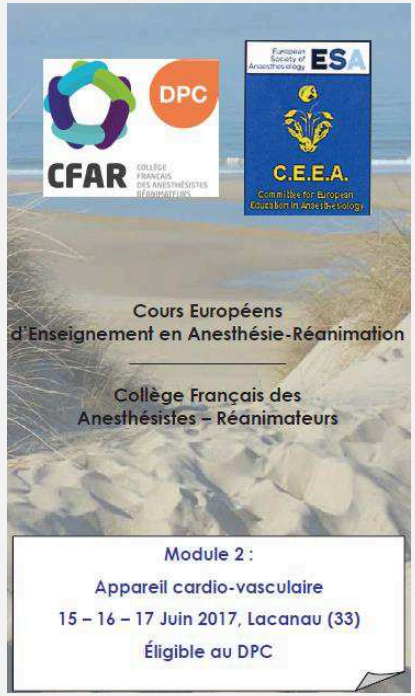


Traitement mécanique de l'insuffisance cardiaque chronique

Vincent VENIARD

Cours Européens d'enseignement en Anesthésie – Réanimation

LACANAU 16 juin 2017

- Pas de conflits d’interet

Insuffisance cardiaque

- **Problème de santé publique :**
  - 150000 nouveaux patients/an
  - Dépenses de santé considérables
  - 100 000 hospitalisations /an
  - 40 000 DC/an

- **Traitements :**
  - Education thérapeutique
  - Réadaptation cardiovasculaire
  - Traitement médicamenteux (IEC, BB, ARM, Entresto®)
  - Traitement électrique (DAI, CRT)
  - Traitement chirurgical (valvulopathie, revascularisation)

Insuffisance cardiaque terminale

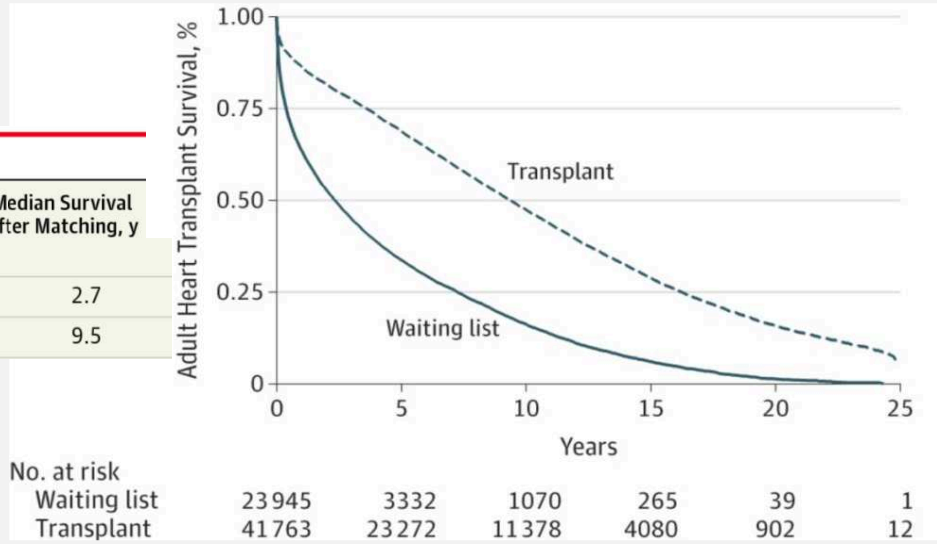
- **Définition**
  - Stade avancé de l'insuffisance cardiaque chronique
  - 3 - 4 NYHA
  - Malgré traitement optimal (médical, électrique et chirurgical)

- **Traitement de référence** → **Transplantation cardiaque**

- **Mauvais pronostic**

Table 2. Survival Benefit of Solid-Organ Transplant After Propensity Score Matching

Transplant Type and Patient Category	No. of Patients	Unadjusted Median Survival, y	No. of Patients After Matching	Median Survival After Matching, y
Heart				
Waiting list	38 578	2.3	31 086	2.7
Transplant	54 039	9.5	53 173	9.5



Survival Benefit of Solid-Organ Transplant in the United States, JAMA Surg. 2015

Insuffisance cardiaque terminale

- **CI à la greffe (Age, comorbidités …)**

- **Pénurie de greffon**

	2015
Liste d'attente	
- malades restant en attente au 1er janvier de chaque année	358
dont malades en attente au 1er janvier et en CIT	107
Part des malades en CIT parmi les malades en attente au 1er janvier	30%
- nouveaux inscrits dans l'année	622
- décédés dans l'année	78
- sortis de la liste d'attente	52
- dont sortis de la liste d'attente pour aggravation	18
Greffes	471

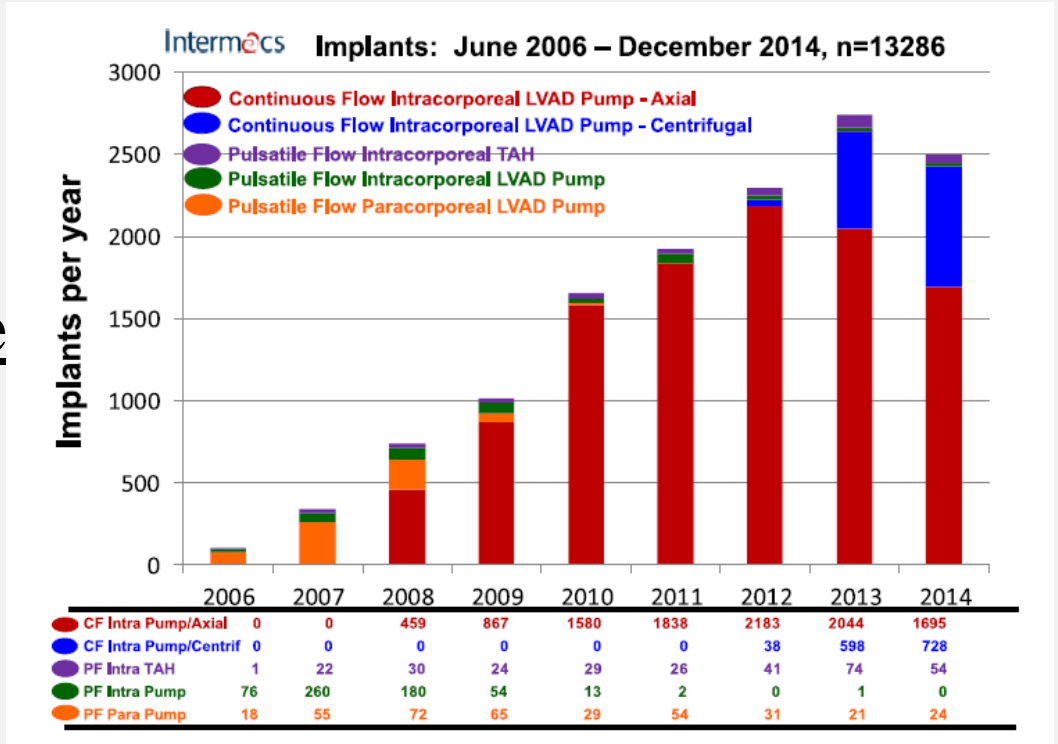
980 inscrits pour 471 greffes

→ **Assistance cardiaque de longue durée**

Assistance cardiaque de longue durée

- **Assistance mono VG (LVAD : left ventricular assist device)**
  - Heart Mate 2®
  - Heart Ware®
  - Jarvik 2000®

- **Assistance bi ventriculaire**
  - BiVAD
    - Berlin Heart®
    - Bi HVAD
  - Cœur artificiel total (Cardiowest®)



Seventh INTERMACS annual report: 15,000 patients and counting

J Heart Lung Transplant 2015;34:1495–1504

Les indications

Table 13.1 Terms describing various indications for mechanical circulatory support

Bridge to decision (BTD)/ Bridge to bridge (BTB)	Use of short-term MCS (e.g. ECLS or ECMO) in patients with cardiogenic shock until haemodynamics and end-organ perfusion are stabilized, contra-indications for long-term MCS are excluded (brain damage after resuscitation) and additional therapeutic options including long-term VAD therapy or heart transplant can be evaluated.
Bridge to candidacy (BTC)	Use of MCS (usually LVAD) to improve end-organ function in order to make an ineligible patient eligible for heart transplantation.
Bridge to transplantation (BTT)	Use of MCS (LVAD or BiVAD) to keep patient alive who is otherwise at high risk of death before transplantation until a donor organ becomes available.
Bridge to recovery (BTR)	Use of MCS (typically LVAD) to keep patient alive until cardiac function recovers sufficiently to remove MCS.
Destination therapy (DT)	Long-term use of MCS (LVAD) as an alternative to transplantation in patients with end-stage HF ineligible for transplantation or long-term waiting for heart transplantation.

Recommendations for implantation of mechanical circulatory support in patients with refractory heart failure

Recommendations	Class [a]	Level [b]	Ref [c]
An LVAD should be considered in patients who have end- stage HFrEF despite optimal medical and device therapy and who are eligible for heart transplantation in order to improve symptoms, reduce the risk of HF hospitalization and the risk of premature death (Bridge to transplant indication).	IIa	C	

Recommendations for implantation of mechanical circulatory support in patients with refractory heart failure

An LVAD should be considered in patients who have end-stage HFrEF despite optimal medical and device therapy and who are not eligible for heart transplantation to, reduce the risk of premature death.	IIa	B	605, 612, 613

2016 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure

European Journal of Heart Failure (2016)

Les indications

Table 13.2 INTERMACS (Interagency Registry for Mechanically Assisted Circulatory Support) stages for classifying patients with advanced heart failure

	INTERMACS level	NYHA Class	Description	Device	1y survival with LVAD therapy	
AIGU	1. Cardiogenic shock "Crash and burn"	IV	Haemodynamic instability in spite of increasing doses of catecholamines and/or mechanical circulatory support with critical hypoperfusion of target organs (severe cardiogenic shock).	ECLS, ECMO, percutaneous support devices	52.6±5.6%	14%
	2. Progressive decline despite inotropic support "Sliding on inotropes"	IV	Intravenous inotropic support with acceptable blood pressure but rapid deterioration of renal function, nutritional state, or signs of congestion.	ECLS, ECMO, LVAD	63.1±3.1%	36%
	3. Stable but inotrope dependent "Dependent stability"	IV	Haemodynamic stability with low or intermediate doses of inotropics, but necessary due to hypotension, worsening of symptoms, or progressive renal failure.	LVAD	78.4±2.5%	30%
CHRO	4. Resting symptoms "Frequent flyer"	IV ambulatory	Temporary cessation of inotropic treatment is possible, but patient presents with frequent symptom recurrences and typically with fluid overload.	LVAD	78.7±3.0%	15%
	5. Exertion intolerant "Housebound"	IV ambulatory	Complete cessation of physical activity, stable at rest, but frequently with moderate fluid retention and some level of renal dysfunction.	LVAD	93.0±3.9%[a]	3%
	6. Exertion limited "Walking wounded"	III	Minor limitation on physical activity and absence of congestion while at rest. Easily fatigued by light activity.	LVAD / Discuss LVAD as option	-	
	7. "Placeholder"	III	Patient in NYHA Class III with no current or recent unstable fluid balance.	Discuss LVAD as option	-	

