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Infecciones de los dispositivos de asistencia ventricular: *diagnóstico, tratamiento y prevención*

Viernes, 5 de Octubre. 10:05-10:25

Patricia Muñoz

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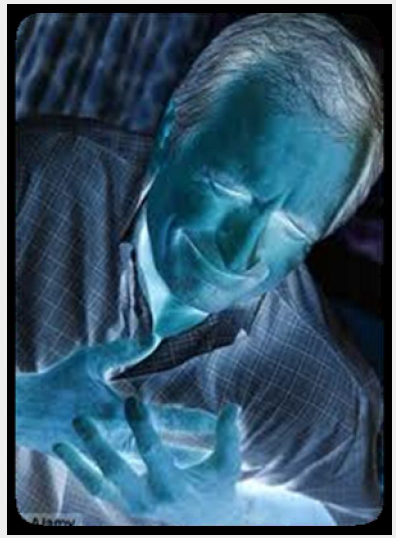
Universidad Complutense de Madrid

Hospital General Universitario GREGORIO MARAÑÓN

Madrid

IGM

Heart failure



- 6-10% individuals >65 years
- Europe: 10 million
- USA: 5 million CHF
- Over 3,500 heart failure pts on the Tx waiting list in US
- Many pts are not candidates for Tx

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Califano S. IDCNA 2012; Gordon RJ. L[redacted]06

Dispositivos asistencia ventricular

1. ***Que son?***
2. Infecciones?
3. Manejo?
4. Prevención?

Tipos, indicaciones
Cuantas?

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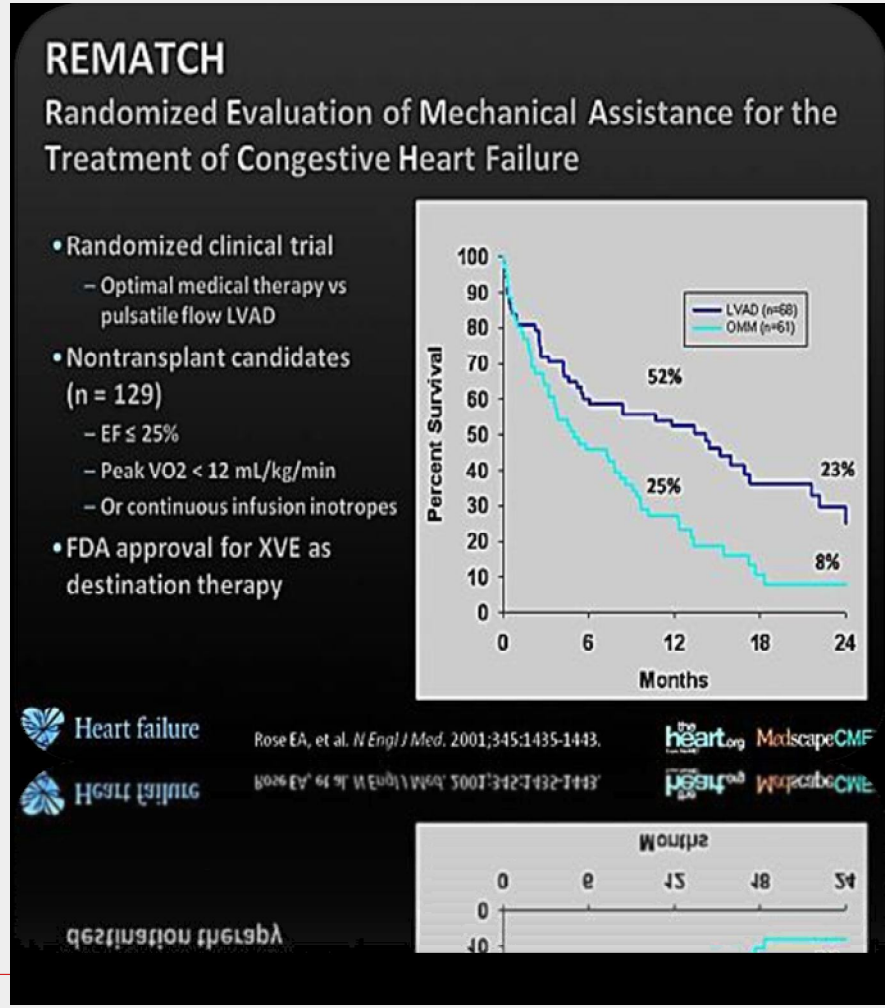
Mechanical assist devices

- Mechanical pumps that take over the function of damaged ventricle/s in patients with refractory HF
  - Improvement in myocardial contractility
  - Reverse remodeling
- **Destination theray: 0.52 relative risk of death compared to optimal medical therapy**



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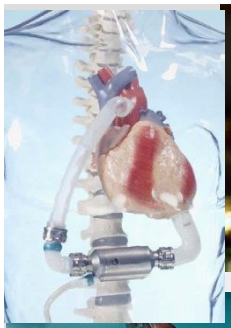
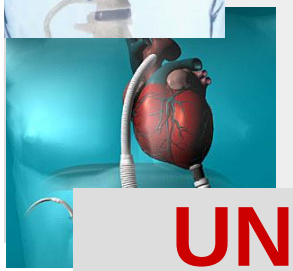
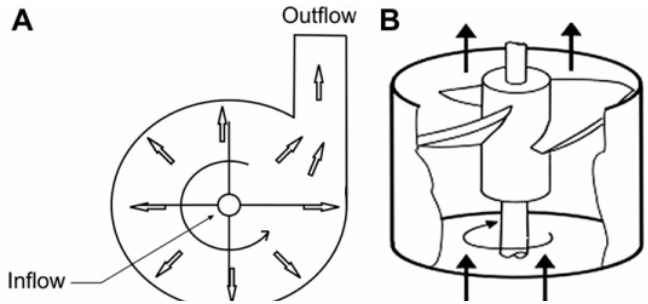






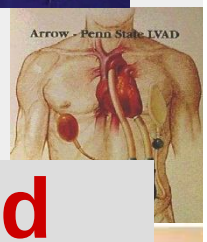
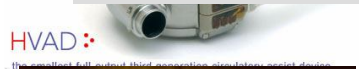


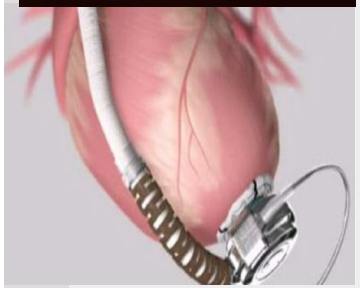
Table 1
2nd generation pumps.

	Manufacturer	Type of Flow	Bearing type	EU approval	FDA approval
	NY		immersed		
Synergy	CircuLite Inc, Saddle Brook, NJ	"Hybrid" (Axial and centrifugal)	Blood immersed	Expected in 2012	IDE for BTT

BTT – Bridge to transplant; DT – Destination therapy; HDE – Humanitarian Device Exemption; IDE – Investigational Device Exemption.

UNOS: since 1999 MCS 33% of all listed patients and 75% of all listed inpatients





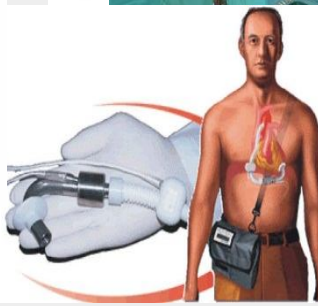
AB5000 Ventricle

2nd generation vs 1st: 46% vs 11% 2 yrs survival

Table 2
3rd generation pumps.

	Manufacturer	Type of flow	Bearing type	EU approval	FDA approval
DuraHeart	Terumo Heart Inc, Grand Rapids, MI	Centrifugal	Magnetic	BTT	IDE for BTT
EVAHEART LVAS	EVAHEART USA, Pittsburgh, PA	Centrifugal	Hydrodynamic	BTT	IDE for BTT
HVAD	HeartWare Inc, Miami, FL	Centrifugal	Hydrodynamic	BTT	IDE for BTT and DT
Incor	Berlin Heart, Berlin, Germany	Axial	Magnetic	BTT	

BTT – Bridge to transplant; DT – Destination therapy; IDE – Investigational Device Exemption.



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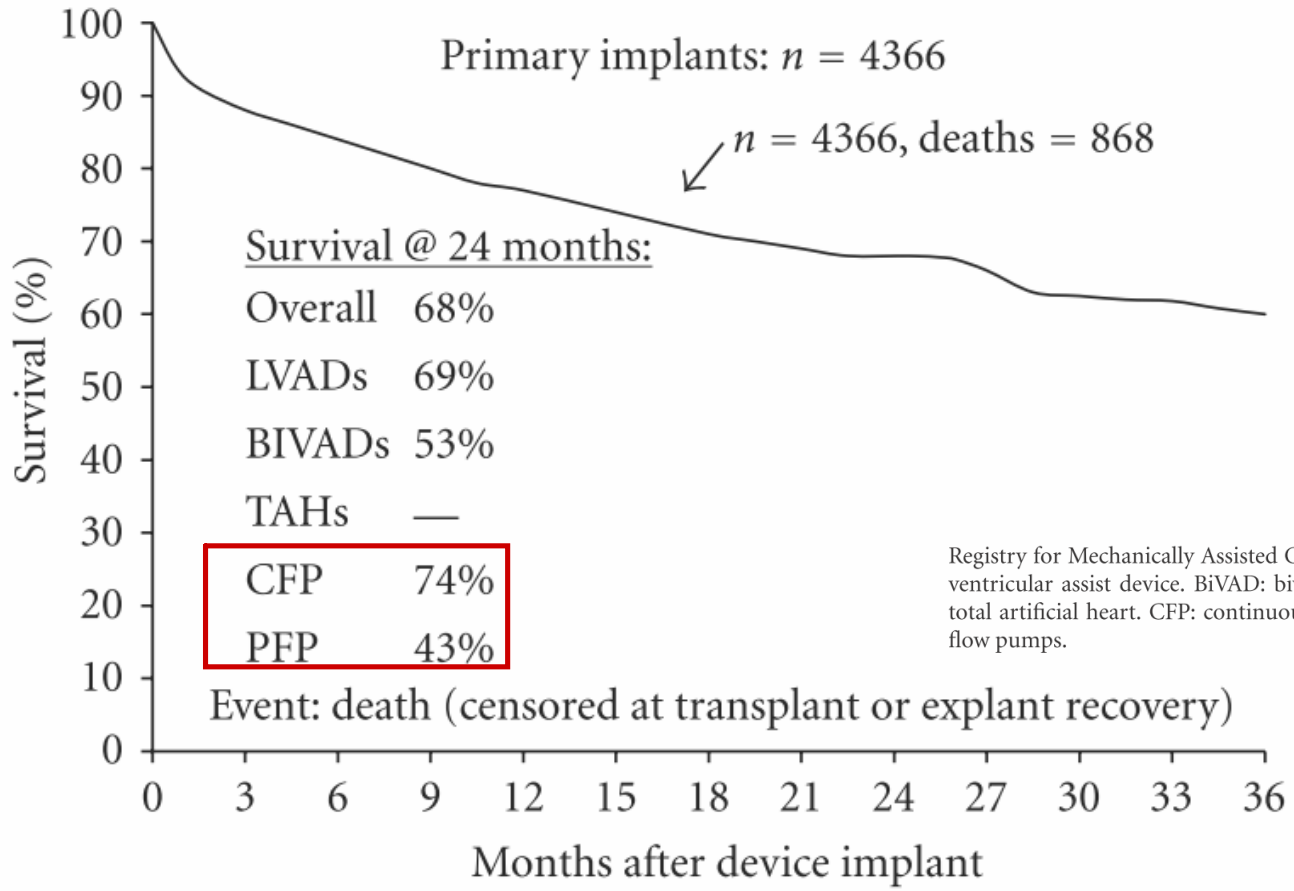
BBBB BBBBBBBB & BBBBBBBB BBBBBBBB BBBBBBBBBBBBBBB 26 (2012) 117

