4.2)
Lead fracture/failure/advisory	30 (25.2)
Device malfunction	1 (0.8)
Thrombus on lead	8 (6.7)
Total	119 (100)

Complication rates according to patient cohort

Complication	Prior TV-ICD infection	Prior TV-ICD no infection	De novo S-ICD	P value
All	10.7%	6.8%	9.6%	0.78
Device system infection	1.3%	4.5%	1.6%	0.34
Erosion	1.3%	2.3%	1.2%	0.83
Incision/superficial infection	0	0	0.4%	0.79

Comparison with infection rates of randomized controlled trials and registries

Arrhythmias and sudden death

openheart

A systematic review of ICD complications in randomised controlled trials versus registries: is our 'real-world' data an underestimation?

Vivienne A Ezzat, Victor Lee, Syed Ahsan, Anthony W Chow, Oliver Segal, Edward Rowland, Martin D Lowe, Pier D Lambiase

Total pooled complication rate from the RCTs (excluding inappropriate shocks) was **9.1%**, including displacement 3.1%, haematoma 1.2% and pneumothorax 1.1%.

NCDR ICD,
Years 2006-2010,
356 515 implants, statistically significant threefold lower total major complication rate of **3.08**% with lead displacement 1.02%, haematoma 0.86% and pneumothorax 0.44%.

Incidence rof infections in RCTs: 1.5%
Years 1999-2013; 18 RCTs, 6433 patients, mean follow-up 3 months-5.6 years.

	Patients, n	All events, n (%)	Infection, n (%)
Calkins *et al*[23]	71	2 (2.8)	0
Deisenhofer *et al*[24]	92	10 (10.9)	0
Kron *et al*[8]	539	68 (12.6)	14 (2.6)
Bänsch *et al*[25]	50	14 (28)	2 (4.0)
Moss *et al*[26]	742	18 (2.4)	5 (0.7)
Vollman *et al*[27]	542	64 (11.8)	–
Bänsch *et al*[28]	102	20 (19.6)	–
Bokhari *et al*[29]	60	21 (35)	3 (5.0)
Hohnloser *et al*[30]	310	25 (8.1)	–
Kadish *et al*[11]	229	13 (5.7)	1 (0.4)
Bänsch *et al*[31]	190	3 (1.6)	–
Reddy *et al*[32]	128	0	0
Almendral *et al*[10]	334	30 (9.0)	4 (1.2)
Russo *et al*[33]	1530	71 (4.6)	–
Steinbeck *et al*[7]	415	76 (18.3)	–
Kuck *et al*[34]	107	15 (14.0)	1 (0.9)
Varma *et al*[35]	1339	81 (6.0)	–
Cheng *et al*[36]	16	1 (6.3)	–
Event rate, % (95% CI)		**9.1** (6.4 to 12.6)	**1.5** (0.8 to 2.6)

Ezzat VA et al. Open Heart. 2015;2:e000198. doi:10.1136/openhrt-2014-000198

S-ICD in patients explanted for infection

Boersma L et al. *Heart Rhythm* 2016;13:157–164

RESULTS

- Mean follow-up: 651 days,
- all-cause mortality: 3.2%
- Patients previously explanted for TV-ICD infection were
  - ***older*** (55.5±14.6, 47.8±14.3 and 49.9±17.3 years in the infection, noninfection, and de novo cohorts, respectively; P = 0.01),
  - more likely to have received the ICD for ***secondary prevention*** (42.7%, 37.2% and 25.6%;P = 0.0001);
  - had ***higher percentages of comorbidities***, including atrial fibrillation, congestive heartfailure ,diabetes mellitus,and hypertension, in line with the highest mortality rate (6.7%).

