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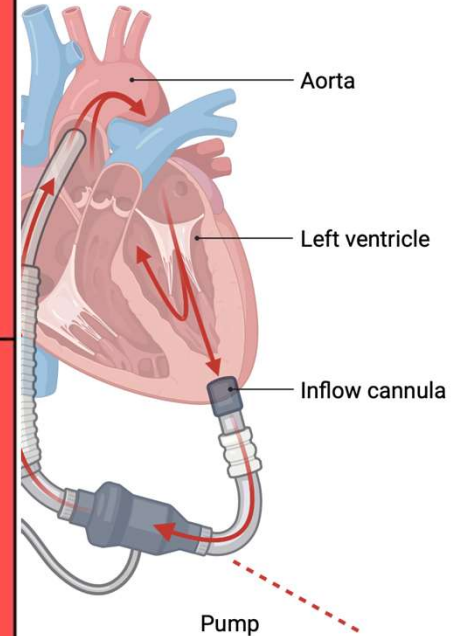
# VAD e Infezioni

**Simone Mornese Pinna, PhD, MD Infectious Diseases**

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1. *Classification of Infections in LVAD patients*
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**rief**



<b>VAD- Specific Infections:</b>  Related to VAD Components	Driveline exit site infection  Tunnel infection  Pump pocket Infection  VAD infection
<b>VAD- Associated Infections:</b>  Related to VAD Implantation	Infective endocarditis  Bloodstream infections  Mediastinitis
<b>Non VAD Related Infections</b>	Pneumonia  Urinary tract infection

# 2024 ISHLT Consensus Definitions for MCS Infections

A unified taxonomy for durable  
and acute Mechanical Circulatory  
Support devices.

## MCS Patient Infections

### MCS-Specific Infections

Specific to hardware; do not occur in non-MCS patients.



Percutaneous /  
Exit Site

- Uncomplicated percutaneous lead infection
- Complicated percutaneous lead infection



Vascular / Cannula

- Uncomplicated vascular cannulation site infection
- Complicated vascular cannula/sheath/graft infection



Internal / Systemic

- Device-specific bloodstream infection
- Device endocarditis
- Infection of the external surfaces of an implantable component

### Non-MCS-Specific Infections

Do not specifically arise from hardware, but can impact the device.

Cardiac & Surgical

- Infective endocarditis of native or prosthetic valves
- Cardiac implantable electronic device (CIED) infections
- Sternal wound infections and mediastinitis

Systemic

- Non-MCS bloodstream infections
- Sepsis

Localized

- Localized infections (e.g., pneumonia, UTI, cholecystitis, diverticulitis, dental abscess)



## Uncomplicated

- ✓ - Localized signs (Pain, tenderness, erythema, drainage, induration)
- ✓ - Systemic signs ABSENT
- ✓ - Blood cultures NEGATIVE (positive drainage culture allowed)
- ✓ - Imaging NEGATIVE for fluid collection/abscess



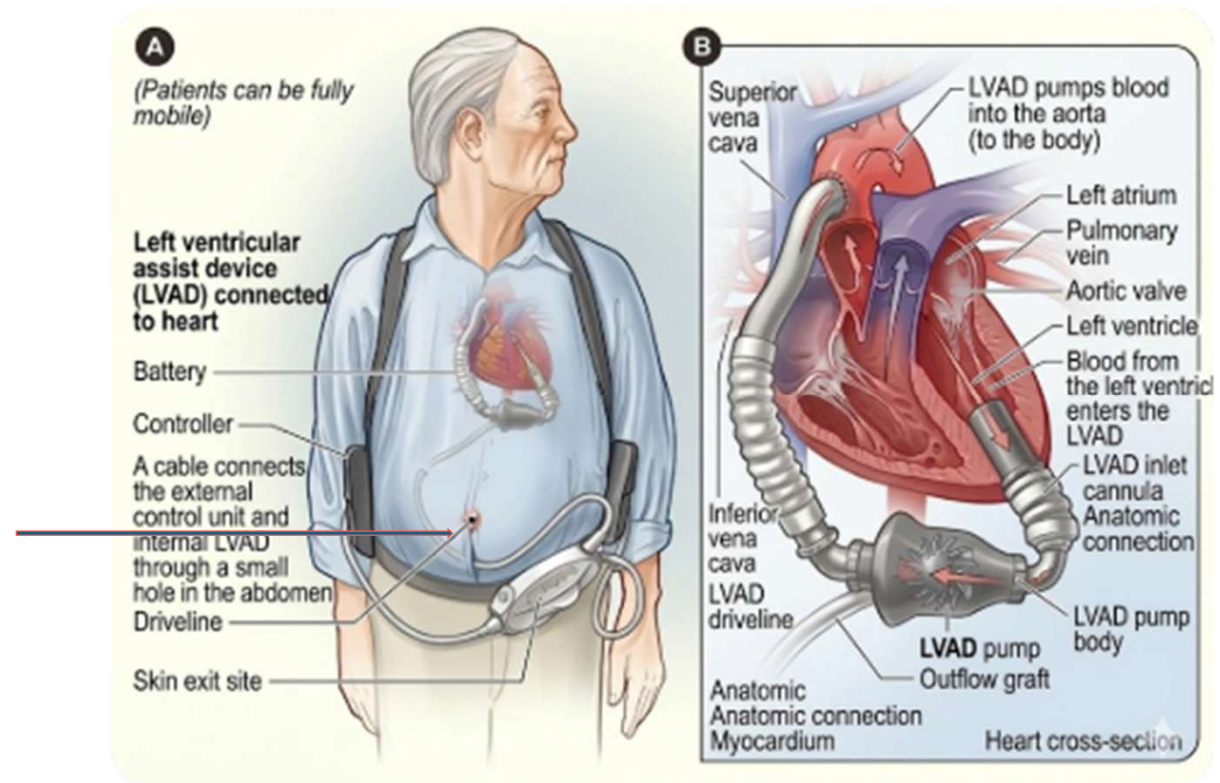
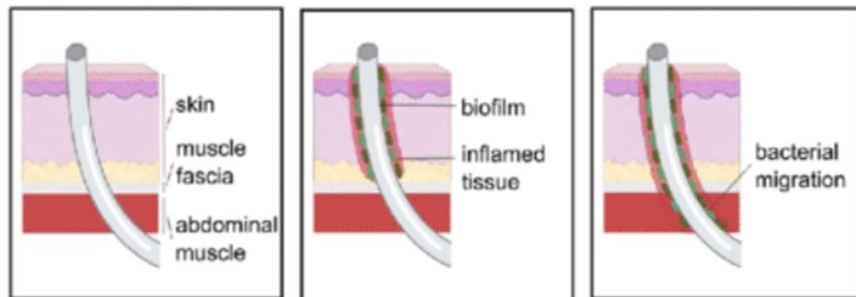
## Complicated.