Current Status of Mechanical Circulatory Support: A Systematic Review

Kyriakos Spiliopoulos,[1,2] Gregory Giamouzis,[3] George Karayannis,[3] Dimos Karangelis,[1] Stelios Koutsias,[4] Andreas Kalogeropoulos,[5] Vasiliki Georgiopoulou,[5] John Skoularigis,[3] Javed Butler,[5] and Filippos Triposkiadis[3]

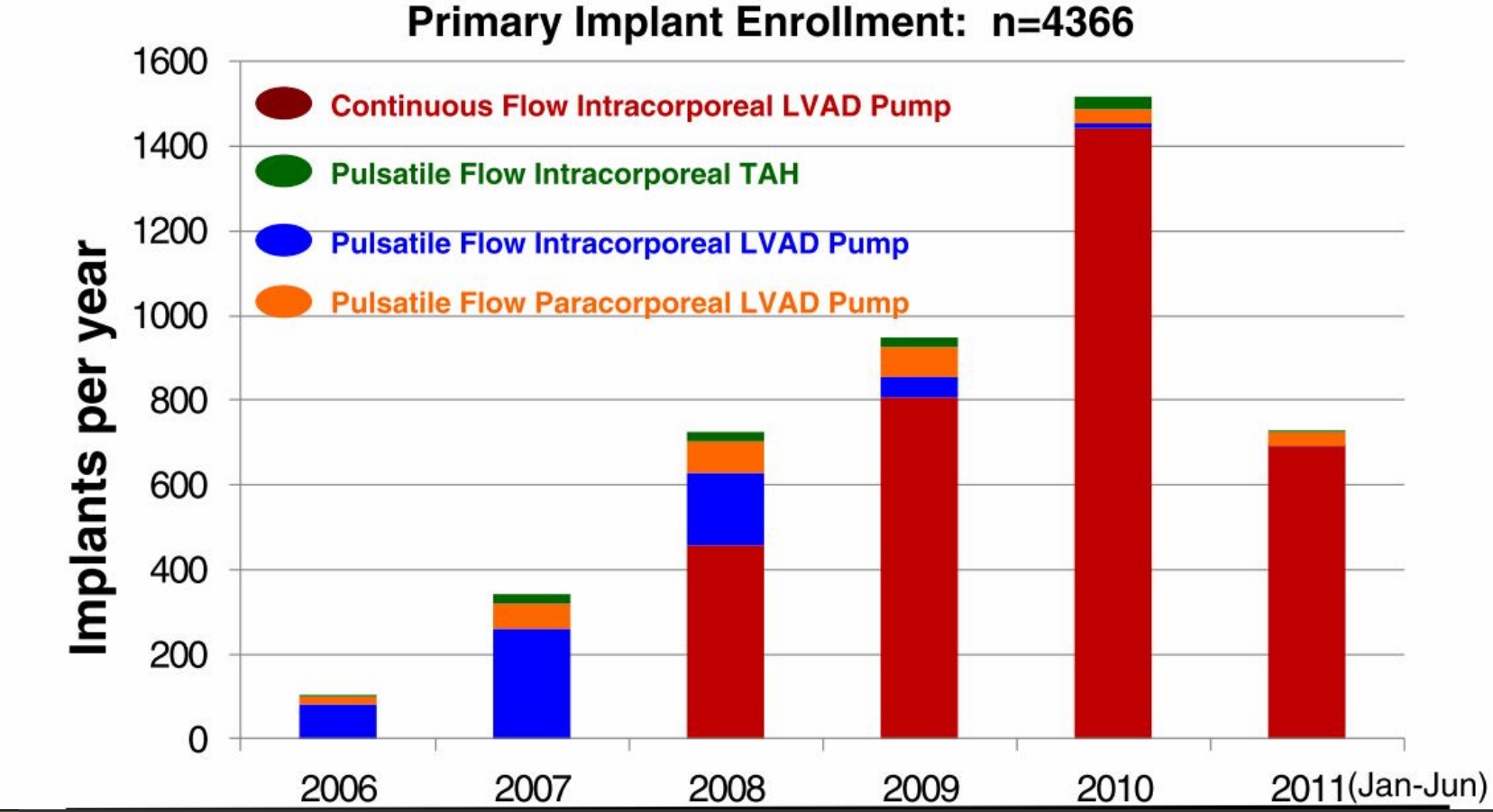


Registry for Mechanically Assisted Circulatory Support. LVAD: left ventricular assist device. BiVAD: biventricular assist device. TAH: total artificial heart. CFP: continuous-flow pumps. PFP: pulsatile-flow pumps.

Cardiology Research and Practice
Volume 2012, Article ID 574198, 1

J Heart Lung Transplant 2012;31:117–26

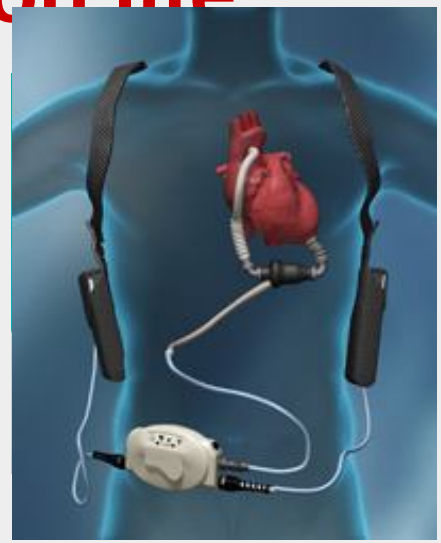
- 1,500 pts/año. Pulsátiles claramente



In Europe: Euromacs

J Heart Lung Transplant 2012;31:117–26

Patient's severe heart failure leads to LVAD surgery and a new lease on life



Uninterrupted connection to a portable external power source
New devices recharged transcutaneously

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Indications

- Indication as **bridge to:**

  a) Transplantation

  (infarction, V tachycardia…)

  b) Candidacy or recovery

  (post-cardiotomy shock) **45%**

  c) Destination therapy **10%**

  (ineligible for Tx: age, renal failure, COPD, ….)

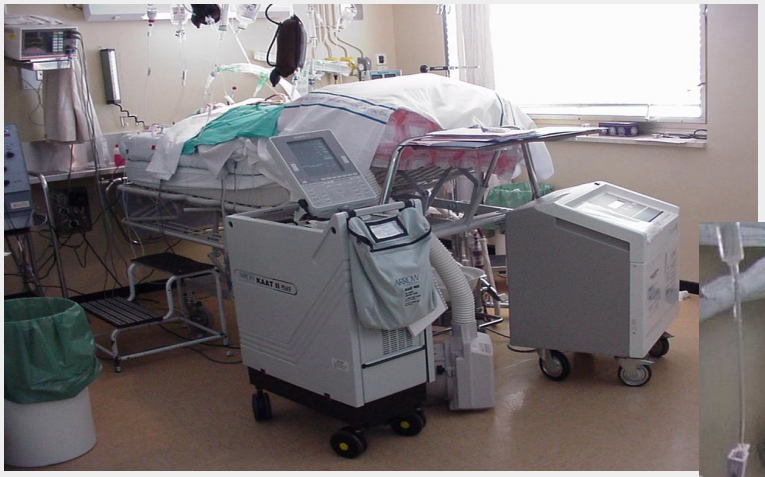
(INTERMACS) 2006- 2010

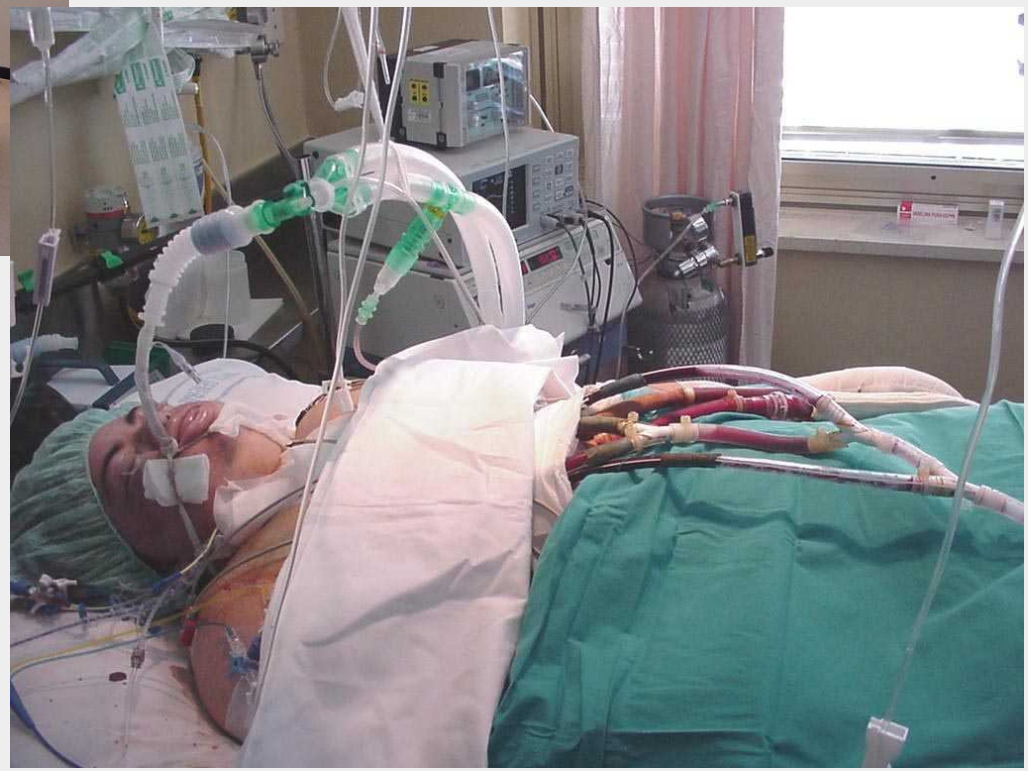
Table 2 Pre-implant Adult Patient Profiles by Year of Implant: June 23, 2006, to June 30, 2011