2016 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure

European Journal of Heart Failure (2016)

Seventh INTERMACS annual report: 15,000 patients and counting

J Heart Lung Transplant 2015;34:1495–1504

Les critères d'exclusion

- **Age** (> 60 ans : Attention aux comorbidités)
- **Hémodynamique** : instabilité hémodynamique majeure
- **Cancer** : néoplasie active et espérance de vie < de 2 ans
- **Sepsis** :
  - Endocardite : plus de bactériémie depuis 5 jours et ATB depuis 7 jours
  - Infection DAI et PM avec bactériémie
- **Atteinte sévère autres organes** (poumon, cerveau, rein, foie)
- **Consommation active drogues** (y compris alcool)

The 2013 International Society for Heart and Lung Transplantation Guidelines for mechanical circulatory support: Executive summary

Les critères d'exclusion

- **Atteinte psychiatrique ou psychologique** (institution ou incapacité à se prendre en charge)
- **ATCD de mauvaise compliance au traitement**
- **Isolement** : patient vivant seul sans personne ressource proche
- **Grossesse**
- **Pour LVAD** :
  - Risque élevé de dysfonction VD post implantation
  - IC FEP (dysfonction diastolique)

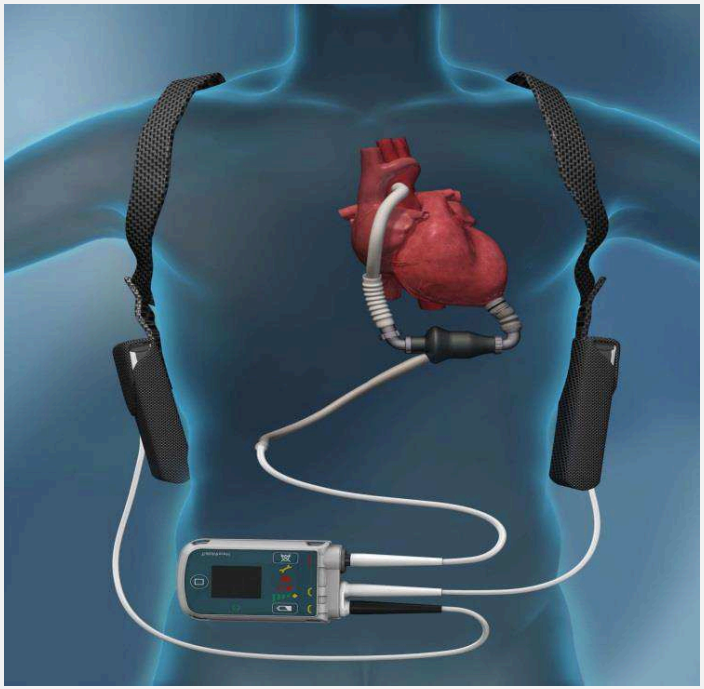
The 2013 International Society for Heart and Lung Transplantation Guidelines for mechanical circulatory support: Executive summary

Assistance de longue durée

- **Assistance mono VG (LVAD)**
  - Heart Mate 2®
  - Heart Ware®
  - Jarvik 2000®

- **Assistance bi ventriculaire**
  - Bi VAD
    - Berlin Heart®
    - Bi HVAD
  - Cœur artificiel total : Cardiowest®

LVAD : Heart Mate 2®



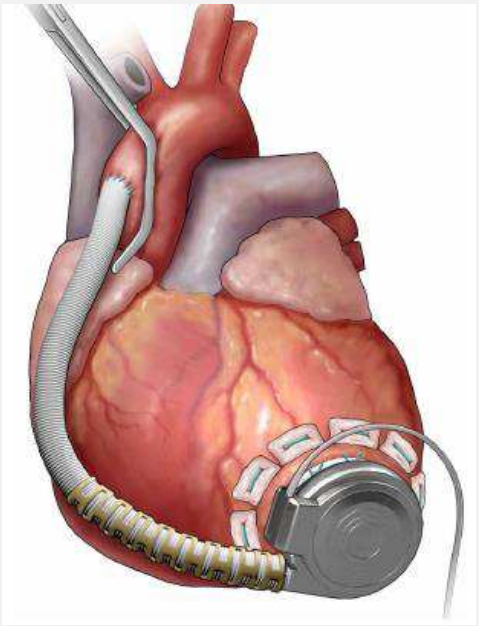
- Pompe axiale à débit continu
- Debit: 3 – 10 L/min
- Dispositif intra-thoracique avec batteries et contrôleur externes
- Câble avec sortie percutanée au niveau abdominal
- Marquage CE : nov 2005

LVAD : Heart Ware®

- Pompe centrifuge à débit continu
- Dispositif intra-thoracique avec batteries contrôleur externes
- Câble avec sortie percutanée au niveau abdominal

- Pompe implantable miniaturisée

(50cc / 160g, 50mm de diamètre externe)



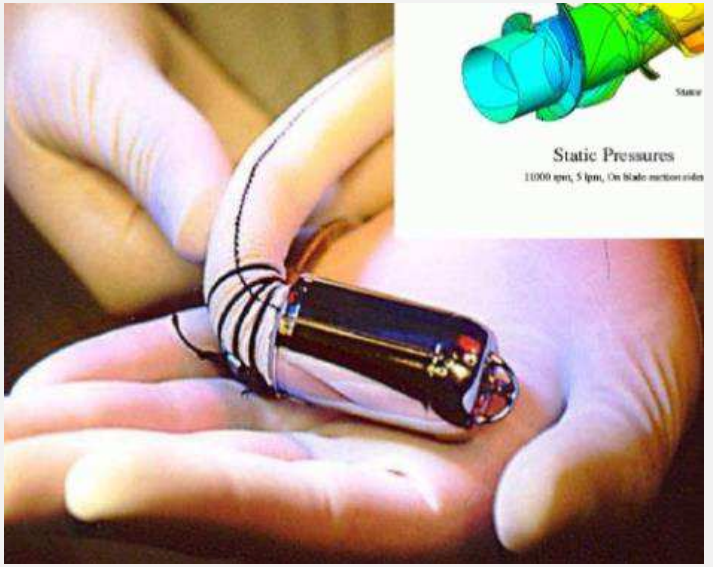
- Début jusqu'à 10 litres/mn

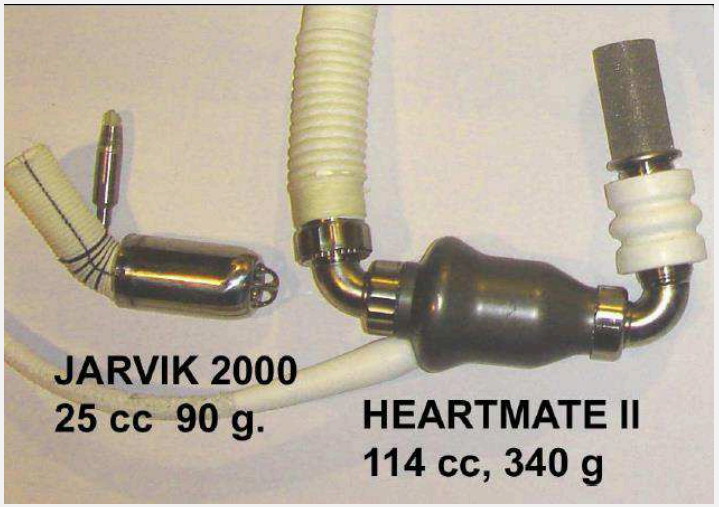
- Marquage CE 2009
- Approuvé FDA en BTT nov 2012

- SC sup 1,2 m²

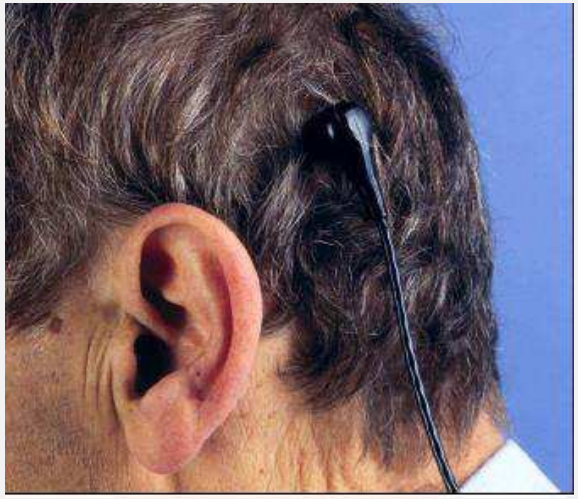
LVAD : Jarvik 2000®

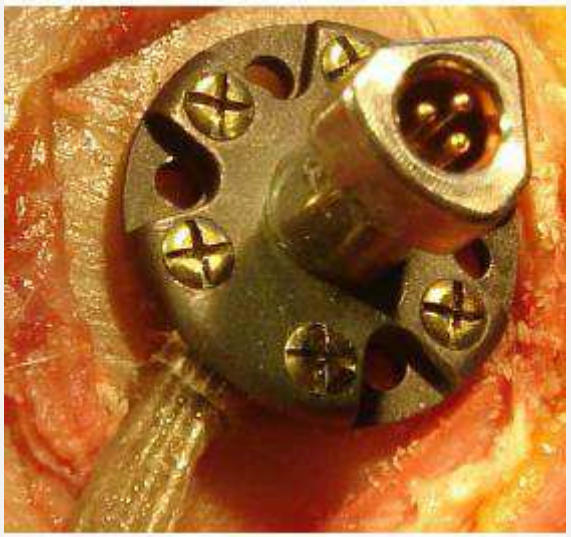
- Pompe axiale à débit continu
- Dispositif intra-thoracique avec batteries et contrôleur externes
- Pompe implantable miniaturisée (25cc / 90g)
- Débit de 2 à 7 litres/mn
- Caractéristique particulière: ***connectique retro auriculaire***