*Presence of ANY of the following escalates the diagnosis:*

- **Systemic Involvement:** Fever, chills, leukocytosis, SIRS, or **Sepsis**.
- **Bacteremia:** Positive blood cultures.
- **High-Risk Pathogens:** Multidrug-resistant (MDR) organisms or **Fungi**.
- **Advanced Local Spread:** Fistulous tract or purulence at cannula-blood vessel interface.
- **Hardware / Deep Tissue:** Fluid collection/abscess on imaging, infection along lead path, or infection of implantable component external surfaces.

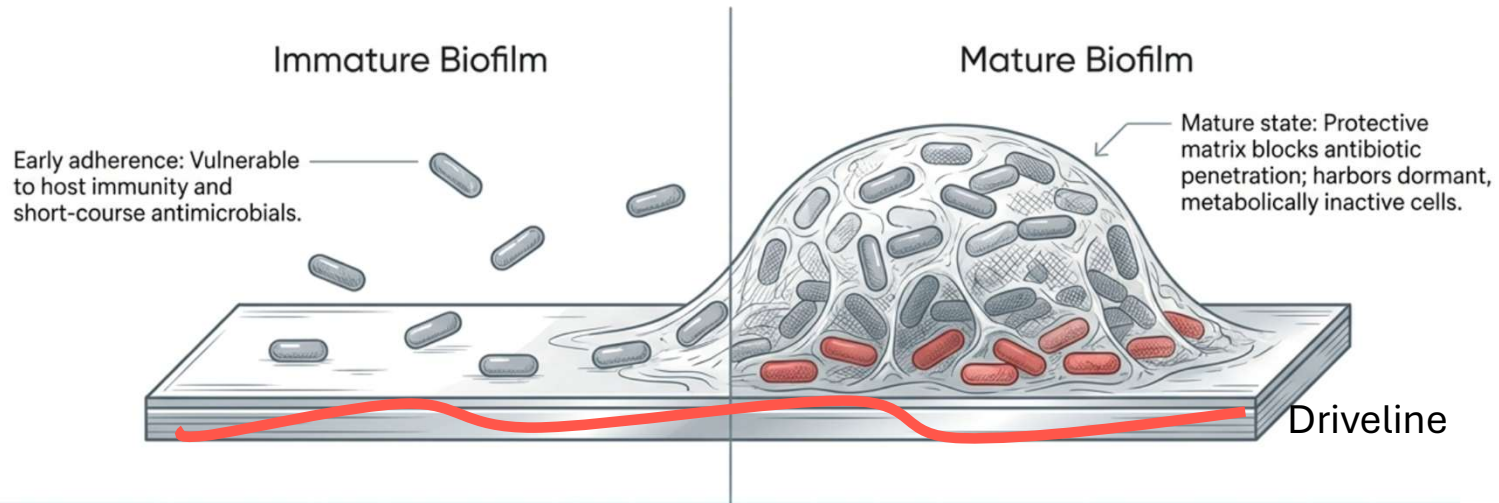
The 'Complicated' designation relies on factors readily observed in clinical practice that dictate the need for surgical intervention, prolonged IV therapy, or device management, independently of physical 'depth'.