Patient pre-implant profile	Implant year 2006 No. (%)	2007 No. (%)	2008 No. (%)	2009 No. (%)	2010 No. (%)	2011 (~Jun) No. (%)	Total
1. "Critical cardiogenic shock" (patient has life-threatening hypotension and profound low cardiac output with rapidly escalating inotropic pressor support)	42 (40.8)	155 (45.2)	213 (29.3)	204 (21.5)	186 (12.3)	102 (14.0)	902
2. "Progressive decline" (patient has been demonstrated "dependent" on inotropic support but nonetheless shows signs of continuing deterioration)	40 (38.8)	122 (35.6)	310 (42.7)	443 (46.7)	637 (42.0)	302 (41.4)	1,854
3. "Stable but inotrope-dependent" (patient is clinically stable on mild-moderate doses of intravenous inotropes, or has a temporary circulatory support device, after repeated documentation of failure to wean without symptoms)	8 (7.8)	33 (9.6)	110 (15.2)	162 (17.1)	384 (25.3)	202 (27.7)	899
4. "Resting symptoms" (patient is at home on oral therapy but frequently has symptoms of congestion at rest or with activities of daily living)	6 (5.8)	25 (7.3)	66 (9.1)	94 (9.9)	211 (13.9)	88 (12.1)	490
5. "Exertion intolerant" (patient is comfortable at rest but unable to engage in any activity, living predominantly within the house or household)	0 (0.0)	6 (1.8)	9 (1.2)	22 (2.3)	49 (3.2)	26 (3.6)	112
6. "Exertion limited" (patient is comfortable at rest without evidence of fluid overload, is able to do some mild activity)	2 (1.9)	2 (0.6)	7 (1.0)	16 (1.7)	30 (2.0)	6 (0.8)	63
7. "Advanced NYHA class III" (patient is clinically stable with a reasonable level of comfortable activity, despite history of previous decompensation)	5 (4.9)	0 (0.0)	11 (1.6)	8 (0.8)	19 (1.3)	3 (0.4)	46
Total	103 (100.0)	343 (100.0)	726 (100.0)	949 (100.0)	1,516 (100.0)	729 (100.0)	4,366

NYHA, New York Heart Association.

Another type of VAD patient





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Hospital Universitario La Fe. Valencia
Hospital Universitario 12 de Octubre (adultos). Madrid
Clínica Universitaria de Navarra. Pamplona
Hospital Universitario Virgen de la Arrixaca. Murcia
Hospital Universitario Puerta de Hierro. Majadahonda (Madrid)
Hospital Central de Asturias. Oviedo
Hospital Universitario Bellvitge. L'Hospitalet de Llobregat (Barcelona)
Hospital Universitario Gregorio Marañón. Madrid
Hospital Universitario Ramón y Cajal. Madrid
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Complejo Hospitalario Universitario. La Coruña

Enrique Pérez de la Sota: Registro de Asistencia Circulatoria y Respiratoria

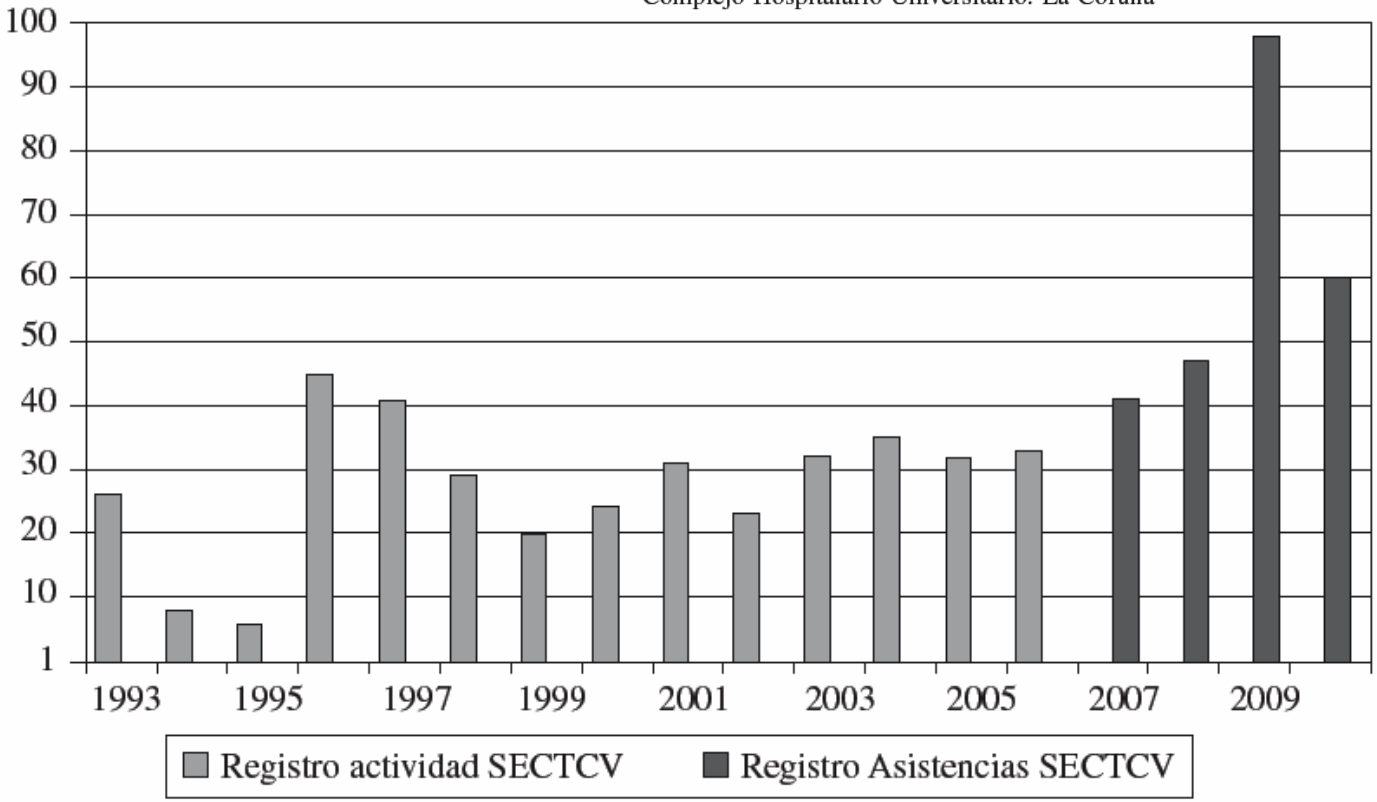
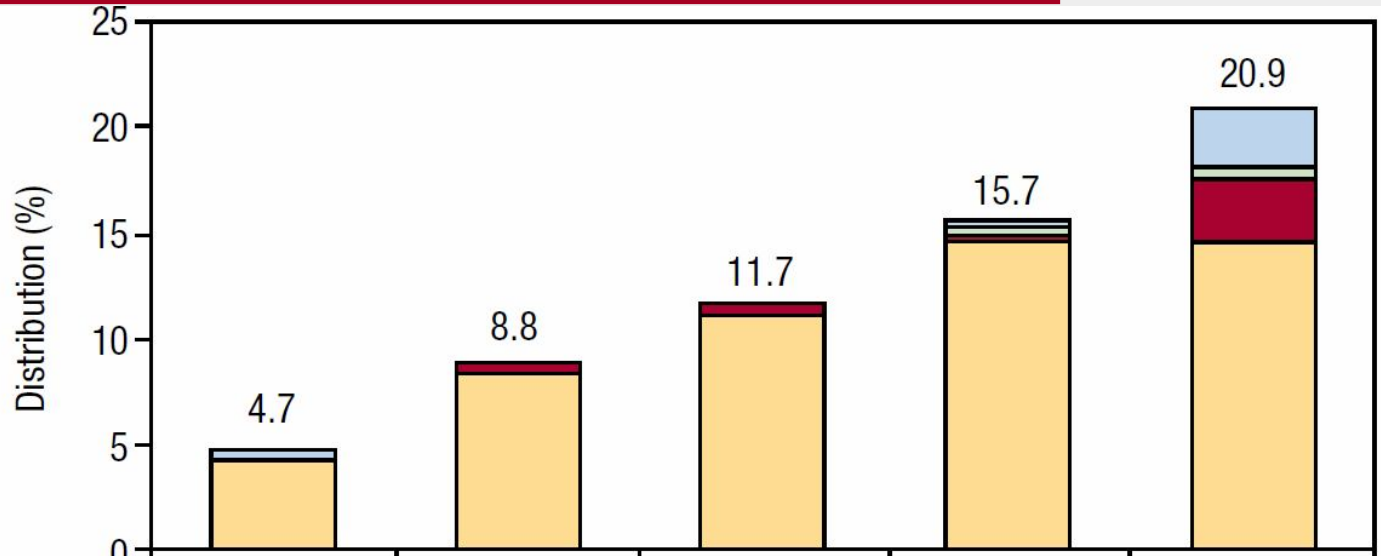


Figura 1. Número anual de asistencias implantadas en España.

Almenar L et al. Spanish Heart Transplantation Registry. 21st Official Report (1984-2009)



	1984-1989	1990-1994	1995-1999	2000-2004	2005-2009
Pulsatile VAD	0.5	0.1	0.1	0.4	2.7
Continuous VAD	0	0.1	0	0.3	0.6
ECMO	0	0.2	0.3	0.3	2.8
Balloon	4.2	8.5	11.3	14.7	14.7

- In the last 5 years, approximately **half the urgent HT** recipients had previously had some sort of ventricular assist implant

Rev Esp Cardiol. 2010;63(11):1317-2

BRIEF REPORT

Ventricular Assist Devices As a Bridge to Transplantation

Guillermo Reyes,[a] Juan Fernández-Yáñez,[b] Hugo Rodríguez-Abella,[c] Jesús Palomo,[b] Ángel Pinto,[c] and Juan Duarte[a]

[a]Servicio de Cirugía Cardiovascular, Hospital Universitario La Princesa, Madrid, Spain
[b]Servicio de Cardiología, Hospital Gregorio Marañón, Madrid, Spain
[c]Servicio de Cirugía Cardiovascular, Hospital General Gregorio Marañón, Madrid, Spain