S-ICD in patients explanted for infection

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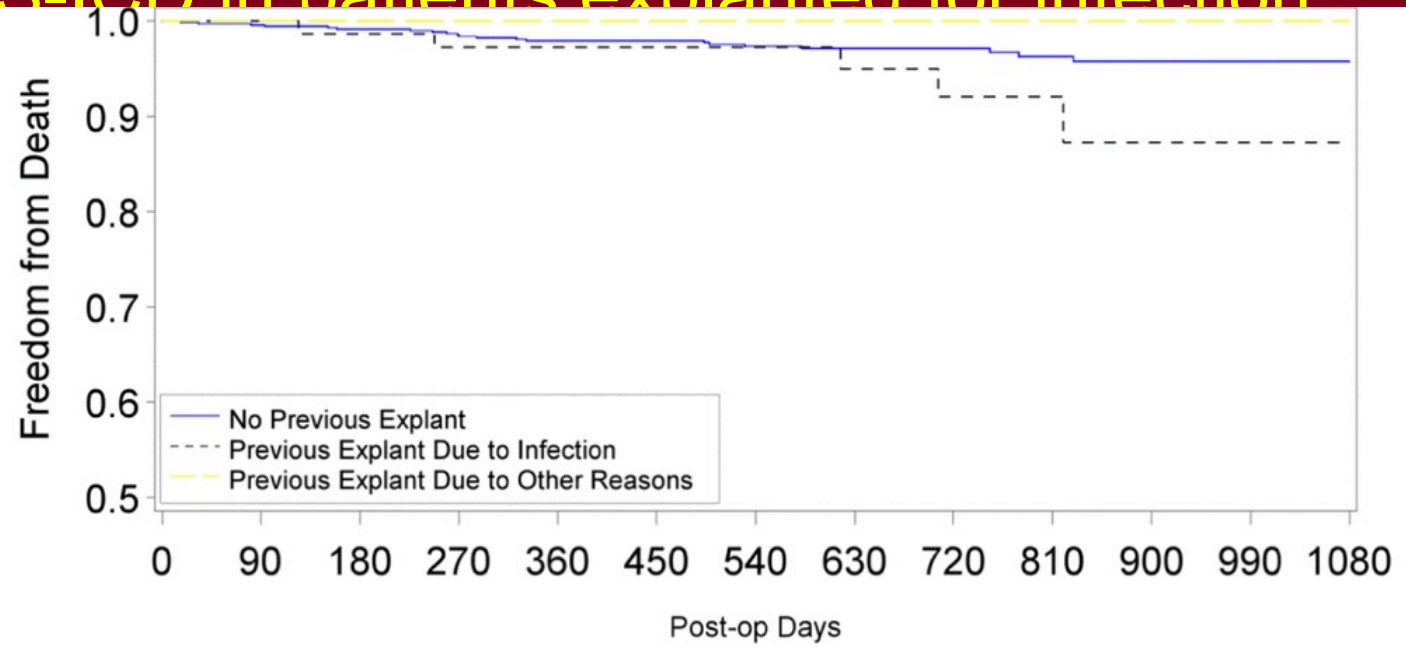


No Previous Explant	100	99.6	99.6	99.6	97.9	97.9	97.3	97.1	97.1	96.3	96.3	95.8	95.8
Prior TV Explant - Infection	100	100	100	100	97.2	97.2	97.2	95.0	92.1	92.1	92.1	87.2	87.2
Prior TV Explant - other reasons	100	100	100	100	100	100	100	100	100	100	100	100	100

Kaplan-Meier survival curves for death from any cause.

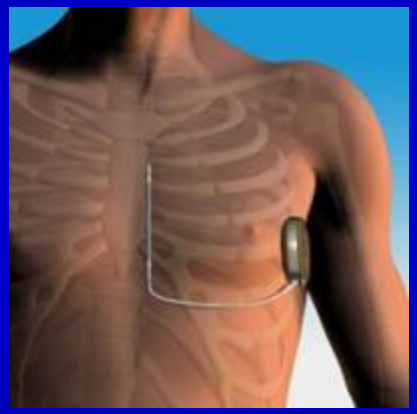
Infections, S-ICD and Leadless PM? A *"global solution"*?

TV-ICD

mCRM™ System*

EMBLEM™ S-ICD
EMPOWER™ Modular Pacing System*

S-ICD



Documented need for Pacing or ATP

Potential need for Pacing or ATP

No need for Pacing or ATP

* Technology under development and not available for clinical use. Courtesy of Boston Scientific Corporation. CCRM-389115-AA APR 2016

Conclusions

- CDI are increasing, with significant increase of mortality, morbidity and costs
- Many, new and old diagnostic tools are available: accurate knowledge of indications, accuracy and drawbacks is needed, for avoiding pitfalls
- TLE is mainstay of therapy
- However, therapy before and after TLE is also associated with important particular issues, and tailoring to the individual complex TLE patient is required

GRAZIE PER L'ATTENZIONE!

Autunno, il Po dal Ponte Isabella