# VAD-specific Infection Model: Lessons From CRBSI

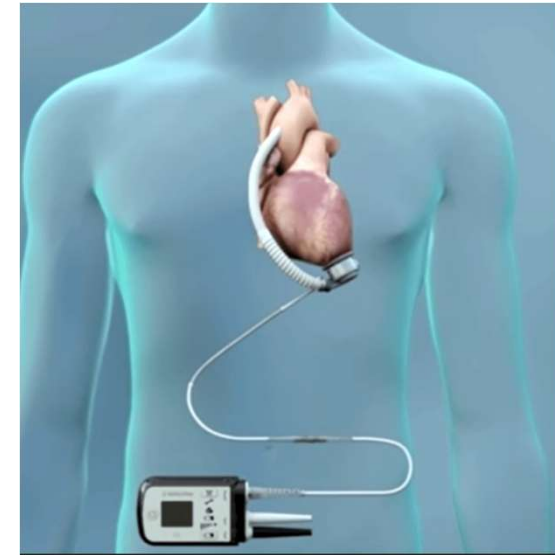


Adapted from Lancet Infect Dis 2006; 6: 426–37

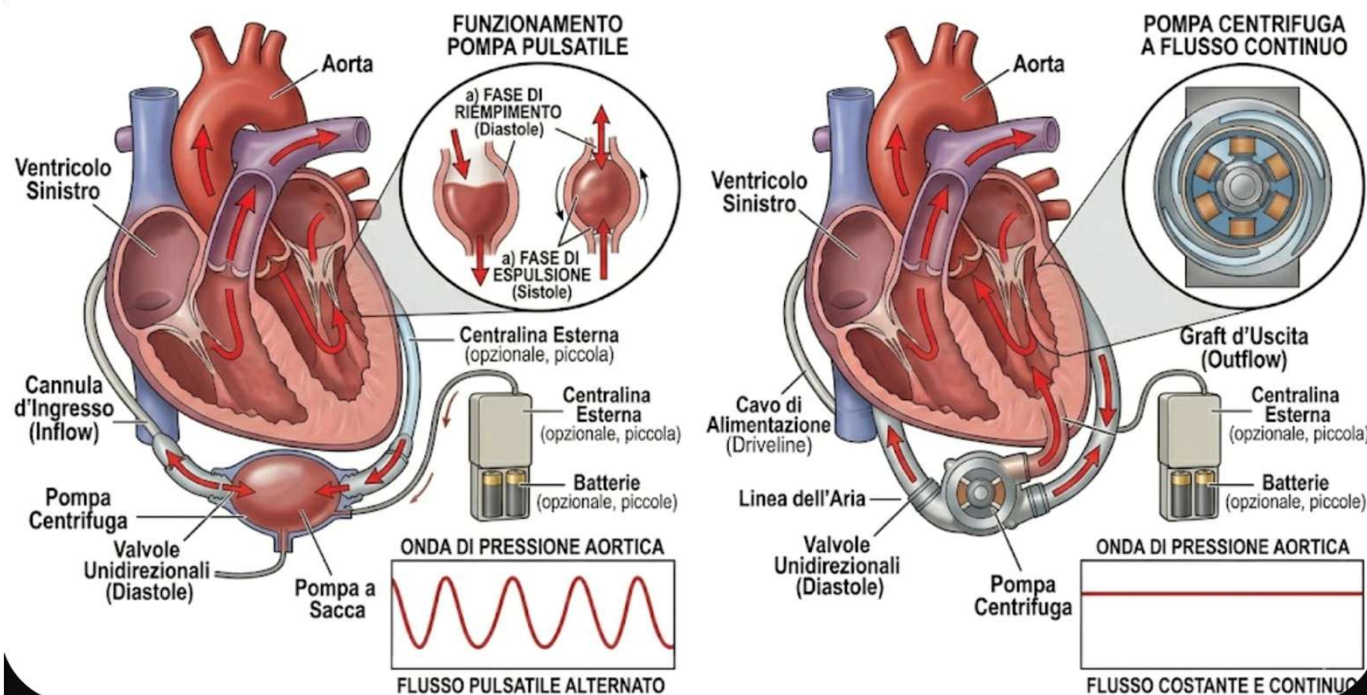
## The Patophysiology: Biofilm Formation



Biofilms render internal and external device infections non-resolving without surgical intervention, requiring distinct, prolonged, or suppressive antimicrobial strategies.



### 4: Biofilm formation reduces antimicrobial penetration



## 1. Less infections with new devices

Time

Incidence of Infections 42–64%

Infections' related deaths 38%

19–39%

10%

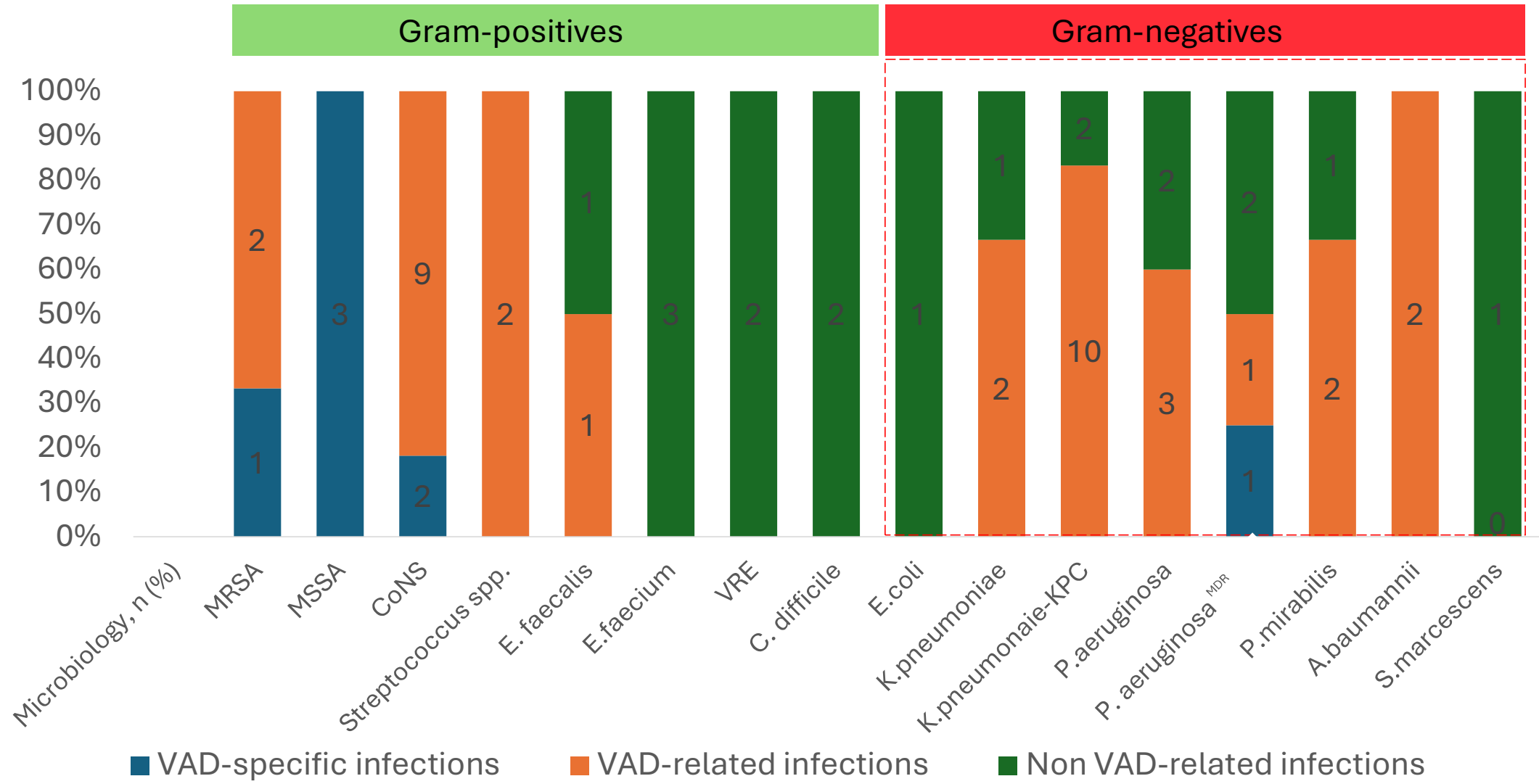


# Nosocomial infections in LVAD



- Monocentric retrospective study
- Adults >18y
- Excluded: died within 48h from implant
- Objective: epidemiology on nosocomial infections