- **Survival**
  - **at 1 year 55.2%**
  - **5 years 32.2%**

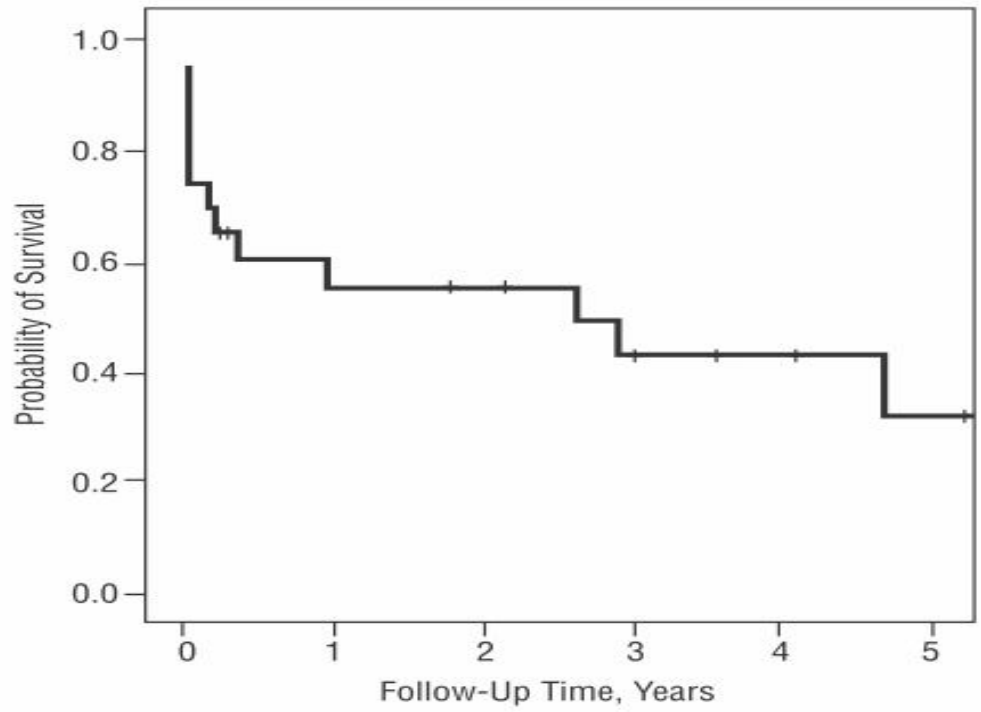
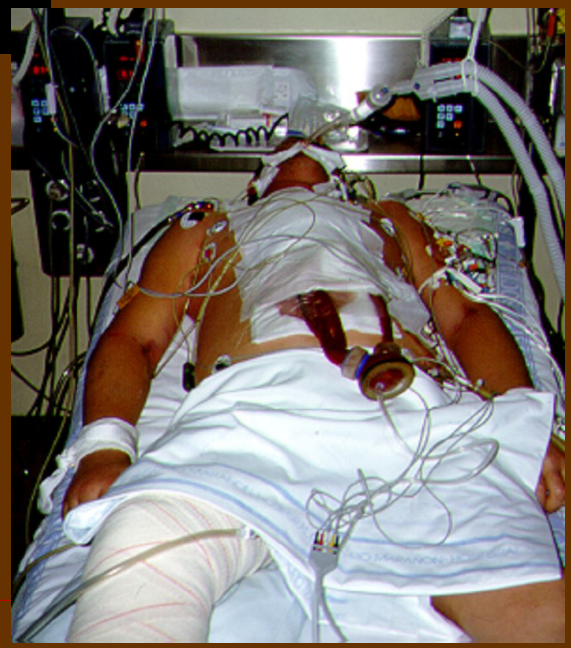


Figure 1. Five year survival curve for patients who underwent a heart transplant after implantation with a ventricular assist device (n=23). Survival at 1 and 5 years was 55.2% and 32.2%, respectively.

Rev Esp Cardiol. 2007;60(1):72-5

DAV

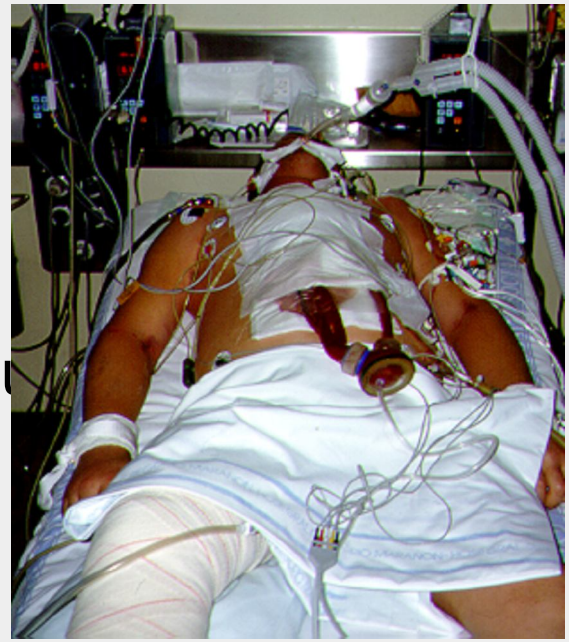
1. Que son?
2. ***Infecciones?*** – Cuales Cuantas
3. Manejo?
4. Prevención?



Complications VAD

- Early
  - Bleeding (30%)

Most reports come from countries with long waiting-lists for heart transplantation (mean>100 d)



- Late
  - **Infection (18-59%)**
    - Nosocomial
    - Device related
  - Thromboembolism (3-35%)
  - Failure of device (6% at 6 months)

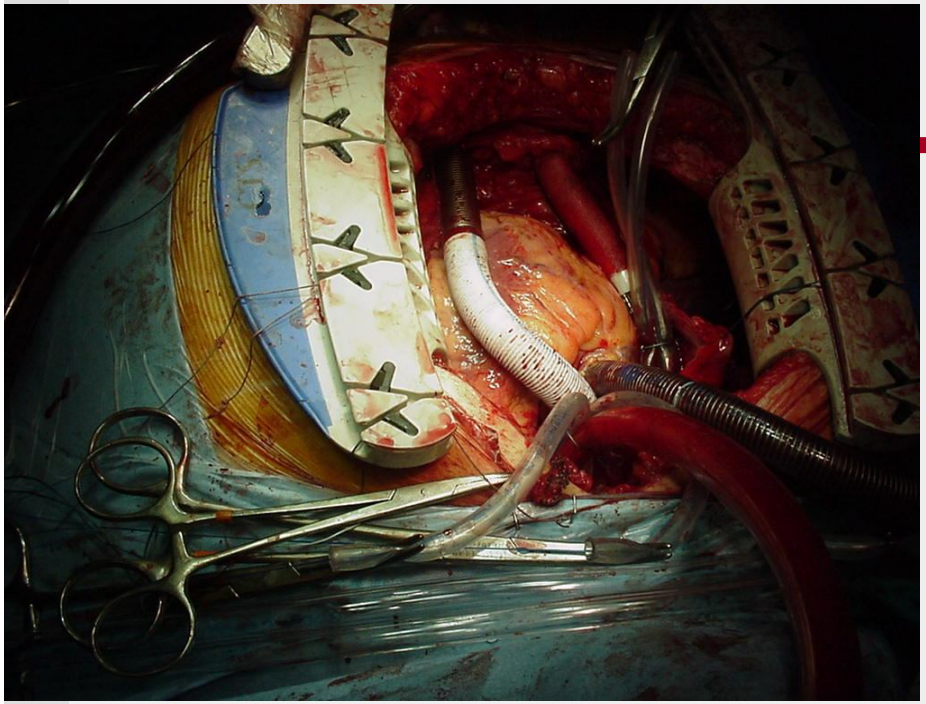
Lancet ID 2006; IDCNA 2012

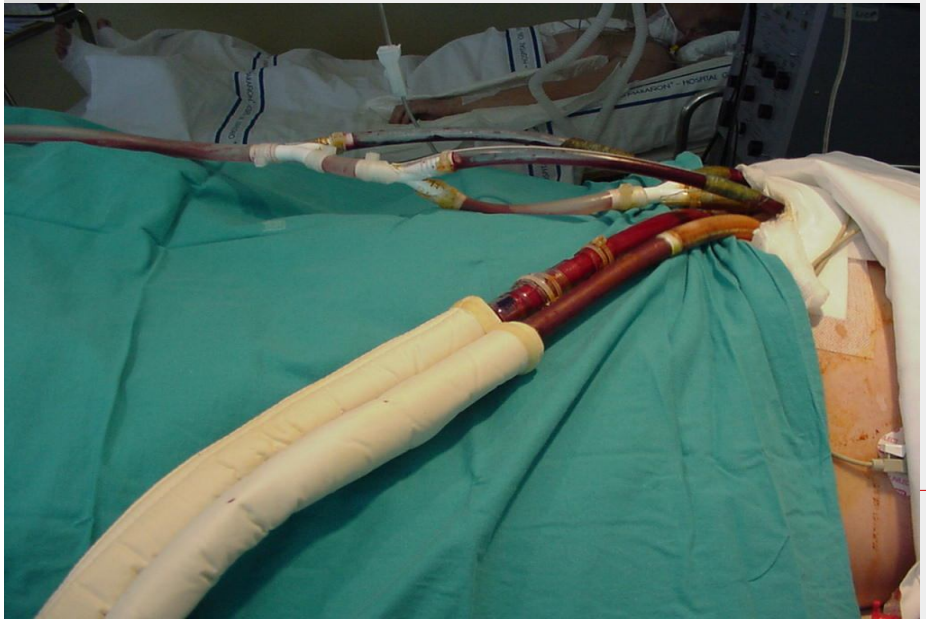
Clinical presentation: UNSPECIFIC

- Fever 14/25 (56%)
- Leucocytosis 7/25 (28%)
- Drainage from exit site7/25 (28%)
- Bleeding, pain, erythema, necrosis
- Lethargy, fatigue, anorexia
- Mechanical problems
  - Inlet obstruction, outflow rupture
- Bacteremia