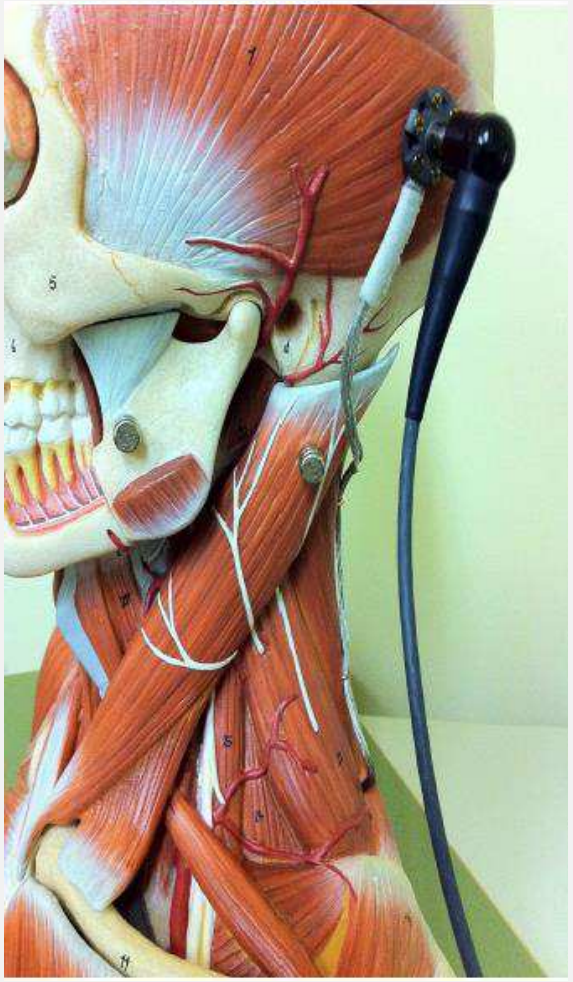


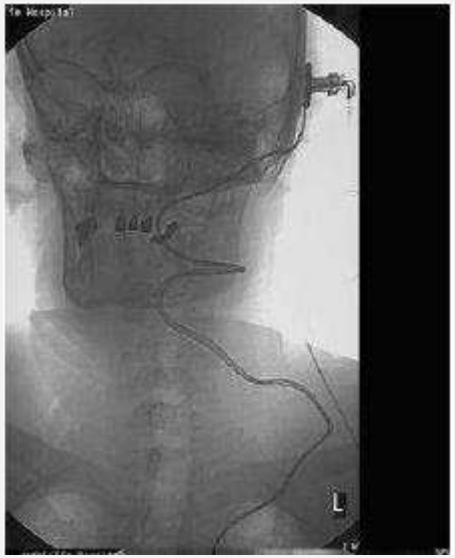


LVAD : Jarvik 2000®









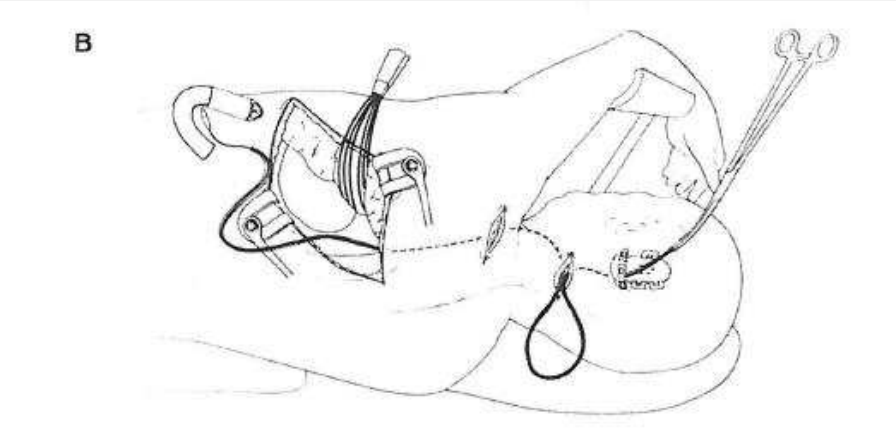
La connexion retro auriculaire

- Pas ou peu d'infection
- Pas de pansement
- Connectique étanche (douche, bain)

LVAD : Techniques chirurgicales

- Sternotomie classique

- Voies mini invasives
  - Thoracotomie gauche avec implantation sur aorte descendante
  - Double thoracotomie G/D



Assistance bi ventriculaire
Cœur artificiel total **Cardiowest®**

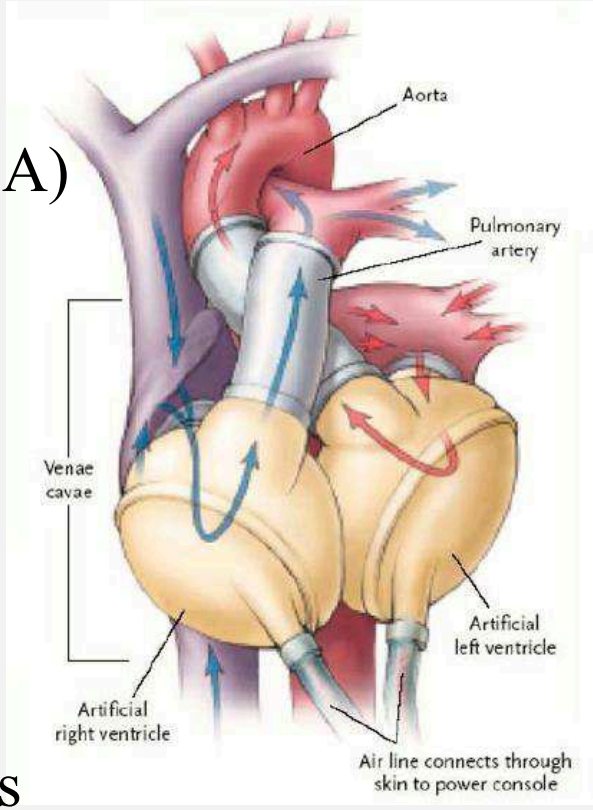
- Assistance bi ventriculaire pneumatique pulsatile
- Totalement implantable

- Première implantation : 2 décembre 1982 (USA)

- **Uniquement en attente de transplantation**

- Debit max: 9 l/min

- Problème de place dans le thorax :
  - surfaces corporelles inférieures à 1,7 m²
  - distance entre le sternum et le 10ème corps vertébral inférieure à 10 cm.

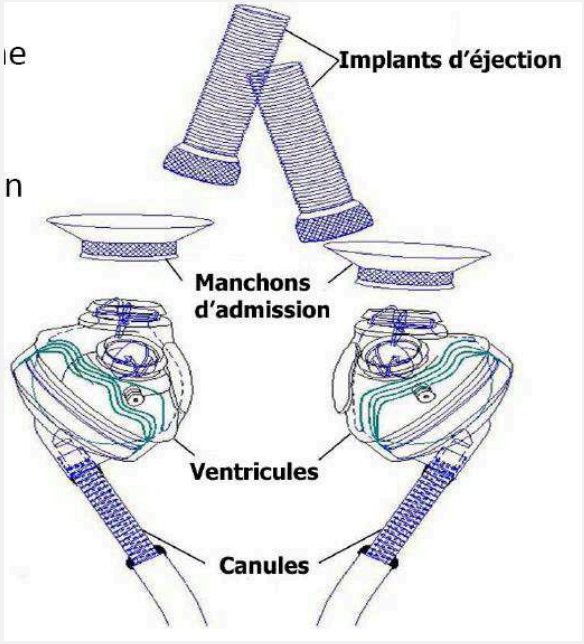


Cœur artificiel total

- **<u>TAH implantable</u>**
  - Deux ventricules artificiels pneumatiques (polyuréthane semi-rigide)
  - diaphragmes flexibles en polyuréthane séparant la cavité sanguine de la cavité aérique
  - 2 collerettes d'admission
  - 4 valves mécaniques

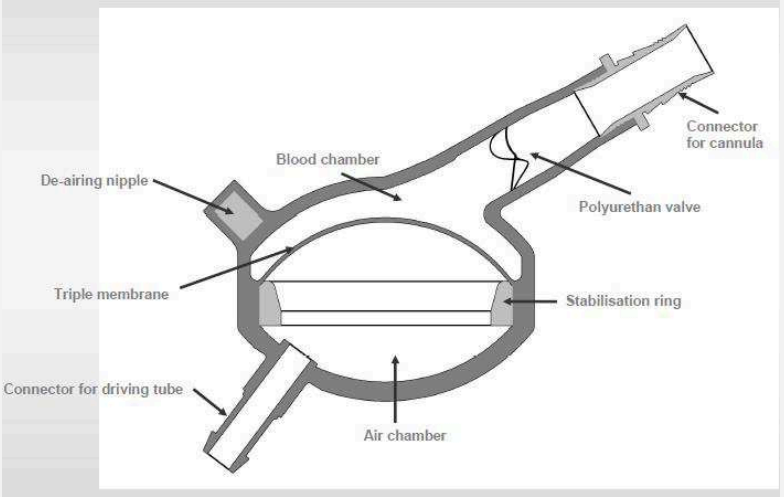
- **<u>Console externe</u>**

- **<u>Tubulures de 2 mètres de long</u>**



Berlin Heart®

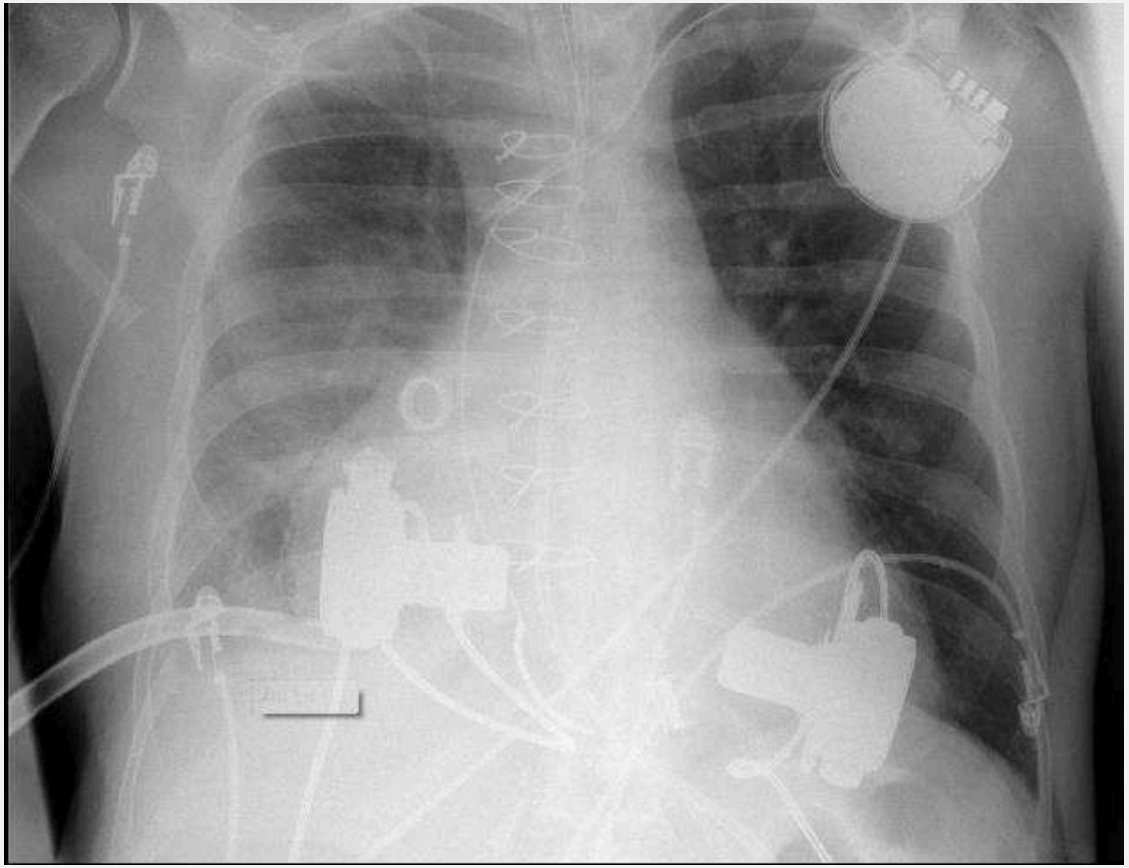
- Assistance bi ventriculaire pneumatique pulsatile
- Para corporelle



- Enfants, adolescents et adultes de petit gabarit

- Pont à la greffe ou pont à la récupération

Double Heart Ware ®



Long-term biventricular HeartWare ventricular assist device support—Case series of right atrial and right ventricular implantation outcomes

J Heart Lung Transplant 2016;35:466–473

Equipe australienne
13 patients
Survie à 1 an : 62%

LVAD ou BiVAD : Fonction VD ??