Nosocomial infections





Baseline Characteristics	Overall	Nosocomial Infection (n=32)	No infection (n=32)	P	
Mean length of surgery (min, IQR)	242.5 (210.0-294.0)	257.5 (210.0-338.75)	235.0 (210.0-282.0)	0.080	
Mean ICU (days)	4 (3.0-11.5)	9.0 (3.0-24.75)	4.0 (2.0-5.0)	<0.0001	Sig 0.022 OR 1.224, 95%IC; 1.049,1.429
Mean time of mechanical ventilation (h)	18 (9.0-33.0)	23.0 (12.25-100)	11.0 (8.0-21.0)	0.070	Sig. 0.622, OR 0.99, 95%IC 0.973,1.013
Mean length of hospital stay (days)	37.5 (28-56)	50.5 (34.0-61.75)	31.0 (23.75-45.75)	<0.001	Sig. 0.119, OR 1.031 95%IC; 0.992,1070
Mean time of ECC (min)	76 (59.3-105.3)	79.0 (60.0-109.0)	66 (55.0-101.5)	0.272	Sig 0.470, OR 0.99, IC95%; 0.962,1.018
CVVH (%)	12 (18.8%)	10 (31.3%)	2 (6.3%)	0.022	Sig. 0.879 OR 0.88, 95%IC; 0.194,4.069
In-hospital mortality, n (%)	4 (6.25%)	3 (9.4%)	1 (3.1%)	0.613	

**2. Nosocomial infections (including MDR) are not associated with worse outcomes**

*Mornese Pinna et al. Life 2024, 14(2), 270*

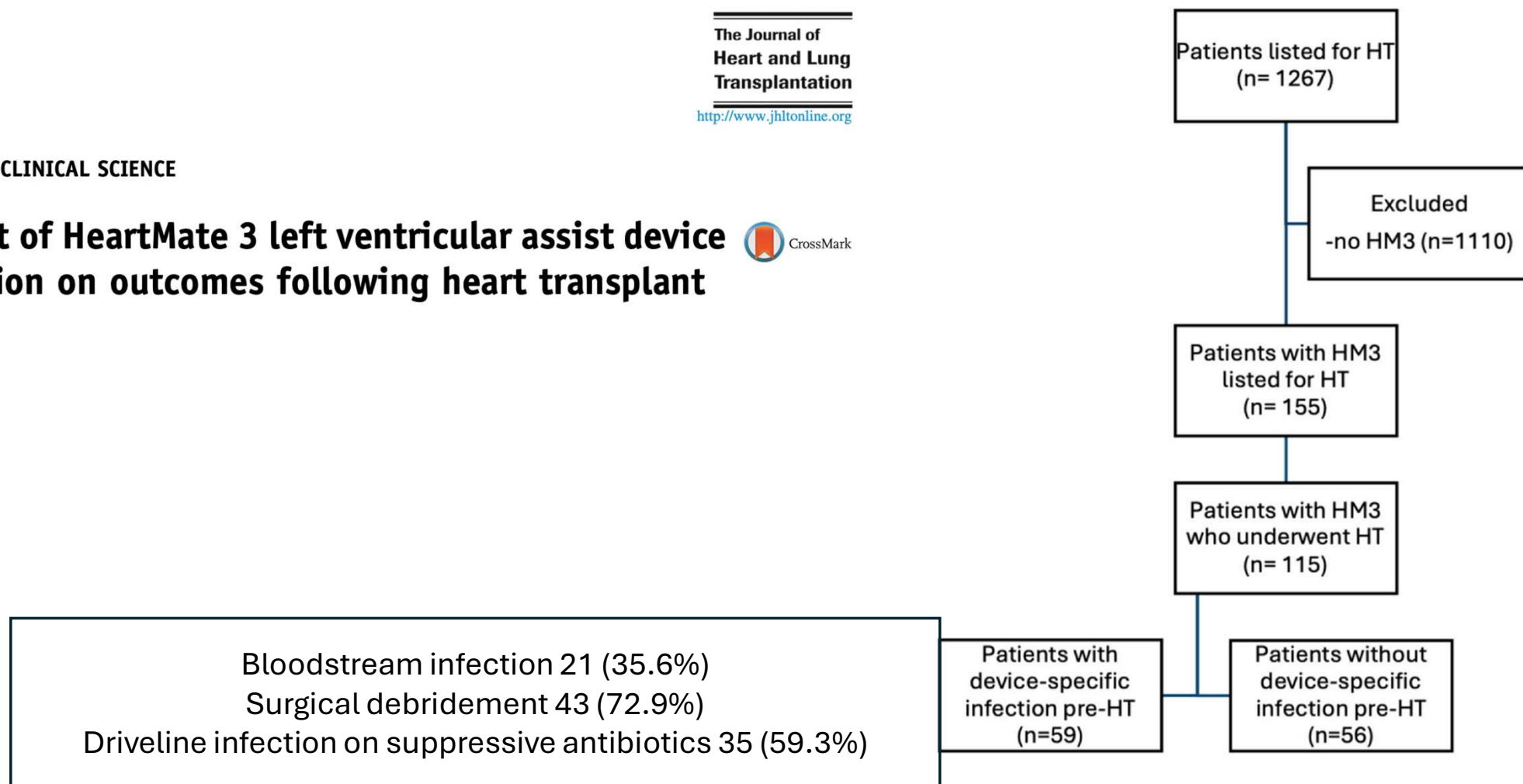
# Driveline Infections in Durable LVAD Support: Risk Factors, Microbiology, and Resistance Patterns

- retrospective cohort study
- durable left ventricular assist device (LVAD) implantation
- January 2012 and December 2024.