Sivaratnam et al. ASAIO Journal 2002; Argenziano JHLT 1997; Simon D. CID 2005

Extracorporeal ventricular assist devices



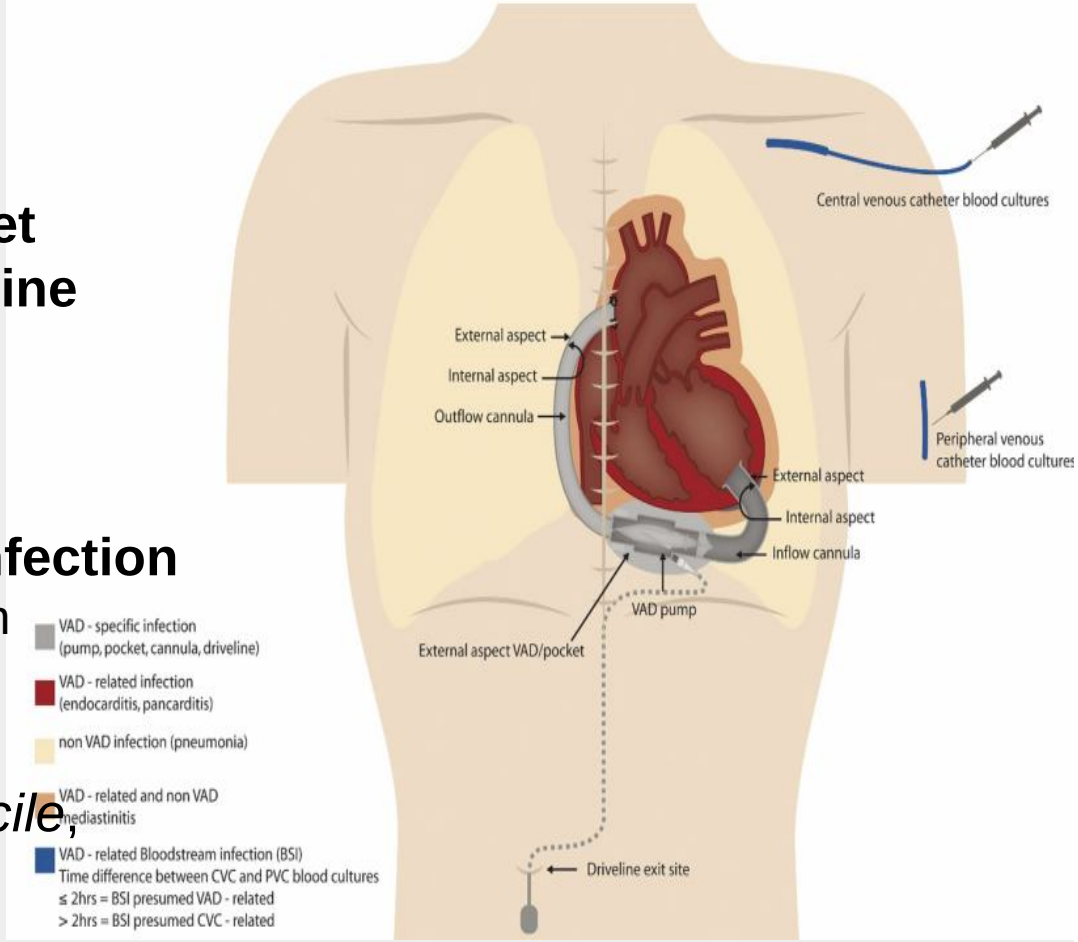


- Implanted through a median sternotomy
- **Inflow cannula** in the left, right or both ventricles
- **Outflow tube** anastomosed to the ascending aorta and/or the pulmonary artery connected
  - to an extracorporeal pump
  - Intra-abdominal or preperitoneal space
- **Percutaneous driveline** to power source
- Multiple IV cath, MV, ….

Working formulation for the standardization of definitions of infections in patients using ventricular assist devices

Margaret M. Hannan, MD[l], Shahid Husain, MD,[b] Frauke Mattner, MD,[c] Lara Danziger-Isakov, MD,[d] Richard J. Drew, MB,[a] G. Ralph Corey, MD,[e] Stephan Schueler, MD, PhD,[g] William L. Holman, MD,[h] Leo P. Lawler, MD,[a] Steve M. Gordon, MD,[d] Niall G. Mahon, MD,[a] John M. Herre, MD,[f] Kate Gould, MB,[g] Jose G. Montoya, MD,[i] Robert F. Padera, MD, PhD,[j] Robert L. Kormos, MD,[k] John V. Conte, MD,[l] and Martha L. Mooney, MD[e]

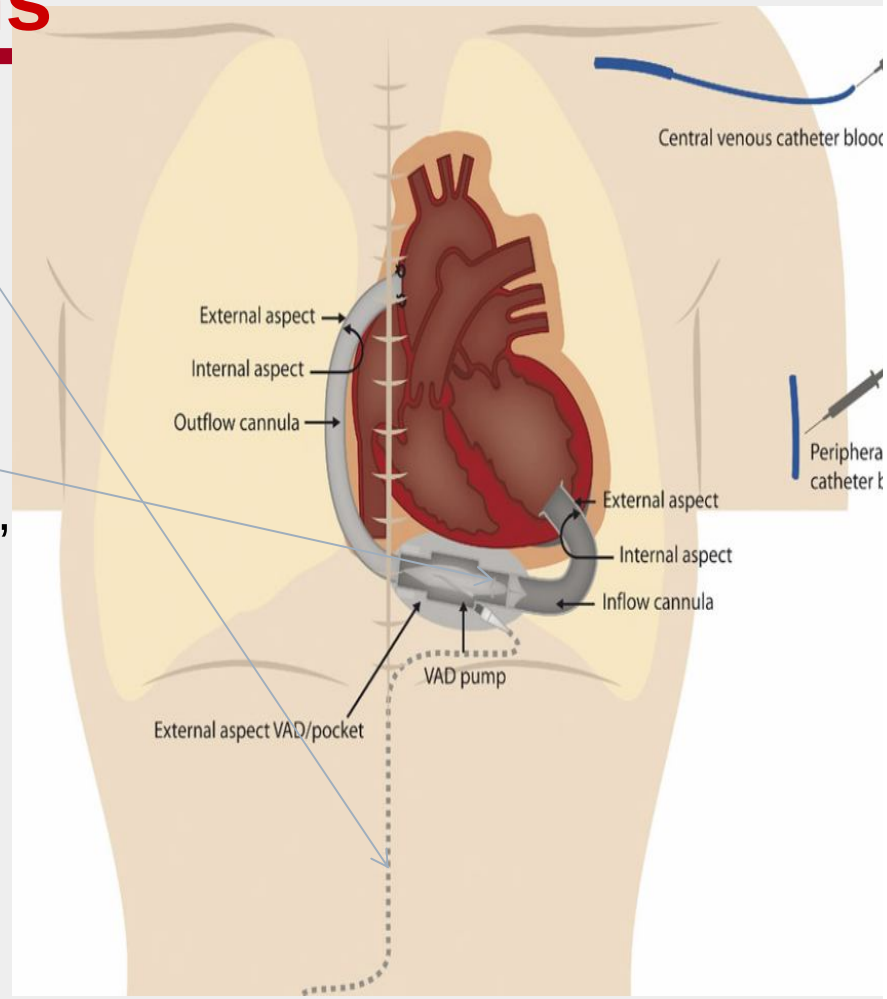
- **VAD-specific infections**
  - Related to hardware
  - Do not occur in other pts
    - **Pump, cannula, pocket &percutaneous driveline**
- **VAD-related infections**
  - Can occur without VAD
    - **IE, BSI, mediastinitis, sternal wound infection**
    - Specific considerations in pts with VADs
- **Non-VAD infections**
  - LRT, cholecystitis, *C. difficile*, UTI



Journal of Heart and Lung Transplantation 2011

VAD-specific infections

- **Percutaneous driveline**
  - Superficial or deep
  - Proven, probable, possible
- **Pump pocket** (intraperitoneal, within left V, Pericardial sack)
- **Inflow** (ventricle) and **outflow** (cardiovascular system) cannula
- **Suture lines**
- LVAD-related **endocarditis**



Hannan et al. JHLT 2011

Superficial VAD-specific percutaneous driveline infection

Table 7 Definitions of Ventricular Assist Device-Specific Percutaneous Driveline Infection

	Surgical/histology	Microbiology	Clinical	General wound appearance
A. Superficial VAD-specific Percutaneous Driveline Infection				
Proven = Surgical/histology criteria ± other criteria	• Involvement of tissues superficial to the fascia and muscle layers of the incision documented	• Aseptic skin culture positive or not cultured	• Local increase in temperature around the exit site	• Purulent discharge from the incision but not involving fascia or muscle layers or • Erythema spreading around the exit site[a]
Probable = No surgical/histology criteria with purulent discharge ± other criteria	• Surgical debridement not performed • No histology	• Aseptic skin culture positive or negative but patient already on antibiotic or had antiseptic used to clean wound	• Local increase in temperature around the exit site and • Treated as superficial infection with clinical response	• Purulent discharge from the incision but not involving fascia or muscle layers or • Erythema spreading around the exit site[a]
Possible = No surgical/histology or purulent discharge ± other criteria	• Surgical debridement not performed • No histology	• Aseptic skin culture positive or negative and patient not on antibiotics or had antiseptic used to clean the wound	• Local increase in temperature around the exit site and • Treated as superficial infection with clinical response	• No discharge • Erythema spreading around the exit site[a]

Proposed criteria

- **Major Clinical Criteria**
  - VAD not removed: persistent B
  - BSI-VAD related or presumed
  - Echocardiogram suggestive of
    - vegetation adjacent to or in im
- **Minor Clinical Criteria**
  - **Fever** ≥ 38°C
  - **Vascular phenomena,** major a infarcts, mycotic aneurysm, intr hemorrhage, and Janeway's le
  - **Immunologic** : glomerulonep
  - **Microbiologic** evidence: positi meet criteria as noted above (e CNS excluding *S. lugdunensis*)

Proven

- Microbiology. Isolation of indistinguishable organism (genus, species, antimicrobial susceptibility pattern) at explantation or intra-operatively from
  - ≥ 2 positive internal aspect culture samples from pump and/or cannula or
  - 1 positive peripheral blood culture and 1 positive culture from VAD internal aspect aspirate or endovascular brushings, (internal aspect refers to the inner lumen of the cannula) or
  - In the case of coagulase–negative staphylococci excluding *Staphylococcus lugdunensis*; 2 or more positive sets of peripheral blood cultures and a positive internal aspect culture of pump and/or cannula
- Histologic features of infection from heart tissue samples from around the VAD pump and/or cannula at explantation or intra-operatively.
- Clinical criteria (see Table 3)
  - 2 major criteria