- Conséquences LVAD sur VD

  - Diminution PTDVG / post charge VD

  - Majoration pré-charge VD
  - Attraction septale vers le VG
    - Perte de la part septale dans la contraction VD
    - Dilatation de l'anneau : majoration IT

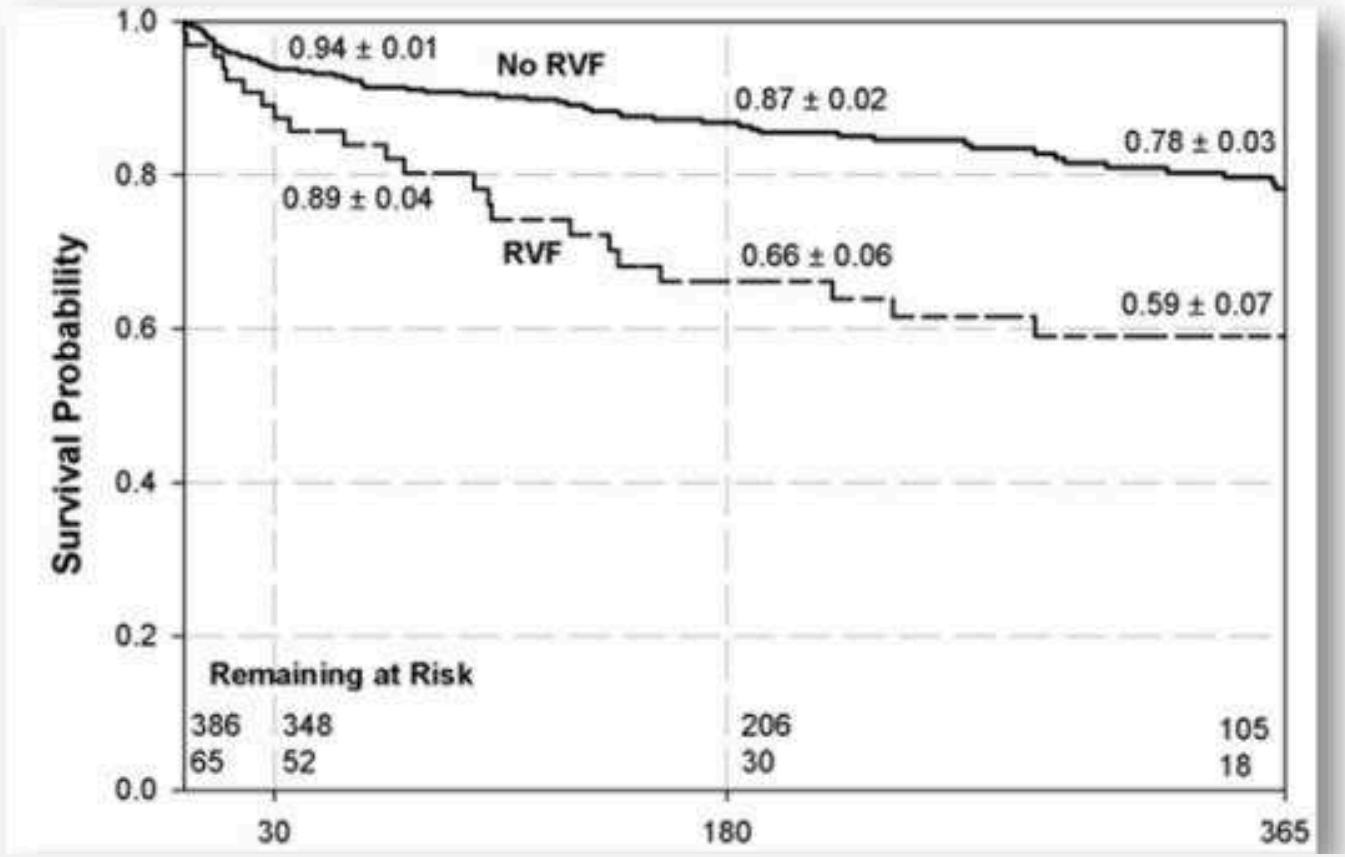
    → Altération FEVD

- Prédire la fonction VD post implantation ??

Right ventricular failure in patients with the HeartMate II continuous-flow left ventricular assist device: Incidence, risk factor and effect on outcomes

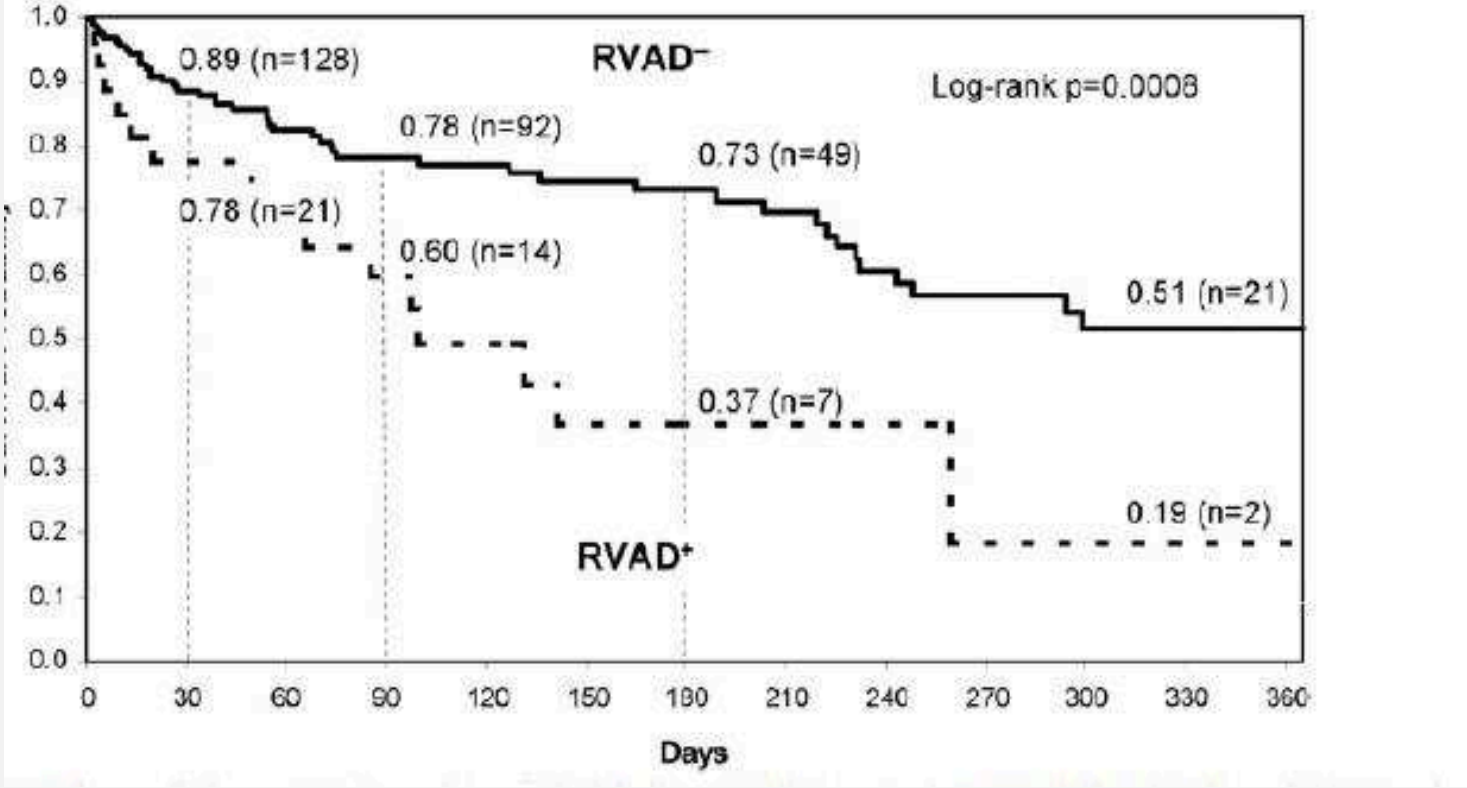
The Journal of Thoracic and Cardiovascular Surgery • May 20

Robert L. Kormos, MD,[a] Jeffrey J. Teuteberg, MD,[b] Francis D. Pagani, MD,[c] Stuart D. Russell, MD,[d]



Decision tree for adjuvant right ventricular support in patients receiving a left ventricular assist device

J Heart Lung Transplant 2012;31:140–9



Fonction VD et LVAD

Comment la prédire la dysfonction droite après LVAD

1. ETT
2. Cathétérisme cardiaque
3. Scores
   - Matthews (2008)
   - Fitzpatrick (2008)
   - Kormos (2008)
   - Atluri (2013)

Recommendations for assessing RV function:[102,130–139]

Class I:

1. All patients should have an echocardiographic assessment of RV function prior to MCSD implantation.
   Level of evidence: C.
2. All patients should have invasive assessment of intracardiac filling pressures prior to MCSD implantation, with a particular emphasis on RV hemodynamics.
   Level of evidence: C.