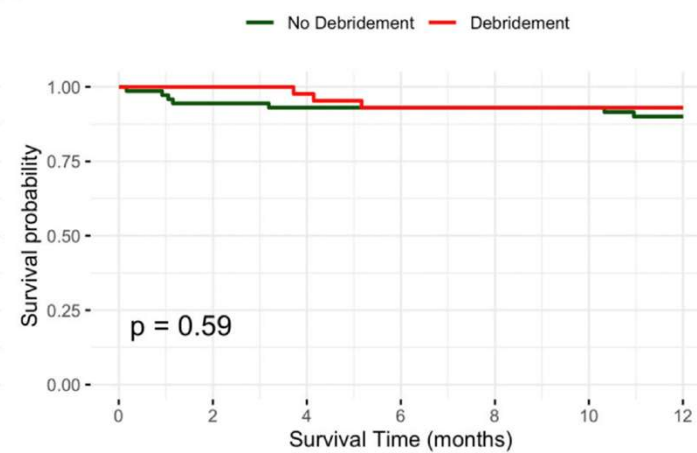
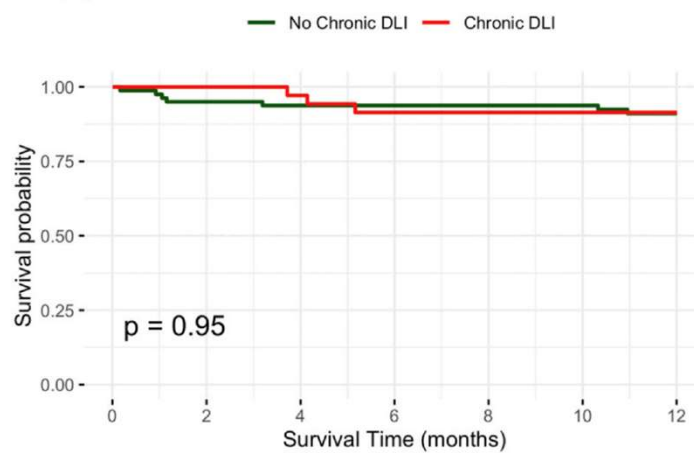
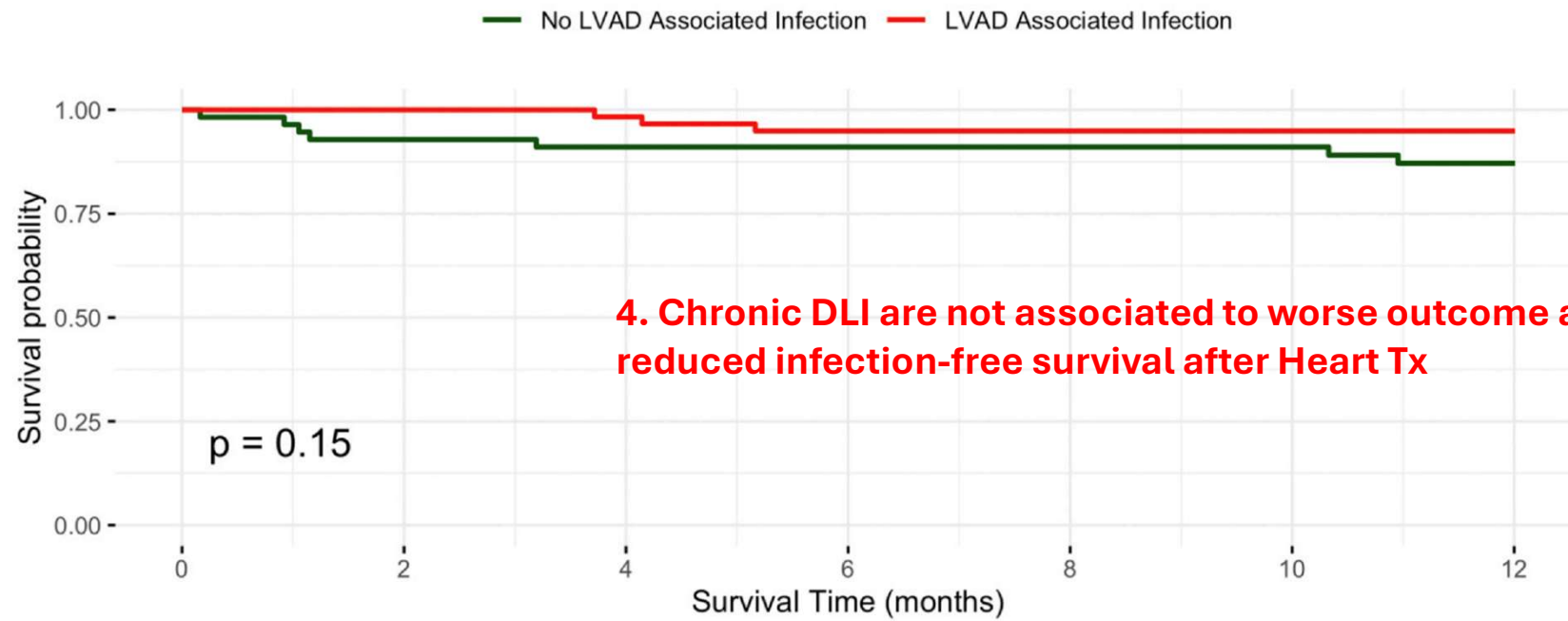
	Risk factors	Microorganisms		20.5% DLI
Variable	Total ( <i>n</i> = 772)	No DLI ( <i>n</i> = 614)	DLI ( <i>n</i> = 158)	<i>p</i> Value
Preoperative lactate (median, range)	1.4 (0–73)	1.4 (0–73)	1.4 (0–6)	0.970
INTERMACS profile, <i>n</i> (%)				0.851
1	65 (8.7)	54 (9.1)	11 (7.1)	
2	238 (31.9)	190 (32.1)	48 (31.0)	
3	278 (37.3)	218 (36.9)	60 (38.7)	
4	159 (21.3)	125 (21.2)	34 (21.9)	
5	6 (0.8)	4 (0.7)	2 (1.3)	