Probable

- 1 major criterion and 3 minor criteria or
- 4 minor criteria

Possible

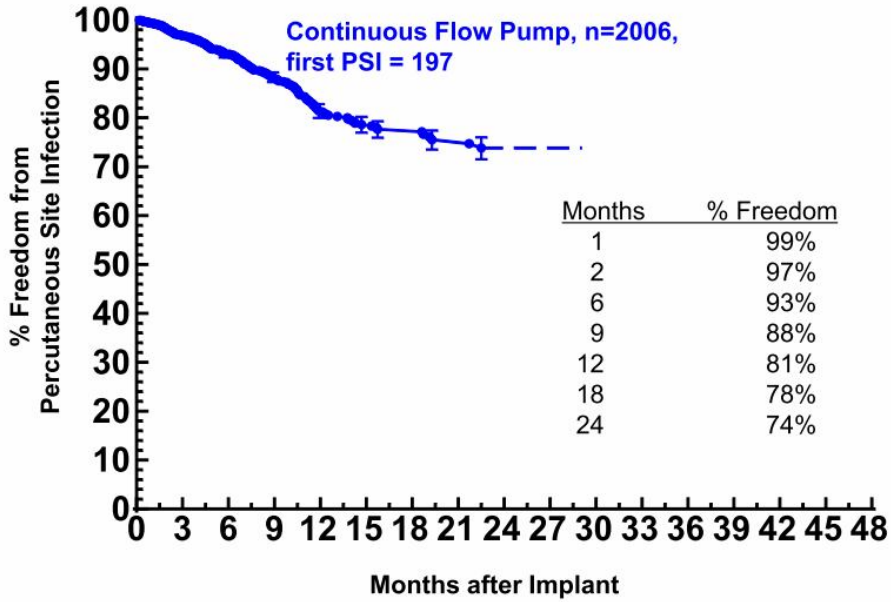
- 1 major and 1 minor or
- 3 minor

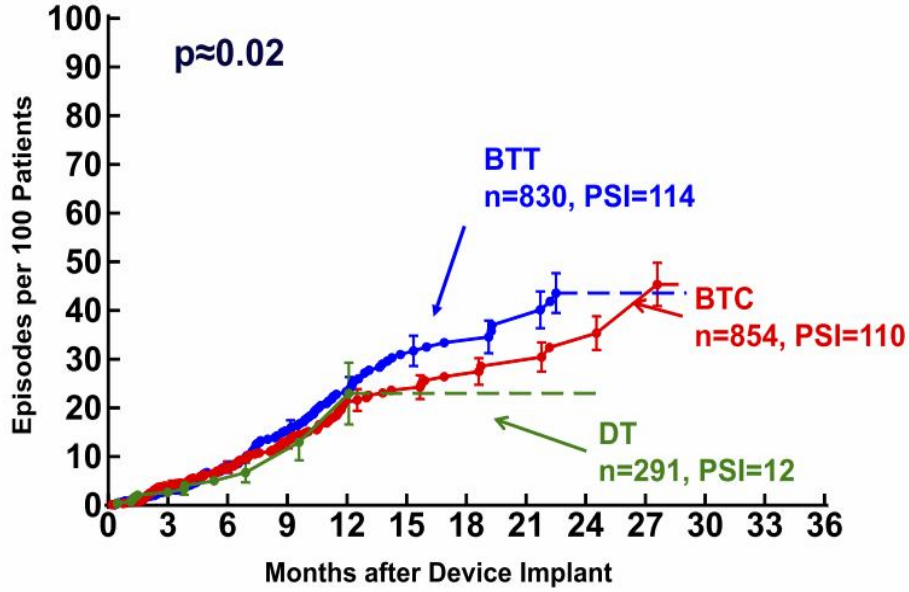
Rejected

- Firm alternative diagnosis explaining the clinical findings
- Resolution of evidence of pump and /or/cannula infection with antibiotic therapy for ≤ 4 days or
- No pathologic evidence of pump and/or cannula infection at surgery or autopsy with antibiotic therapy for ≤ 4 days or
- Does not meet criteria for possible pump and/or cannula infection

Continuous-flow devices. Heart mate II (n=2006)

- Driveline infection: 1 yr **19%**; Two yrs **25%**
- Percutaneous site infection **9.8%**. Mean time: 6 months





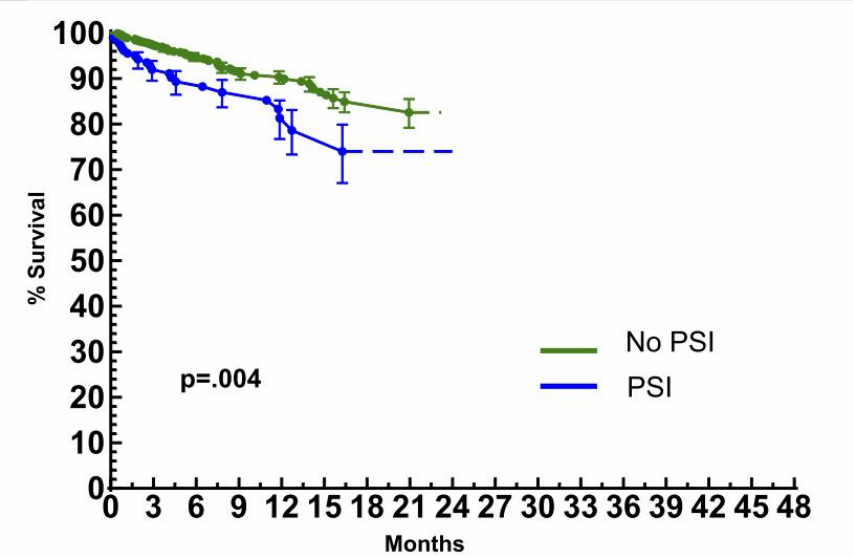
Driveline infection

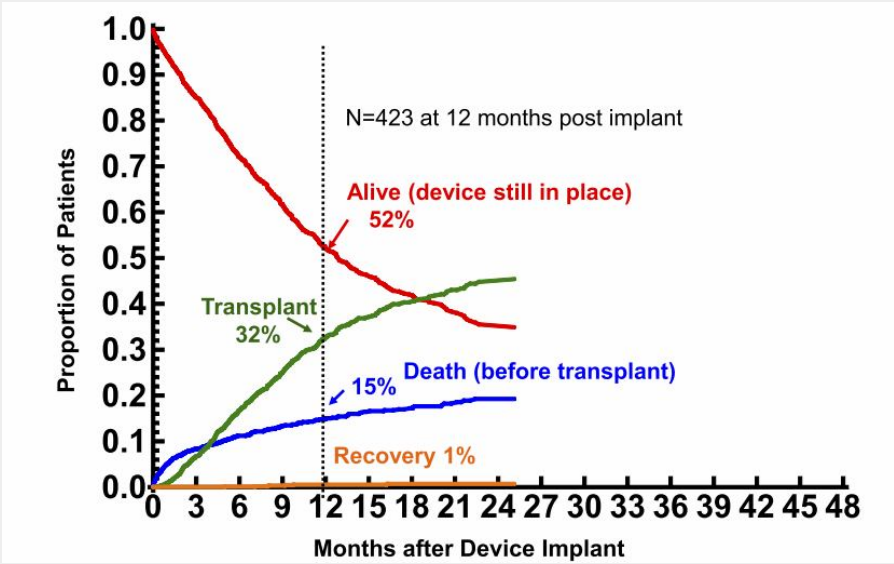
Percutaneous site

Goldstein DJ. JHLT 2012

Continuous-flow devices

- Risk factor: younger age.
- **Sepsis: most common cause of death (26%)**





Independent cause of death

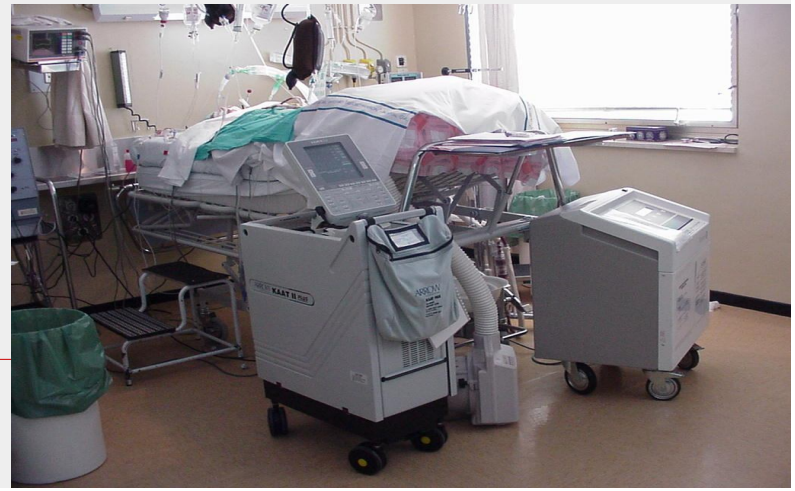
Final outcome

Risk factors
Device size and surface, turbulence of flow, entry routes

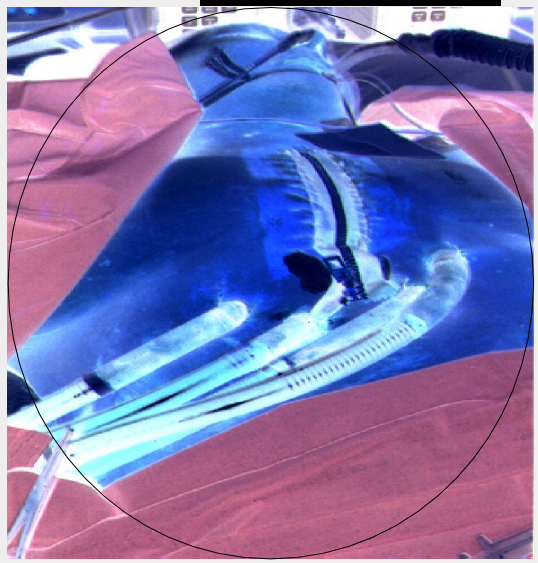
Goldstein DJ. JHLT 2012; Kirklin JK. JHLT 2010

Some experience from our center

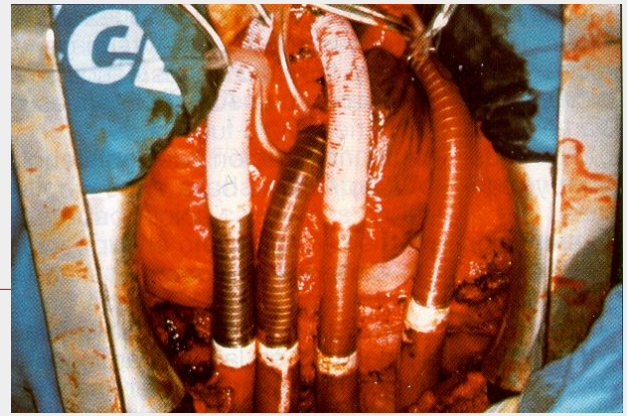
- 58 patients
- TYPE OF VAD (Extracorporeal pulsatile)
  - ABIOMED BVS 5000 31 (53.4 %)
  - BCM 24 (41.3 %)
  - BIOMEDICUS 3 (5.1 %)
- Mean support duration: 6.5 days (1-52)
- IMPLANTATION VENTRICLE :
  - Left ventricle 31 (53.4%)
  - Bi-ventricular 22 (37.9%)
  - Right ventricle 5 (8%)



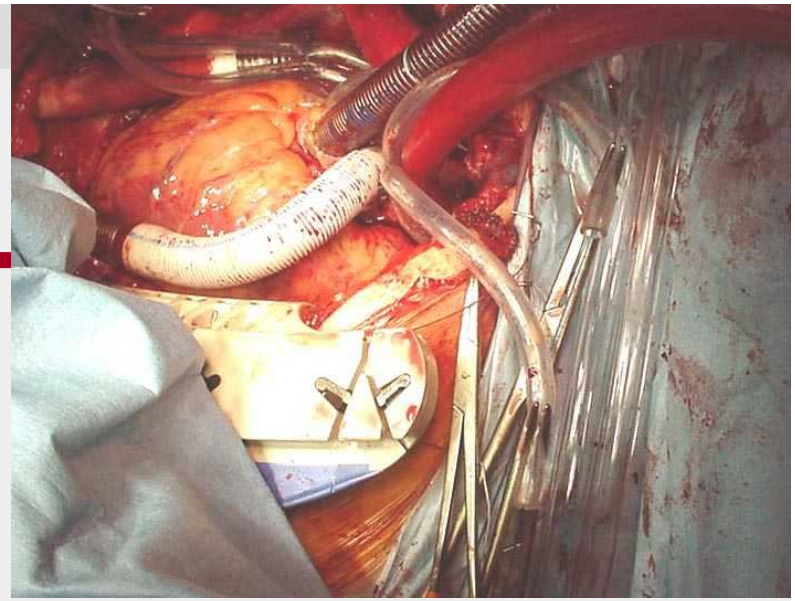
Infectious complications



- 50% of the patients (29/58)
  - 34 infectious episodes
- 67.6% of patients >3 days on VAD (25/37)