The 2013 International Society for Heart and Lung Transplantation Guidelines for mechanical circulatory support: Executive summary

The Journal of Heart and Lung Transplantation, Vol 32, No 2, February 2013

Données échographiques

Table 2 Echocardiographic Parameters Correlated with Right Ventricular Failure After Left Ventricular Assist Device

- Qualitative right ventricular dysfunction
- Tricuspid annular plane systolic excursion (TAPSE)
- Fractional area change
- Right ventricular index of myocardial performance
- Right ventricular systolic and diastolic longitudinal strain
- Right ventricle short-axis–to–long-axis ratio
- Right ventricle end-diastolic dimension-to-left ventricle end-diastolic dimension ratio
- Tricuspid annular dilation without significant tricuspid regurgitation
- Left ventricular ejection fraction
- Left ventricular end diastolic dimension
- Tricuspid regurgitation duration corrected for heart rate
- Peak systolic (S') velocity of the right ventricular free wall at the tricuspid annulus assessed with tissue Doppler
- Early diastolic (E') velocity of the right ventricular free wall at the tricuspid annulus assessed with tissue Doppler
- Right ventricular E/E' ratio
- TAPSE increase in response to dobutamine infusion
- Severity of tricuspid regurgitation
- 3-Dimensional right ventricular end-systolic and end-diastolic volume index

Echocardiographic parameters associated with right ventricular failure after left ventricular assist device: A review

The Journal of Heart and Lung Transplantation, Vol 35, No 3, March 2016

Kukucka[12]	2011	115	Pulsatile 56% Continuous 44%	1. **RV-to-LV end-diastolic diameter (R/L) ratio obtained from transesophageal echo**
Grant[13]	2012	117	Continuous 100%	1. **RV free wall peak longitudinal strain**
Kato[14]	2012	111	Pulsatile 29% Continuous 71%	1. **LVEDD** 2. **LV ejection fraction** 3. **Left atrial diameter/ LVEDD** 4. Total bilirubin 5. Albumin 6. RV stroke work index
Atluri[15]	2013	167	Pulsatile 51% Continuous 49%	1. CVP >15 mm Hg 2. **Severe RV dysfunction** 3. Preoperative intubation 4. **Severe tricuspid regurgitation** 5. Heart rate >100 beats/ min
Vivo[16]	2013	109	Pulsatile 15% Continuous 85%	1. **RV-to-LV end-diastolic diameter (R/L) ratio obtained from transthoracic echo**
Kiernan[17]	2015	24	Continuous 100%	1. **RV end-systolic volume index** 2. **RV end-diastolic volume index**
Potapov[10]	2008	54	Pulsatile 31% Continuous 69%	1. **Tricuspid incompetence** 2. **RV end-diastolic diameter >35 mm** 3. **RV ejection fraction <30%** 4. **Right atrial dimension <50 mm** 5. **Short-/long-axis ratio >0.6**

Données hémodynamiques

Facteurs pronostics de défaillance droite post op:

1. CVP > 15 mm Hg
2. CVP / PAPO > 0.63
3. RVSWI < 300/600

$$RVSWI = (PAPm\text{-}PVC) * SV/BSA$$

4. PAPi < 2

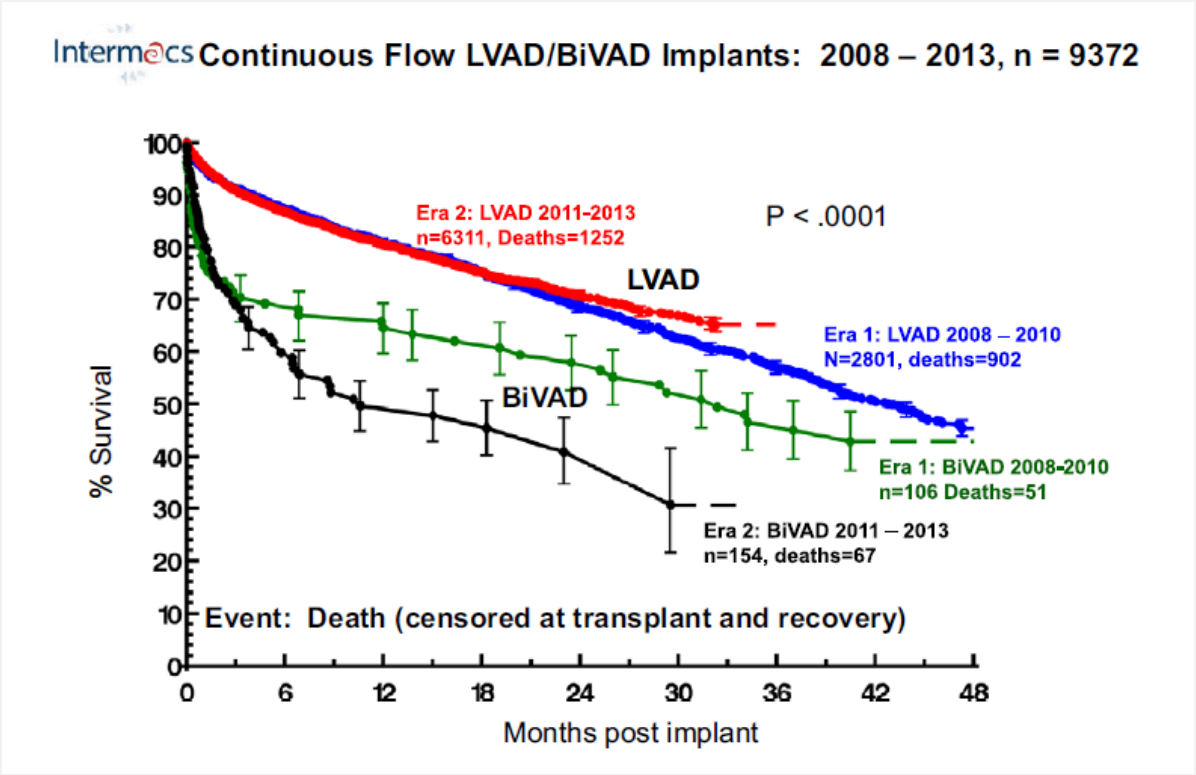
$$PAPi = (PAPs\text{-}PAPd) / CVP$$

5. PACi < 0.89

$$PACi = (PAPs\text{-}PAPd) * SV/BSA$$

Assistance mono VG / BiVAD : Les bénéfices

1. Survie



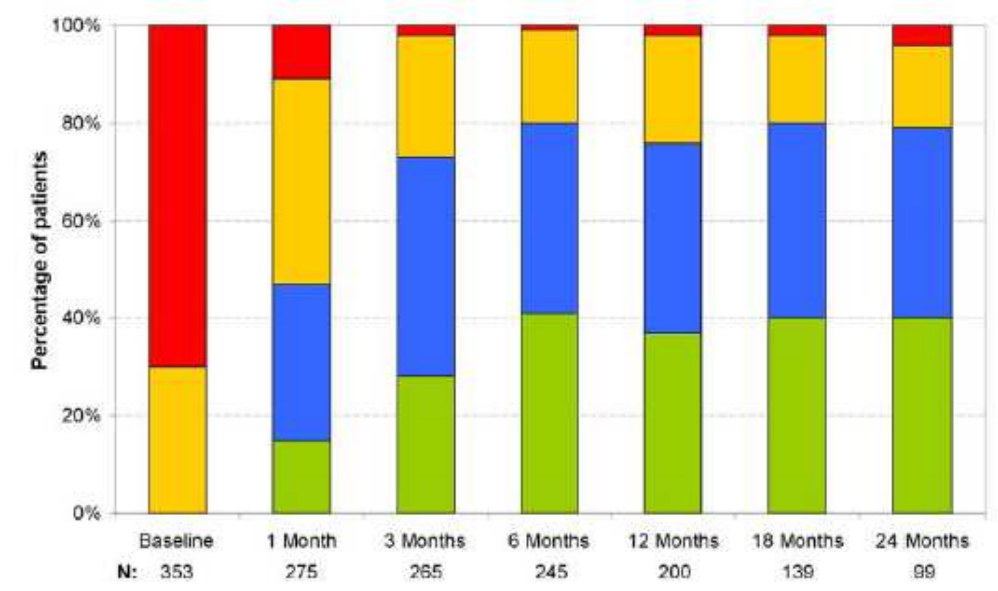
Months	% Survival
1	95%
12	80%
24	69%
36	59%
48	47%

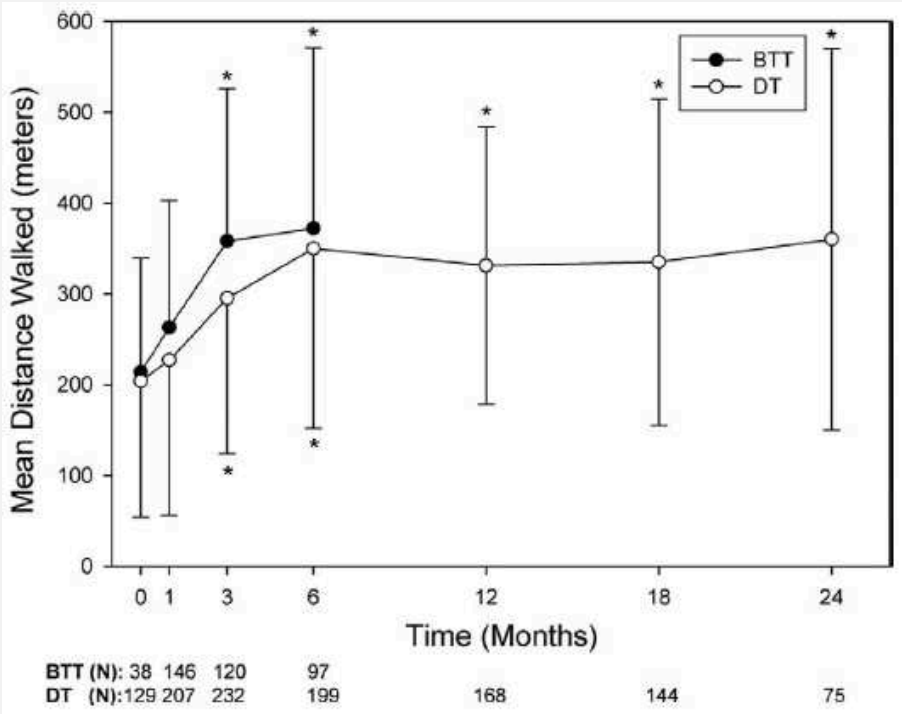
Sixth INTERMACS annual report: A 10,000-patient database