ORIGINAL CLINICAL SCIENCE

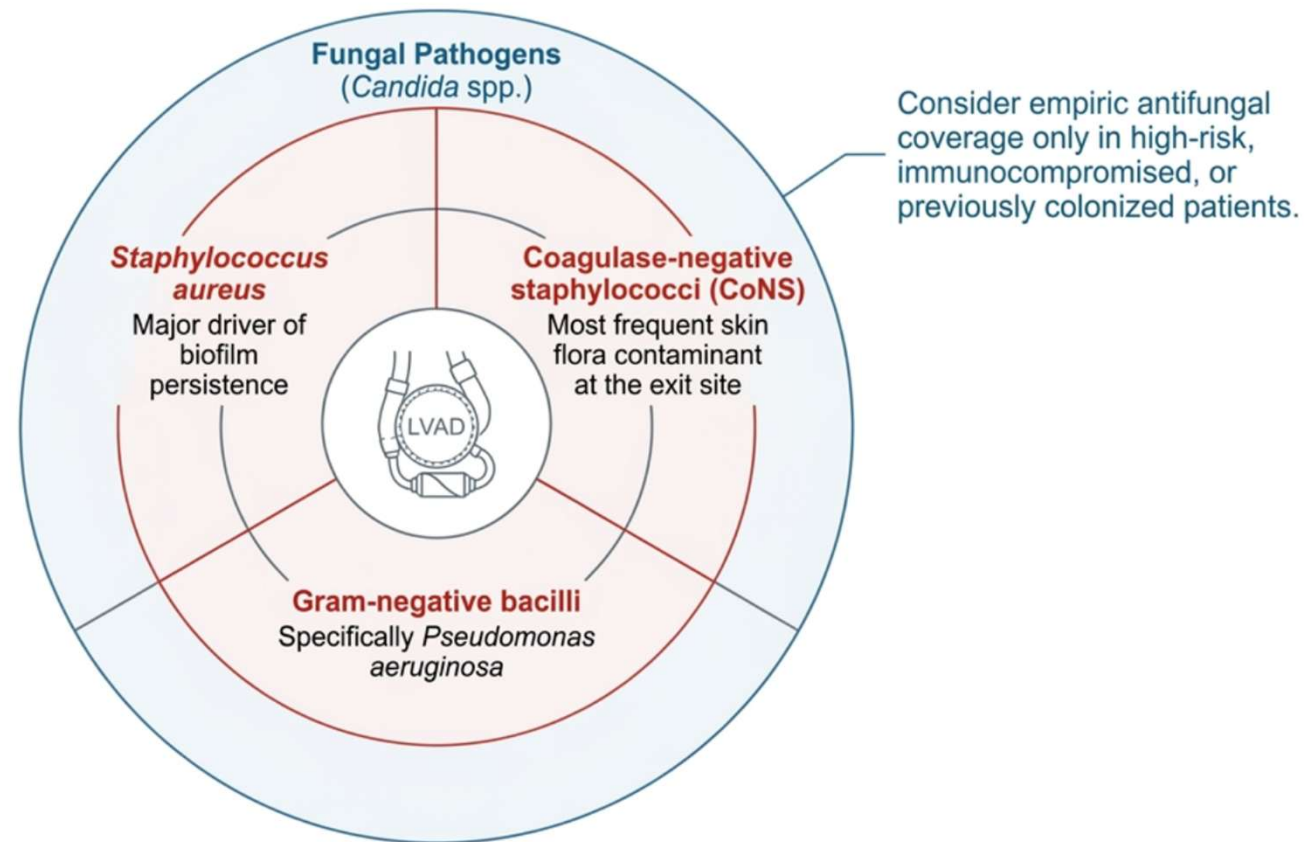
# Impact of HeartMate 3 left ventricular assist device infection on outcomes following heart transplant



## 1-Year Survival After Heart Transplant



# Principles Of Antimicrobial Treatment



# How long do you treat?

# 14 Days

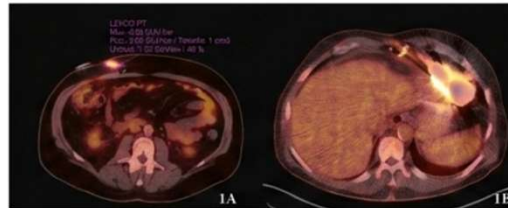
**Pathology:** Immature biofilm, no deep tract extension.

**Clinical Evidence:** 91% clinical resolution achievable with strict targeted therapy. Extended courses are unnecessary for confidently established superficial disease.

## Deep, Pocket, or Pump Infections

# 6 Weeks

**Pathology:** Mature biofilm, poor tissue vascularization, bacteremia, or *S. aureus* involvement.



**Clinical Evidence:** Short-course regimens fail due to microbiological persistence in deep tissue.

## Non-Eradicable Deep Biofilm Infection

### Surgical Source Control

Pump explant, exchange, or driveline relocation.

Often unfeasible in Destination Therapy (DT) or high-risk patients.

63% reinfections after device exchange

### Suppressive Antimicrobial Therapy (SAT)

Long-term pharmacological suppression.



Relapse :  
33-37% immediately upon discontinuation  
Biofilm!!!!



**Non-Eradicable Deep  
Biofilm Infection**

**Surgical Source Control**

Pump explant, exchange, or  
driveline relocation.

Often unfeasible in  
Destination Therapy (DT)  
or high-risk patients.

**Suppressive Antimicrobial Therapy (SAT)**

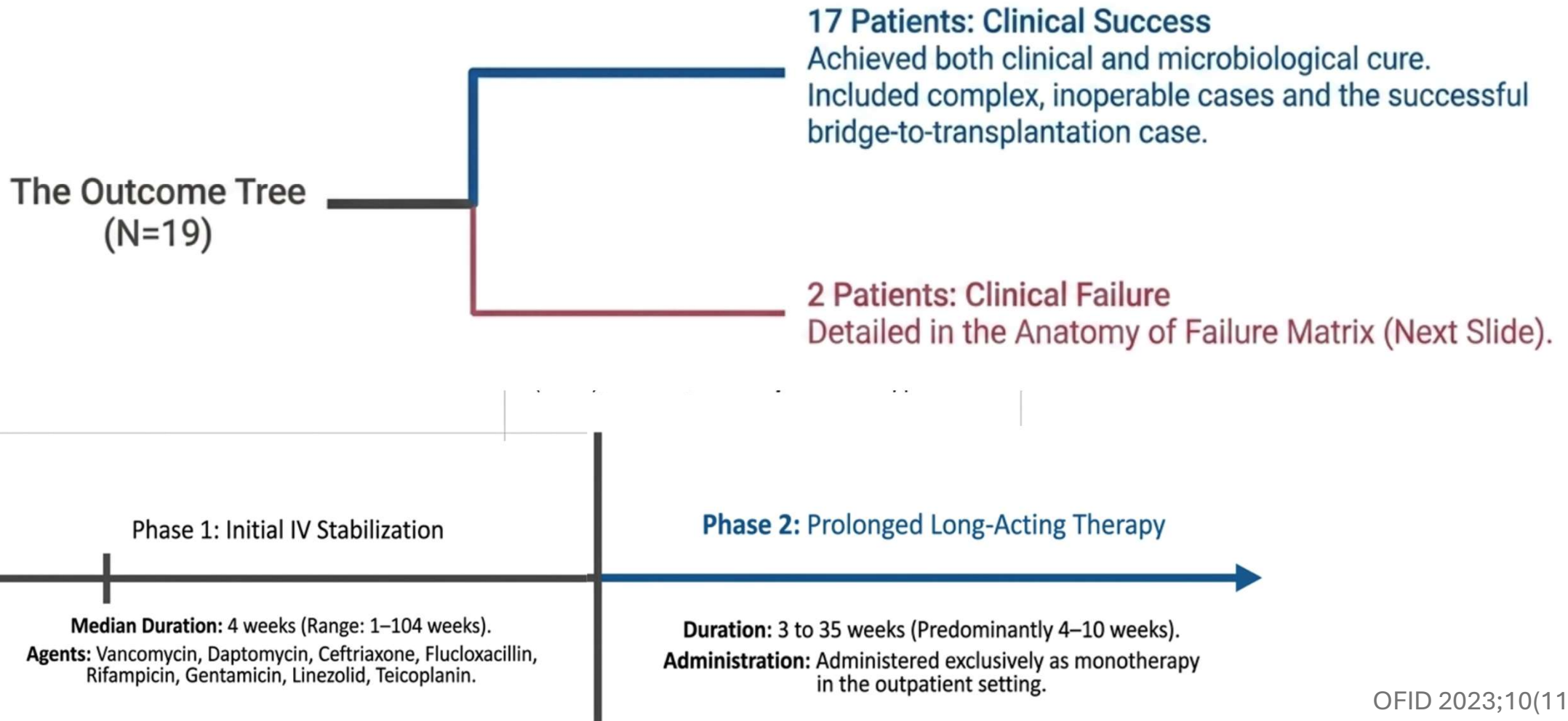
Long-term pharmacological suppression.