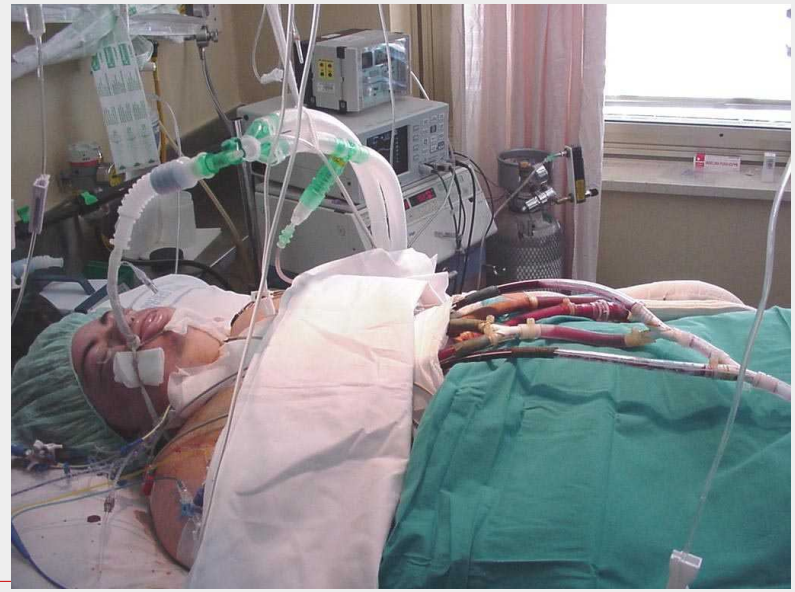
RESULTS



- 5 Device- related Infections

8% of the patients and 15% of IE

- Postsurgical Mediastinitis 2
- Wound Infection 1
- Cannulas and mediastinal infection 1
  - *Aspergillus*
- Primary Bacteremia 1

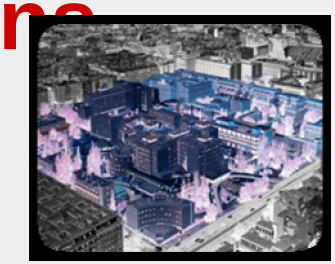


- 29 non related infections

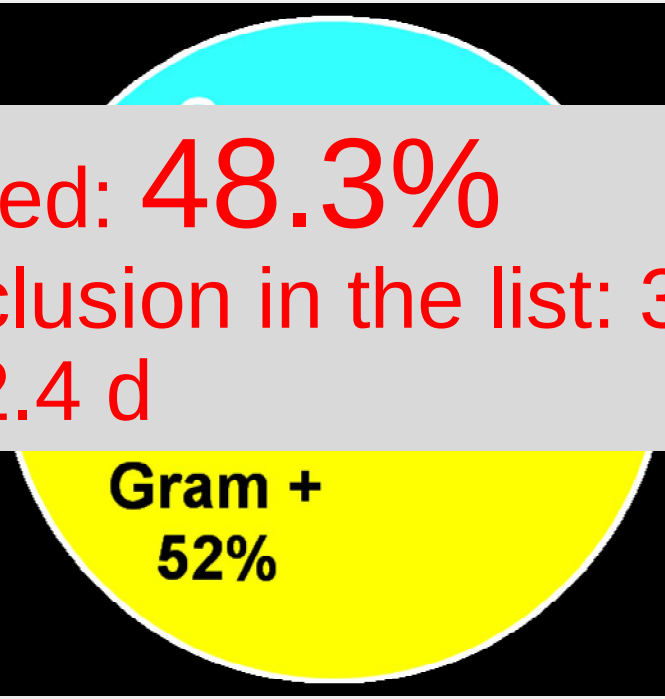
41.4% of the patients and 85% of IE

- VAP 14

Etiology of Patient-related infections



	n
Gram positive: 52.6%	
MRSA	**6**
CNS	6
Enterococcus sp	5
MSSA	2
Coryneb	
Gram negat	
P. aeru	
E. coli	
Acinetobacter sp.	3
Klebsiella sp	2
H. influenzae	2
Fungi: 8%	
Candida sp.	2
Aspergillus sp.	1



ungi
8%

HT performed: 48.3%

Time to TX till inclusion in the list: 3 ± 2.4 d

Risk Analysis of Bloodstream Infection During Long-Term Left Ventricular Assist Device Support

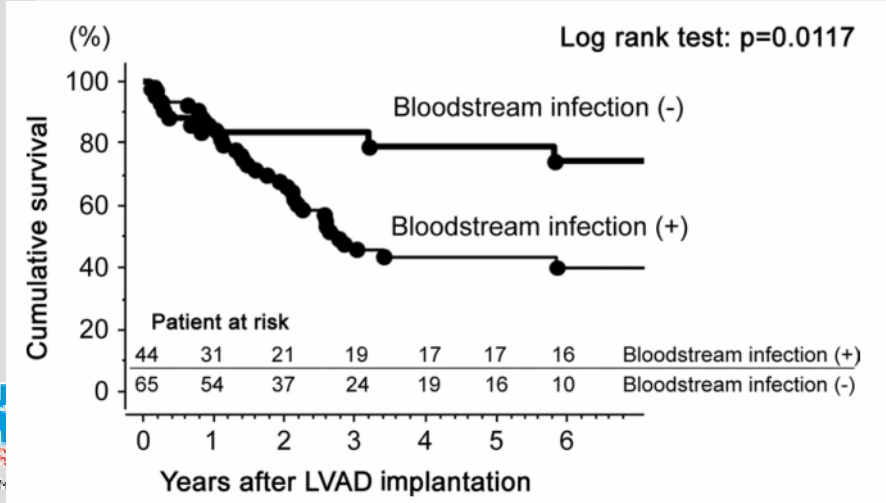
Koichi Toda, MD, PhD, Yumiko Yonemoto, MD, Tomoyuki Fujita, MD, Yusuke Shimahara, MD, Shyunsuke Sato, MD, Takeshi Nakatani, MD, PhD, and Junjiro Kobayashi, MD, PhD

Department of Cardiovascular Surgery, National Cerebral and Cardiovascular Center, Osaka, Japan

- 109 pacientes (99-2010)
- 584 ±389 d

Pathogens	No. (%)
Gram-positive cocci	159 (72)
Staphylococcus aureus	
Methicillin-resistant	65 (29)
Bacillus spp	18 (8)
Gram-negative bacilli	37 (17)
Pseudomonas aeruginosa	11 (5)
Serratia spp	6 (3)
Klebsiella spp	6 (3)
Enterobacter spp	4 (2)
Acinetobacter spp	4 (2)
Stenotrophomonas maltophilia	2 (1)
Others	4 (2)
Fungi	13 (6)
Candida albicans	7 (3)
Candida parapsilosis	6 (3)

Upgraded to UNOS priority 1A for urgent Tx



DAV

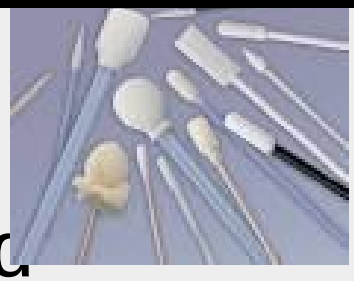
1. Que son?
2. Infecciones?
3. **Manejo?**
4. Prevención?

Diagnóstico
Tratamiento

SEICAV
Sociedad Española de Infecciones Cardiovasculares

Diagnosis

- Cardiothoracic surgeons, cardiologi interventional radiologist, Micro-ID
  - Fluid surrounding devices



- All drivelines should be surgically and histopathologically examined at removal
- Internal and external samples from the OR
- Sonication or scraping of biofilm

SEICAV
Sociedad Española de Infecciones Cardiovasculares

Investigations for Suspected Infection in a Patient Using VAD

If VAD removed: samples to be obtained at the time of explantation

- Aspirate from external aspect of VAD (anterior) for culture
- Aspirate from external aspect of VAD (posterior) for culture
- Aspirate from outflow cannula part of VAD (internal aspect) for culture
- Aspirate from inflow cannula part of VAD (internal aspect) for culture
- Culture of saline instilled into VAD (internal aspect)
- Sample of pus from for Gram stain, KOH, bacterial and fungal culture
- $\geq$ 2 tissue samples from suspicious tissue surrounding VAD, driveline or anastomoses sent for histology, Gram stain, KOH, bacterial and fungal culture

When clinically indicated:

- Nasal, throat and groin aspirate for *Staphylococcus aureus* carriage
- If suspicious of a pocket infection obtain an abdominal US, CT abdomen/thorax, $\pm$ nuclear imaging study
- Image guided aspiration or brush of pocket/driveline
- Rule out all other possible causes of the septic episode (e.g. sputum culture and urine for microscopy and culture etc.)

Empiric treatment. Obtain cultures BEFORE

- Suspected site (s) of infection and severity
- Broad spectrum:
  - Gram positives (driveline exit site)
  - Gram negatives (wound, pump pocket)
  - Fungi
- Consider
  - Previous therapy
  - Resistance pattern

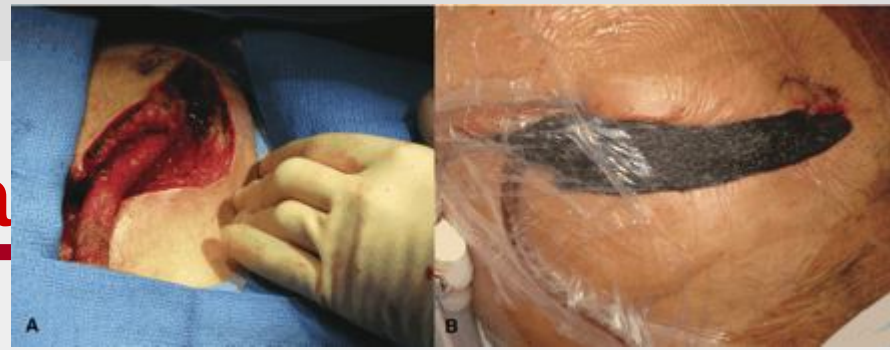
Multidrug-Resistant Gram-Positive Infections in Patients With Ventricular Assist Devices: The Role of Daptomycin

A. Beiras-Fernandez, F. Kur, S. Kiefer, R. Sodian, M. Schmoeckel, M. Weis, B. Reichart, and F. Weis

- Daptomycin n=9; mean duration 16 days
  - 66% CRI. MRSA 33%; *E. faecium* 25%; S. epi 12.5%; MSSA, 12.5%; others, 17%
  - Successful outcomes 78%
  - No adverse events
- Length of therapy
  - Superficial: until healing
  - Endovascular: at least until device is removed
    - Continue after removal if endocarditis or septic metastasic foci