J Heart Lung Transplant 2014;33:555–564

Assistance mono VG / BiVAD : Les bénéfices

2. Statut fonctionnel : dyspnée et test de marche de 6 minutes

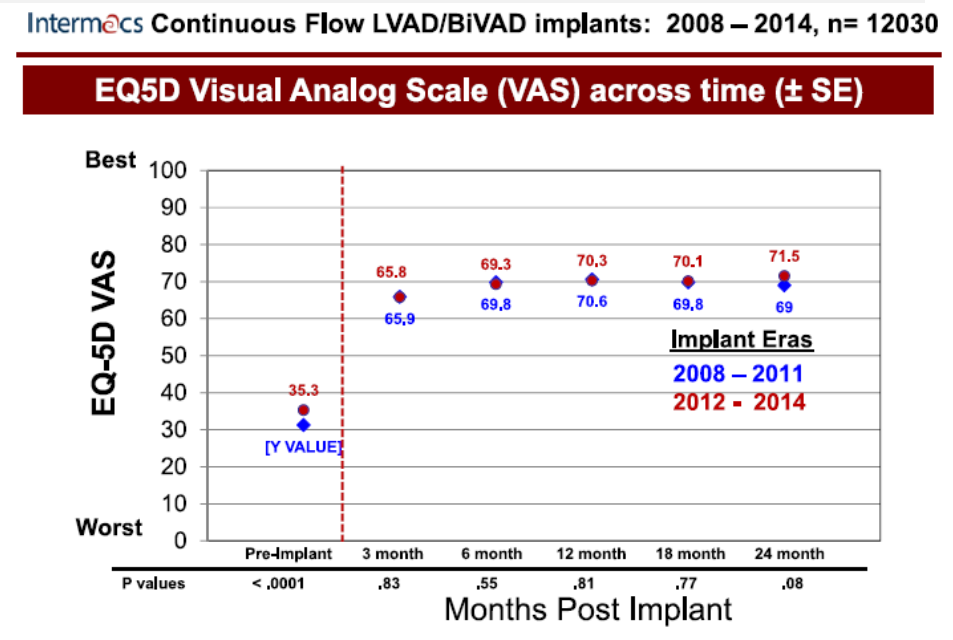


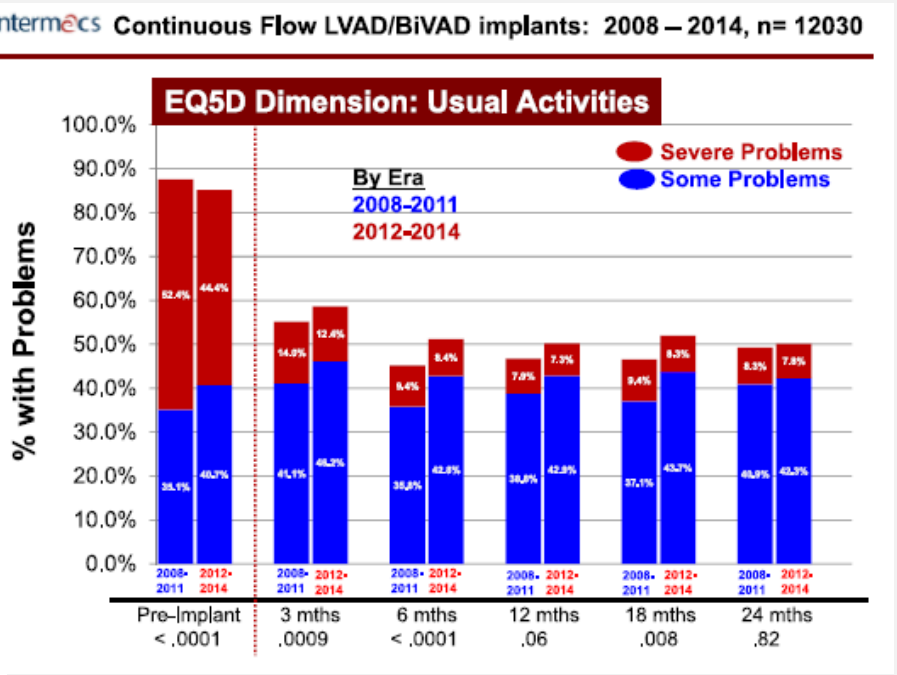


Rogers JG JACC.2010; 55:1826-34

Assistance mono VG / BiVAD : Les bénéfices

3. Echelle de qualité de vie





Seventh INTERMACS annual report: 15,000 patients and counting

J Heart Lung Transplant 2015;34:1495–1504

Assistance mono VG :

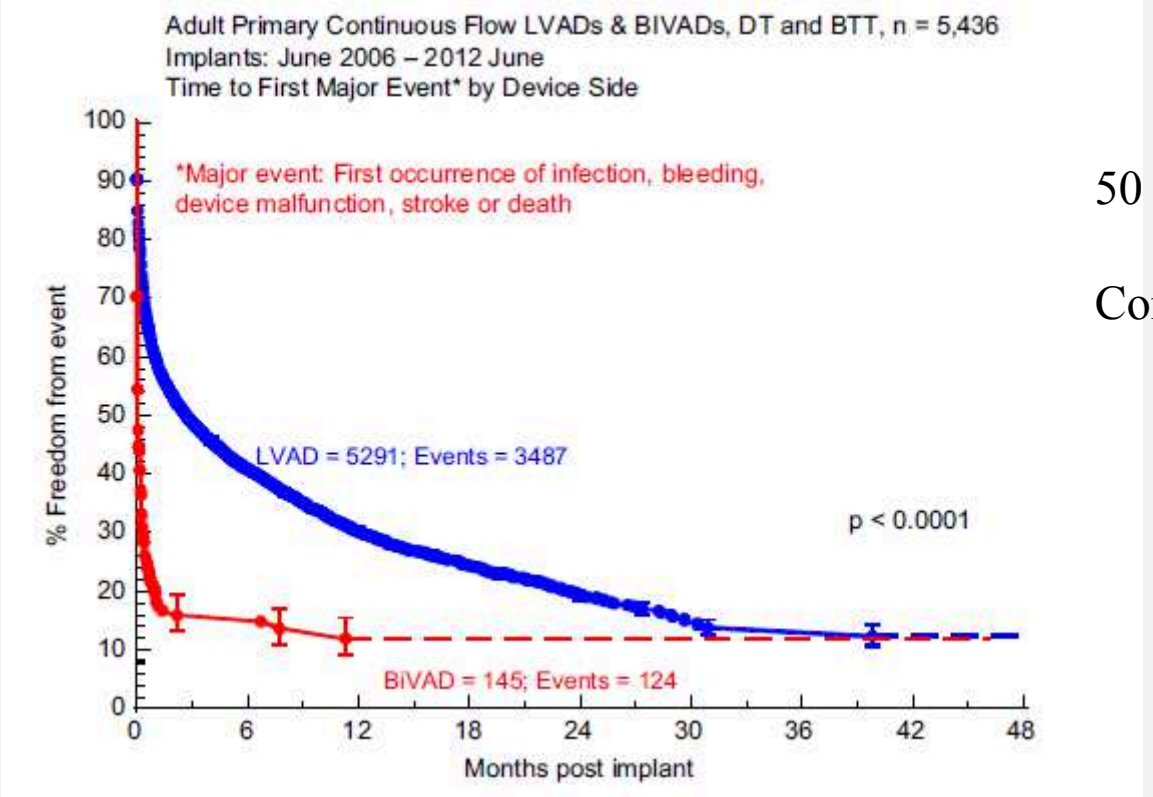
Les complications

Adverse event	Era 2 (n = 7,286): continuous 2012 to 2014 Events	Rate
Bleeding	4,420	7.79
Cardiac/vascular		
Right heart failure	276	0.49
Myocardial infarction	34	0.06
Cardiac arrhythmia	2,303	4.06
Pericardial drainage	305	0.54
Hypertension	115	0.20
Arterial non-CNS thrombosis	94	0.17
Venous thrombotic event	286	0.50
Hemolysis	314	0.55
Infection	4,132	7.28
Stroke	916	1.61
Renal dysfunction	876	1.54
Hepatic dysfunction	326	0.57
Respiratory failure	1,551	2.73
Wound dehiscence	96	0.17
Psychiatric episode	525	0.93
Total burden	16,569	29.20

Seventh INTERMACS annual report: 15,000 patients and counting

J Heart Lung Transplant 2015;34:1495–1504

Assistance mono VG / BiVAD
Les complications



50 patients avec TAH (Cardiowest)

Complications :

- 19% infections systémiques
- 20% infection de câble
- 15% d' évènement ischémiques
- 20% d' évènements hémorragiques

Seventh INTERMACS annual report: 15,000 patients and counting

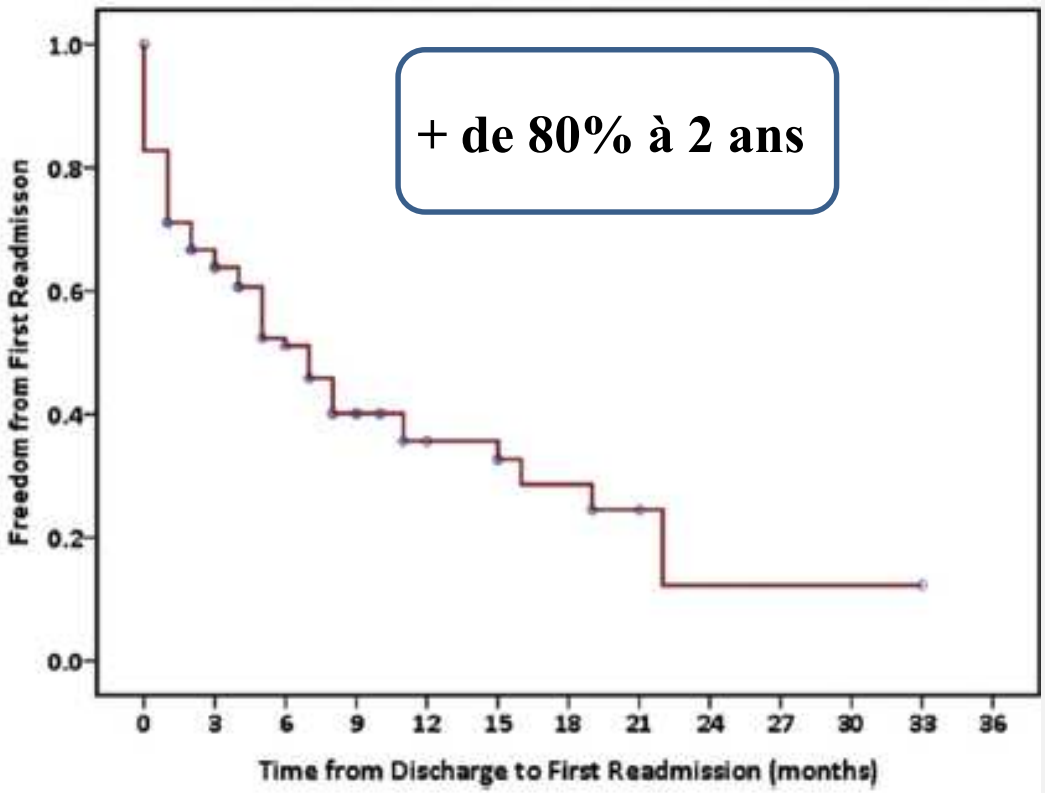
J Heart Lung Transplant 2015;34:1495–1504

Long Term Results with Total Artificial Heart: Is It Prime Time for Destination Therapy?