22%  
Emergence of MDR strains

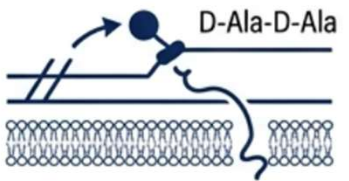
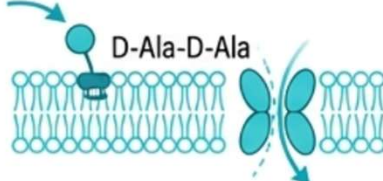
10%  
C. difficile

Iatrogenic Toxicity

# SAT With Long-acting Antimicrobials



# Long-acting Lipoglycopeptides

Dalbavancin	Oritavancin
<b>Origin:</b> Semisynthetic derivative of A40926 ( <i>Nonomuraea</i> spp.).	<b>Origin:</b> Semisynthetic derivative of chloroeremomycin ( <i>Kibdelosporangium orienticin</i> ).
<b>Target Spectrum:</b> Broad Gram-positive activity. Highly potent against MRSA, <i>Streptococcus</i> spp., and vancomycin-susceptible <i>E. faecalis</i> .	<b>Target Spectrum:</b> Broad Gram-positive activity. Exceptional in vitro potency against Vancomycin-Resistant Enterococci (VRE), VRSA, and VISA.
<b>Mechanisms of Action:</b>  <p>Lipophilic Side Chain Anchor</p> <ol style="list-style-type: none"> <li>1. Binds to carboxyl-terminal D-Ala-D-Ala terminus, inhibiting transpeptidation.</li> <li>2. Lipophilic side chain anchors to membrane, increasing binding affinity.</li> </ol>	<b>Mechanisms of Action:</b>  <p>Rapid Membrane Disruption</p> <ol style="list-style-type: none"> <li>1. Binds D-Ala-D-Ala.</li> <li>2. Unique Secondary Mechanism: Homodimerizes and anchors directly into the lipid membrane, causing rapid depolarization and disruption.</li> </ol>
<b>Killing Kinetics:</b> Concentration-independent (time-dependent) bactericidal activity.	<b>Killing Kinetics:</b> Rapid, concentration-dependent killing (active even against dormant/non-dividing bacteria).
<b>Dosing Regimen (FDA ABSSSI):</b> 1500 mg single-dose OR two-dose regimen (1000 mg Day 1, followed by 500 mg Day 8).	<b>Dosing Regimen (FDA ABSSSI):</b> 1200 mg single intravenous infusion (over 3 hours).
<b>Clinical Nuance:</b> Excreted mostly unchanged. Requires dosage reduction (750 mg to 375 mg) for severe renal injury ( $\text{CrCl} < 30 \text{ mL/min}$ ).	<b>Clinical Nuance:</b> Elimination is extremely slow. No dose adjustment required for renal or hepatic impairment.

# Long-acting Lipoglycopeptides

## Structural Advantage

Both agents feature a lipidic moiety driving massive plasma protein binding and intracellular accumulation, functionally trapping the drug in the systemic circulation.