Weis F. Ann Thorac Surg 2007; Transplantation Proceedings, 41, 2589–2591 (2009)

Other aspects of thera



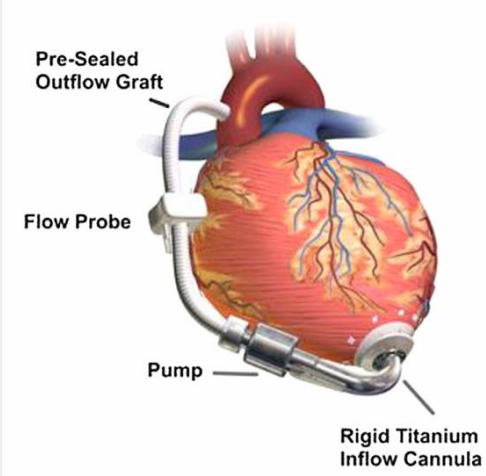
- Debridement and **vacuum-assisted closure** system, Ab-impregnated beads in the pocket
- Removal of the device??
  - Donor heart available
  - Replacement: high risk of complications and relapse
    - REMATCH study: 1 and 2 yr survival after replacement: 41% and 33%
- Alternatives: transplantation, suppressive therapy

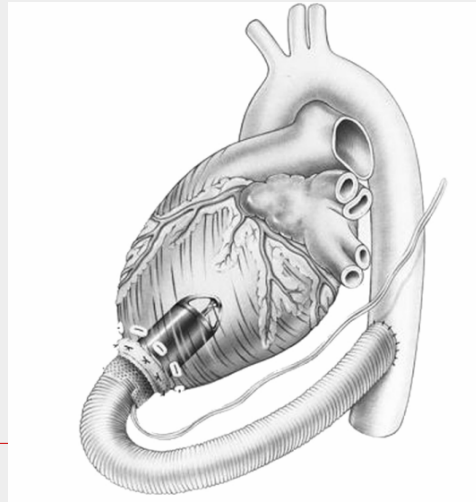
DAV

1. Que son?
2. Infecciones?
3. Manejo?
4. ***Prevención?*** → **Antimicrobianos**
   Otros

Prevention. No clinical trials

- Maximum **surgical prevention** strategies
  - Operating room traffic, HEPA filters
  - Wrapping the pump and drivelines in Ab pads??
  - Tunneling driveline contralateral to pump pocket
  - Occlusive dressing of driveline exit
  - Chlorhexidine bathing
- **Postoperative infection prevention**
  - Extubation, pulmonary toilet
  - Removal of catheters
  - Nutrition…..
- **Prophylactic antibiotics**





Broad-spectrum Preemptive Treatment of Infectious Complications of Short-Term Ventricular Assist Devices (VAD)

Muñoz P, Padilla C, Barrio JM, Ruiz M, Palomo J, Pinto A, F. Cañizo, and Bouza E

Hospital General Universitario Gregorio Marañón, Madrid, Spain

- January 89-December 2009
- 87 patients: 66 CP (cephazolin) and 21 PT (meropenem + vancomycin or linezolid + fluconazole for 7 days)

- Multivariate analysis **infection**
  - each day on the device (OR 1.4, p=0.001)
  - **PT independent protective factor** (OR 0.14, p=0.02).

	CP Group (n=66)	PT Group (n=21)	P value
Age, mean (range)	52 (20 – 68)	52 (20 – 73)	0.21
Gender	M: 59% F: 41%	M: 71% F: 29%	0.44
APACHE, mean	19	21	0.220
ASA Score	3.8	3.8	0.499
Charlson comorbidity index	1.8	2.4	0.001

Broad-spectrum Preemptive Treatment of Infectious Complications of Short-Term Ventricular Assist Devices (VAD)

Muñoz P, Padilla C, Barrio JM, Ruiz M, Palomo J, Pinto A, F. Cañizo, and Bouza E

Hospital General Universitario Gregorio Marañón, Madrid, Spain

- Risk of **death**
  - neurologic event
  - BSI (OR 1.5, p=0.005).
- No increase in multiresistant microorganisms
- No fungal infections in the PT

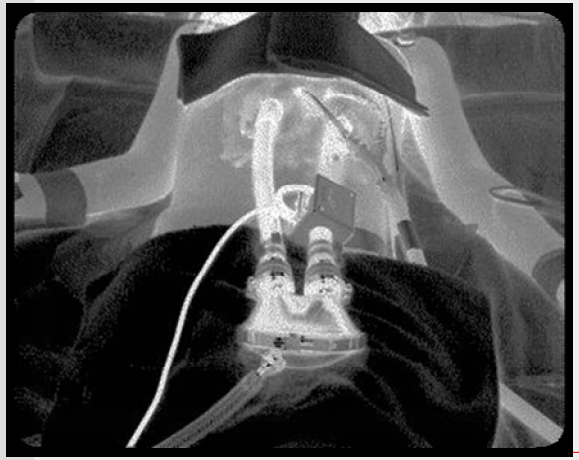
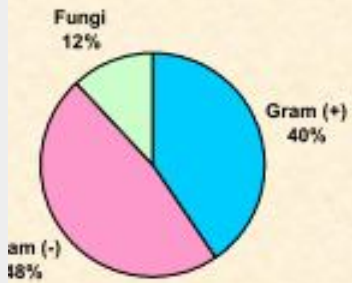
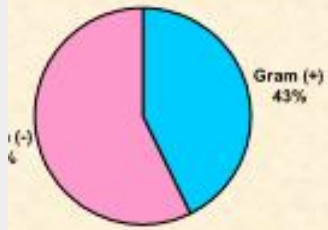


Figure 2. Etiology of Infections in the CP Group



	n (%)
•Gram (+)	
•CNS	7 (17)
•MSSA	3 (7)
•MRSA	3 (7)
•*Enterococcus* spp.	4 (10)
•Gram (-)	
•*Enterobacteriaceae*	12 (29)
•*Pseudomonas* spp.	4 (10)
•Other GNB	3 (7)
•Fungi	
•*Candida* spp.	3 (7)
•*Aspergillus* spp.	3 (7)

Figure 3. Etiology of Infections in the PT Group



	n (%)
•Gram (+)	
•CNS	9 (43)
•MSSA	-
•MRSA	-
•*Enterococcus* spp.	-
•Gram (-)	
•*Enterobacteriaceae*	4 (19)
•*Pseudomonas* spp.	4 (19)
•Other GNB	4 (19)
•Fungi	
•*Candida* spp.	-
•*Aspergillus* spp.	-

Interactive CardioVascular and Thoracic Surgery 14 (2012) 209–214
doi:10.1093/icvts/ivr054 Advance Access publication 30 November 2011

BEST EVIDENCE TOPIC

What is the optimum antibiotic prophylaxis in patients undergoing implantation of a left ventricular assist device?

Metesh Nalin Acharya[a,*], Robin Som[a] and Steven Tsui[b]

- Many different regimes
  - NY Columbia Presbyterian: vancomycin + fluoroquinolone + rifampicin + fluconazole (REMATCH trial)
- Vancomycin: reduction from 41 to 20.8 days*
- **Recent meta-analysis**
  - Cephalosporin/vancomycin – antifungal – mupirocin
  - Fluoroquinolones ?
  - 48-72 hours

*[illegible] 2009; 30:484-486

En resumen

- Infección produce importante morbi-mortalidad en pacientes con DAV, pero no excluye el Tx
- La incidencia es menor con los nuevos dispositivos intracorporales, pero no son comunes en nuestro país
- Primeros criterios diagnósticos recientemente publicados
- Estrategias de prevención por definir
- La frecuencia de la IC, la escasez de donantes y el envejecimiento ha conducido a una gran revolución en este campo. Hemos de estar preparados

Bibliografía recomendada

Ventricular assist device-related infections

Rachel J Gordon, Bianca Quagliarello, Franklin D Lowy

Lancet Infect Dis 2006; 6: 426–37

Working formulation for the standardization of definitions of infections in patients using ventricular assist devices

Margaret M. Hannan, MD[l], Shahid Husain, MD,[b] Frauke Mattner, MD,[c] Lara Danziger-Isakov, MD,[d] Richard J. Drew, MB,[a] G. Ralph Corey, MD,[e] Stephan Schueler, MD, PhD,[g] William L. Holman, MD,[h] Leo P. Lawler, MD,[a] Steve M. Gordon, MD,[d] Niall G. Mahon, MD,[a] John M. Herre, MD,[f] Kate Gould, MB,[g] Jose G. Montoya, MD,[i] Robert F. Padera, MD, PhD,[j] Robert L. Kormos, MD,[k] John V. Conte, MD,[l] and Martha L. Mooney, MD[e]

The Journal of Heart and Lung Transplantation, Vol 30, No 4, April 2011

Left Ventricular Assist Device–Related Infection: Treatment and Outcome

CID 2005:40

David Simon,[1] Staci Fischer,[3] Angela Grossman,[1] Carol Downer,[1] Bala Hota,[2] Alain Heroux,[1] and Gordon Trenholme[1]

Driveline Infections in Left Ventricular Assist Devices: Implications for Destination Therapy

Vikas Sharma, MD, Salil V. Deo, MS, MCh, John M. Stulak, MD, Lucian A. Durham III, MD, PhD, Richard C. Daly, MD, Soon J. Park, MD, Larry M. Baddour, MD, Kashish Mehra, MBBS, and Lyle D. Joyce, MD, PhD

Divisions of Cardiovascular Surgery and Infectious Diseases, Mayo Clinic, Rochester, Minnesota

(Ann Thorac Surg 2012;

Best Practice & Research Clinical Anaesthesiology 26 (2012) 117–130

Contents lists available at SciVerse ScienceDirect

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journal homepage: www.elsevier.com/locate/bean

3

Newer-generation ventricular assist devices

Shvetank Agarwal, M.D., Fellow in Cardiothoracic Anesthesia,
Kane M. High, M.D., M.S., Associate Professor of Anesthesiology and Critical Care *

Department of Anesthesiology, Penn State Hershey, PO Box 850, Hershey, PA 17033, USA

Continuous-flow devices and percutaneous site infections: Clinical outcomes

J Heart Lung Transplant 2012

Daniel J. Goldstein, MD,[a] David Naftel, PhD,[b] William Holman, MD,[b] Lavanya Bellumkonda, MD,[c] Salpy V. Pamboukian, MD, MSPH,[d] Francis D. Pagani, MD,[e] and James Kirklin, MD[b]

Left Ventricular Assist Device–Associated Infections

Sophia Califano, MD[a], Francis D. Pagani, MD, PhD[b], Preeti N. Malani, MD, MSJ[c,*]

Infect Dis Clin N Am 26 (2012) 77–87
doi:10.1016/j.idc.2011.09.008

Left Ventricular Assist Device Driveline Infections

Daniel Pereda, MD, John V. Conte, MD*

Cardiol Clin 29 (2011) 515–527
doi:10.1016/j.ccl.2011.08.004

Muchas gracias