The Journal of Heart and Lung Transplantation, *April 2013*, G. Torregrossa, J. Copeland

Assistance mono VG : Les réadmissions

126 LVAD (HM2)



Bleeding	34
GI	30
Other[a]	4
Infections	32
Pump related (driveline)	21
Non–pump related[b]	11
Cardiac	21
Chest pain/MI	3
Arrhythmia	8
CHF	10
Stroke	13
Hemorrhagic	4
Ischemic	6
TIA	3
Pump events	13
Device malfunction	10
Pump alarms	3
Anticoagulation management	5
GI events	9
Acute kidney injury	6
Syncope/hypotension	5
N/V/D/abd pain NOS	5
Other[c]	13

Hospital Readmissions After Continuous-Flow Left Ventricular Assist Device Implantation: Incidence, Causes, and Cost Analysis

(Ann Thorac Surg 2015;100:884–9)

Traitement médical

- Traitement de l'insuffisance cardiaque (BB, IEC, ARM)
- Contrôle la PA
  - PAM entre 70 et 80 mmHg
  - Facteur de risque AVC
- Anticoagulation et AAP
- Autre traitement si nécessaire

Anticoagulation

Table 9 Anti-coagulation and Anti-platelet Therapy for Approved Mechanical Circulatory Support Devices

Device	INR range
AbioCor TAH[a]	2.5–3.5
HeartMate II[b,c]	2.0–3.0
HeartWare HVAD[d]	2.0–3.0
MicroMed DeBakey[e]	2.5–3.5
Syncardia TAH[f]	2.5–3.5
Thoratec IVAD[c]	2.5–3.5
Thoratec PVAD[c]	2.5–3.5

Table 11 Postoperative Anti-coagulation Guidelines for the HeartMate II Based on Results From the Clinical Trial

Timing	Action
Before leaving OR	Completely reverse the anti-coagulation.
Immediate post-op period	Generally, no action. Patients with other indications for anti-coagulation therapy, such as atrial fibrillation, history of LVA or LA thrombus, or low LVAD flow should be treated with anti-coagulants.
Day 2 to 5	Once there is no evidence of bleeding and the chest tubes have been removed, begin warfarin therapy with a target range for the INR of 1.5 to 2.5. Also begin aspirin at a dose of 81 to 325 mg daily.
Duration of support	Maintain on aspirin and warfarin,

INR, international normalized ratio; IV, intravenous; LA, left atrium; LVA, left ventricular aneurysm; LVAD, left ventricular assist device; OR, operating room.

J Heart Lung Transplant. 2010 Apr;29(4):S1-S39

Le suivi du patient

- Consultations 1 fois/mois – 1 fois /3 mois
  - Examen clinique avec orifice de sortie du câble
  - Poids, PAM
  - Bilan sanguin (BNP, INR, créatinine, CRP, LDH, hémoglobine plasmatique…)
  - Evaluation du statut fonctionnel (NYHA, 6MWT)
  - Radio pulmonaire et échographie cardiaque
  - Interrogation assistance (alarmes, puissance, débit)

Particularités

- Pouls périphérique parfois absent
- Mesure TA pas toujours évidente : prendre PAM avec stylo doppler et brassard manuel
- Arythmies graves « mieux » tolérées
  - Patient en FV sans pouls conscient !!!
- Choc électrique possible
- Pas d'IRM

Le futur …..

Technologie TET – Transcutaneous Energy Transmission

en collaboration avec **Dualis MedTech** (spin-off de German Aerospace Center)

Conclusion

- **IC terminale**
  - De + en + fréquente
  - Mauvais pronostic
  - Pénurie de greffon et nombreuses contre indication à la greffe

- **ACM de longue durée** : progrès évidents et majeurs

- **Place dans l'IC systolique terminale**
  - Aigues ou chroniques
  - Apres éventuelles assistances de courte durée
  - Indication : BTT / DT / BTR / BTD

Conclusion

- **LVAD :** (Défaillance VG seule)
  - Survie sur les 2 premières années équivalente à la transplantation cardiaque
  - Qualité de vie améliorée
  - Complications nombreuses
  - Surveillance rapprochée essentielle
  - Solution adaptée en attente de greffe ou en alternative à la greffe

- **Bi VAD** (Défaillance bi ventriculaire)
  - Morbi-mortalité plus élevée
  - Qualité de vie moins bonne
  - Indication : attente de greffe

Merci de votre attention

Les critères d'exclusion

- **Consommation active drogues** (y compris alcool)
- **Atteinte psychiatrique ou psychologique** (institution ou incapacité à se prendre en charge)
- **ATCD de mauvaise compliance au traitement**
- **Isolement** : patient vivant seul sans personne ressource proche
- **Grossesse**

CI relative

- Maladie vasculaire périphérique étendue et sévère
- Diabète avec rétinopathie proliférative, mauvais contrôle glycémique, neuropathie sévère , néphropathie ou atteinte vasculaire
- Valvulopathie: VA Meca / VA bio RM / RVM bio Iao / RVA bio

The 2013 International Society for Heart and Lung Transplantation Guidelines for mechanical circulatory support: Executive summary

LVAD en pont à la transplantation

Use of a Continuous-Flow Device in Patients Awaiting Heart Transplantation

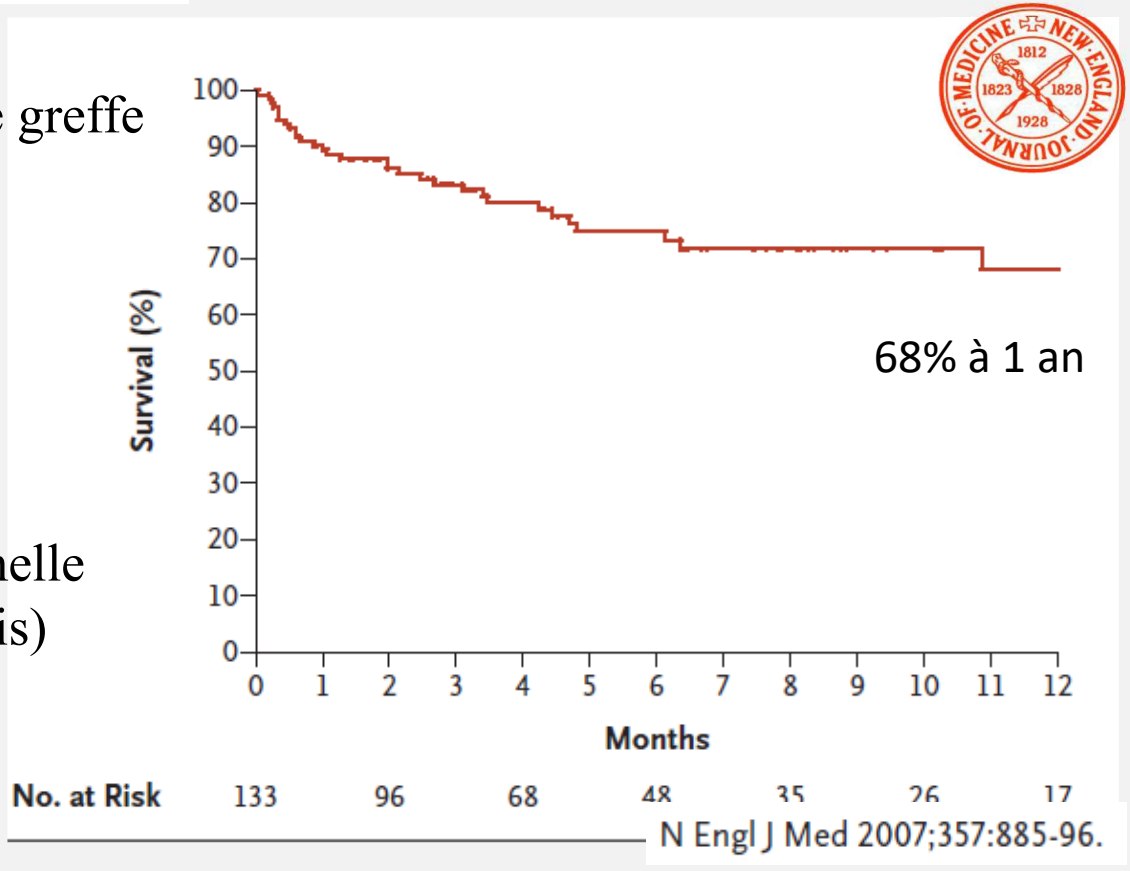
Leslie W. Miller, M.D., Francis D. Pagani, M.D., Ph.D., Stuart D. Russell, M.D., Ranjit John, M.D., Andrew J. Boyle, M.D., Keith D. Aaronson, M.D., John V. Conte, M.D., Yoshifumi Naka, M.D., Donna Mancini, M.D., Reynolds M. Delgado, M.D., Thomas E. MacGillivray, M.D., David J. Farrar, Ph.D., and O.H. Frazier, M.D., for the HeartMate II Clinical Investigators*

Avant la greffe

- 133 patients inscrits sur liste de greffe
- NYHA 4, FEVG 16%
- 90% sous inotropes
- 133 LVAD (HM2)

Résultats :

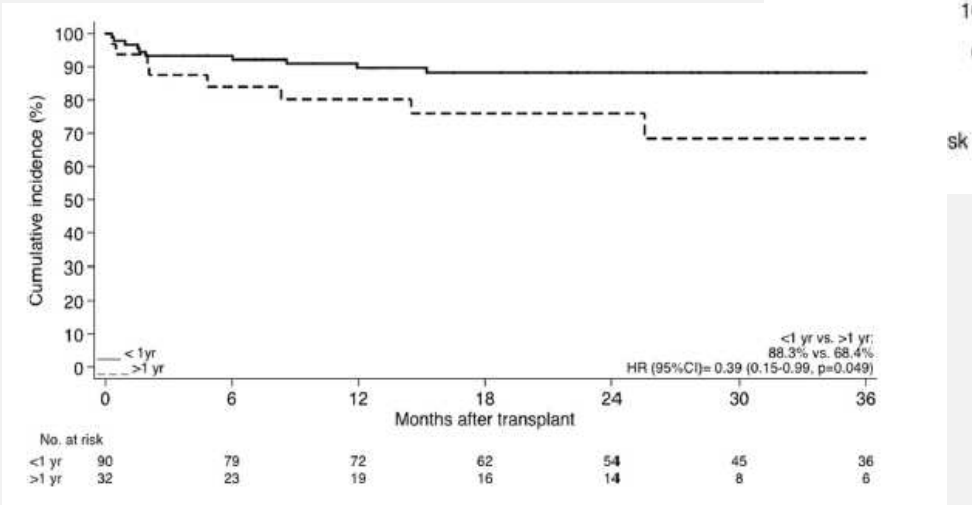
- Meilleur survie
- Meilleur capacité fonctionnelle (80% NYHA1 ou 2 à 6 mois)



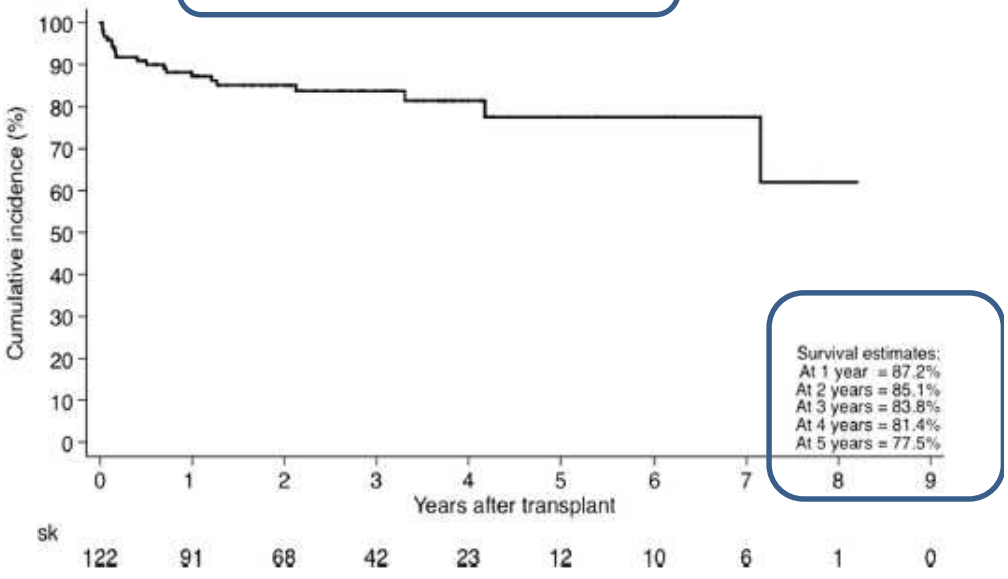
N Engl J Med 2007;357:885-96.

LVAD en pont à la transplantation

192 patients avec HM2 en BTT
New York 2003 – 2013

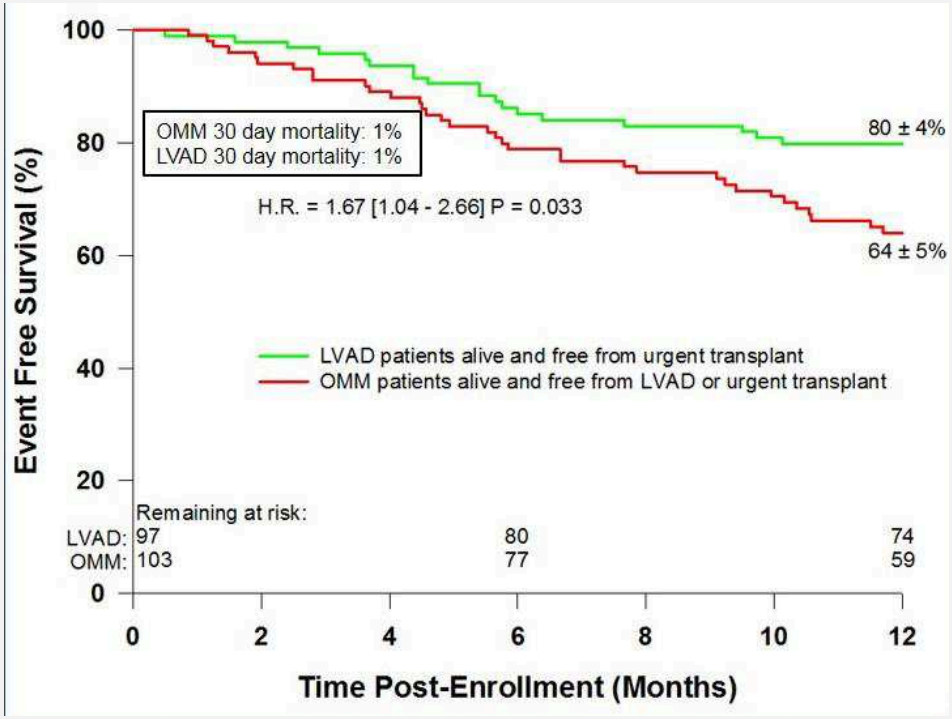


Après la greffe



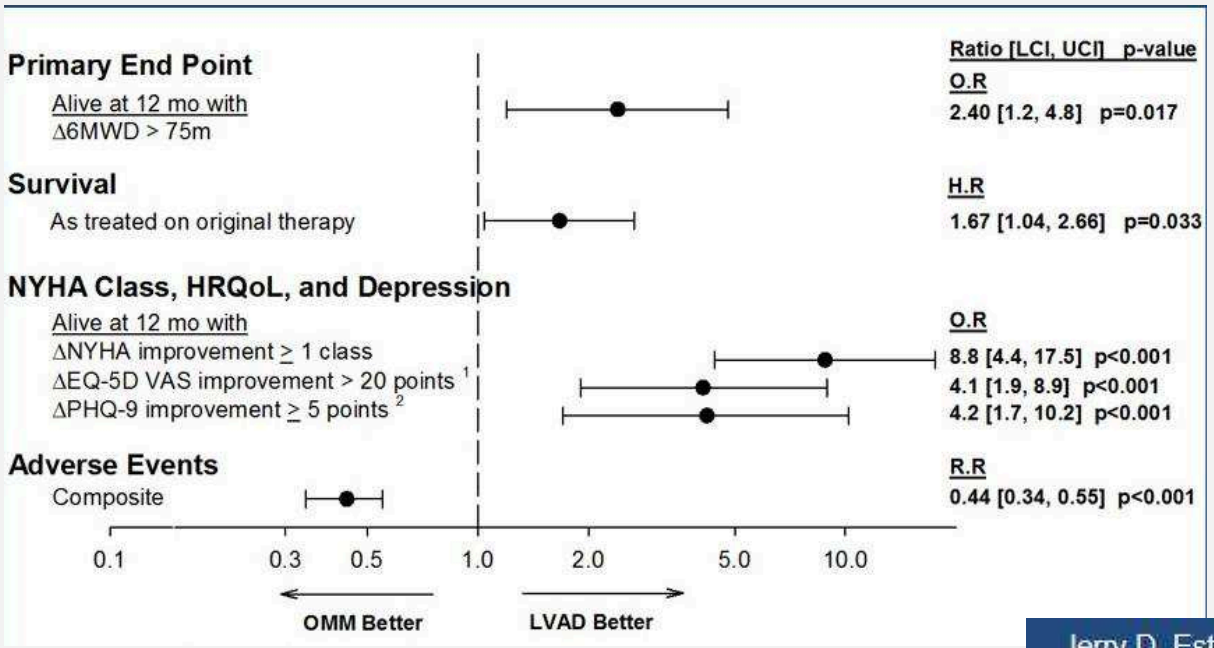
Outcome of cardiac transplantation in patients requiring prolonged continuous-flow left ventricular assist device support

The Journal of Heart and Lung Transplantation, Vol 34, No 1, January 2015



200 patients

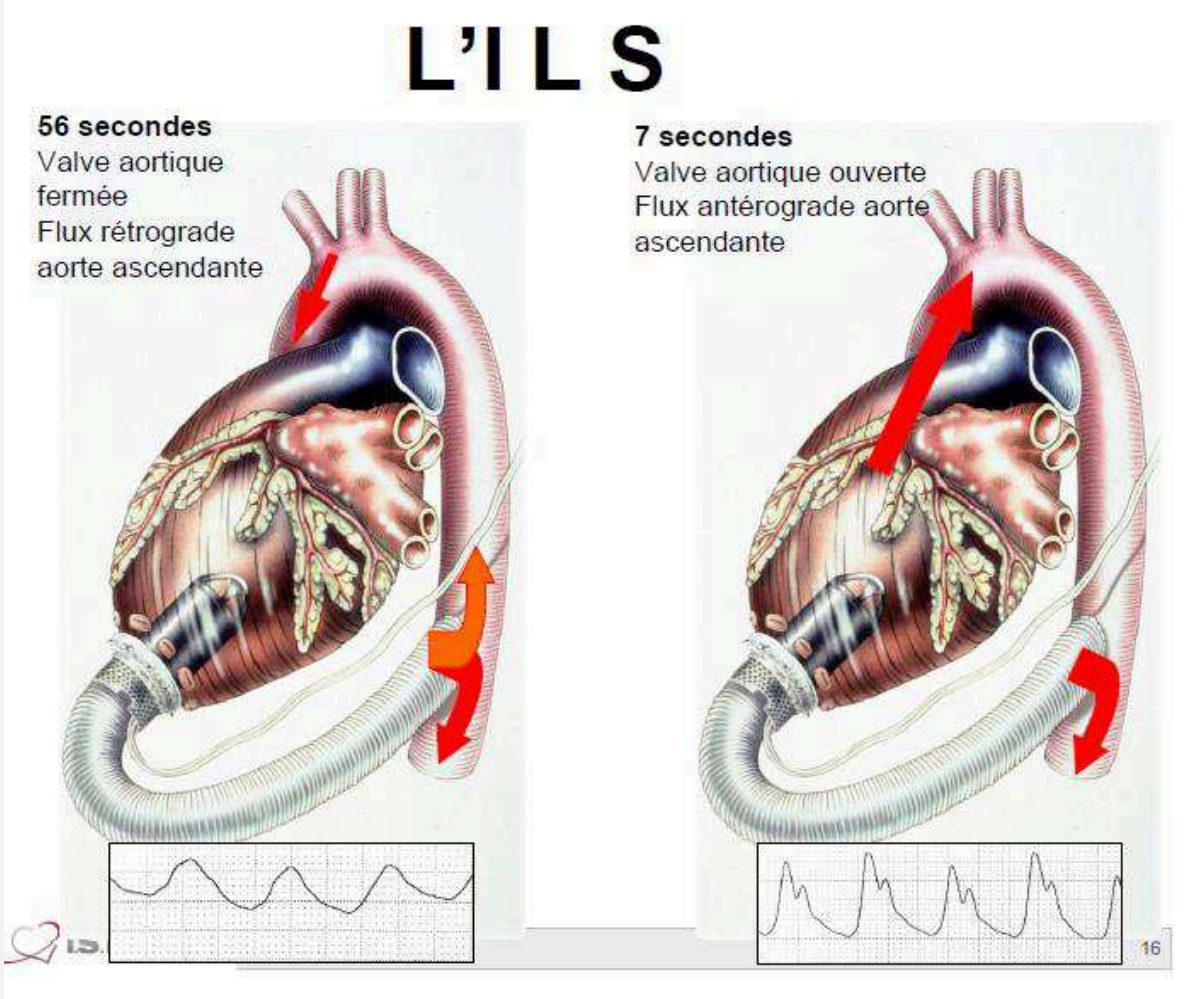
- NYHA 3 ou 4
- Test de marche < 300 m
- FEVG < 25%
- Pas de projet de greffe
- Traitement médical optimal
- Décompensations cardiaques +++



ROADMAP Clinical Study 5

Jerry D. Estep, MD – Presented at ISHLT on April 17, 2015

LVAD : Jarvik 2000®



Intérêts:

1. Lavage de la crosse et de la valve aortique
2. Permettre poursuite ouverture de la valve aortique (moins de fusion de la valve aortique)

LVAD/BiVAD

En pont à la transplantation

Recommendations for implantation of mechanical circulatory support in patients with refractory heart failure

Recommendations	Class [a]	Level [b]	Ref [c]
An LVAD should be considered in patients who have end- stage HFrEF despite optimal medical and device therapy and who are eligible for heart transplantation in order to improve symptoms, reduce the risk of HF hospitalization and the risk of premature death (Bridge to transplant indication).	IIa	C	

2016 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure

European Journal of Heart Failure (2016)

LVAD en destination therapy

Recommendations for implantation of mechanical circulatory support in patients with refractory heart failure

An LVAD should be considered in patients who have end-stage HFrEF despite optimal medical and device therapy and who are not eligible for heart transplantation to, reduce the risk of premature death.	IIa	B	605, 612, 613

2016 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure

European Journal of Heart Failure (2016)