### Dalbavancin PK Profile

**Terminal Half-life:** 14.5–16.5 days

**Protein Binding:** 93% (primarily to albumin)

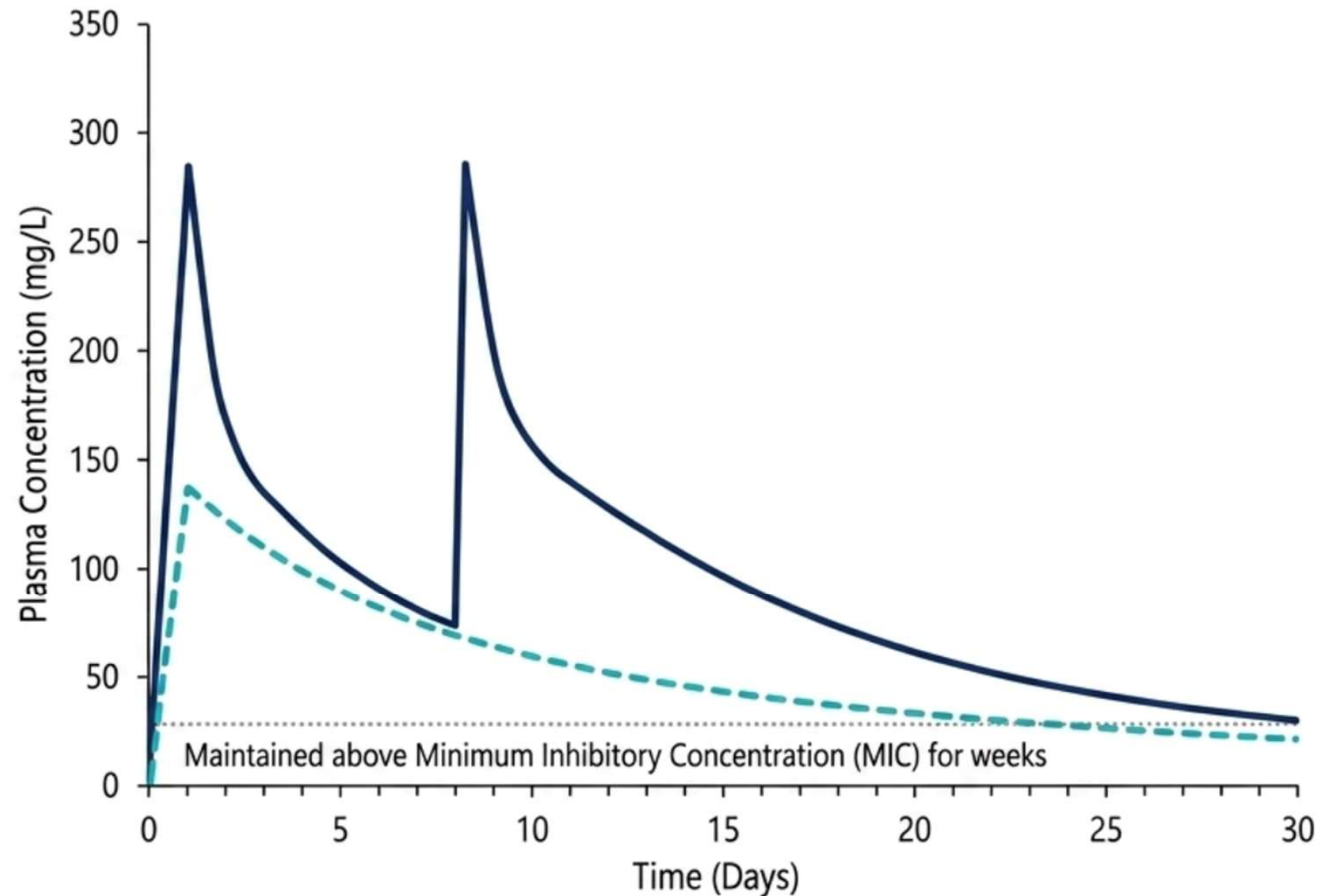
**Volume of Distribution:** 15.7 L

### Oritavancin PK Profile

**Terminal Half-life:** ~245 hours (~10.2 days)

**Protein Binding:** ~85%

**Volume of Distribution:** Massive (87.6 L)



5. SAT is commonly adopted in clinical practice

# Chronic Suppressive Antimicrobial Therapy in LVAD with DLI



## DRIVELINE INFECTION CLASSIFICATION

### Uncomplicated Percutaneous Lead Infection

Localized pain, erythema, and exit-site drainage. Imaging negative for deeper fluid collections or abscesses; blood cultures and systemic symptoms remain negative.

### Complicated Percutaneous Lead Infection

Local exit-site signs accompanied by deep collections/abscesses, bacteremia, MDR pathogens, device-related endocarditis, or involvement of internal hardware components.

### Relapse vs. Reinfection

*Relapse:* Return of identical pathogen within 3 months of therapy.

*Reinfection:* New episode triggered by a completely distinct organism.

## RESEARCH OUTCOMES

### PRIMARY TARGET PARAMETERS

- 💀 12-month all-cause mortality following primary infection diagnosis.
- 🏥 Cumulative rate of infection relapse and reinfection at the 12-month milestone.

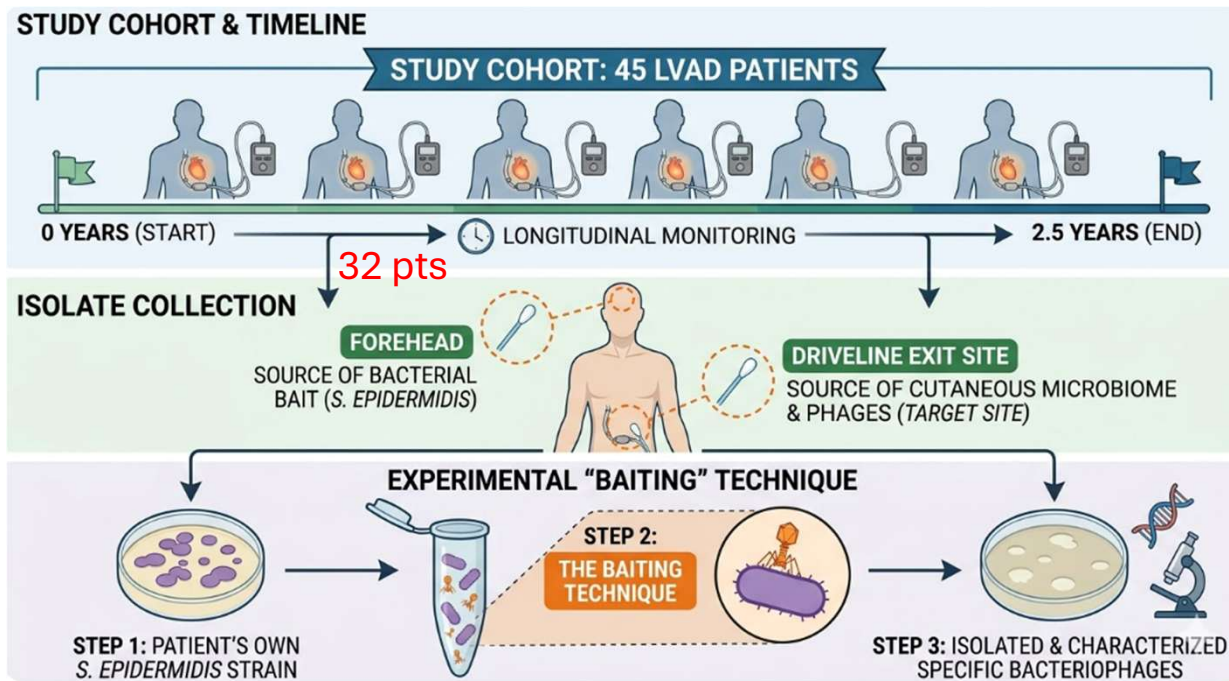
### SECONDARY CLINICAL TARGETS

- ✅ **Treatment Success:** Full clinical and biological resolution.
- 🏥 **Readmission Rates:** Hospitalization due to DLI or bacteremia.
- Surgical Need:** Requirement for debridement or surgical revision.

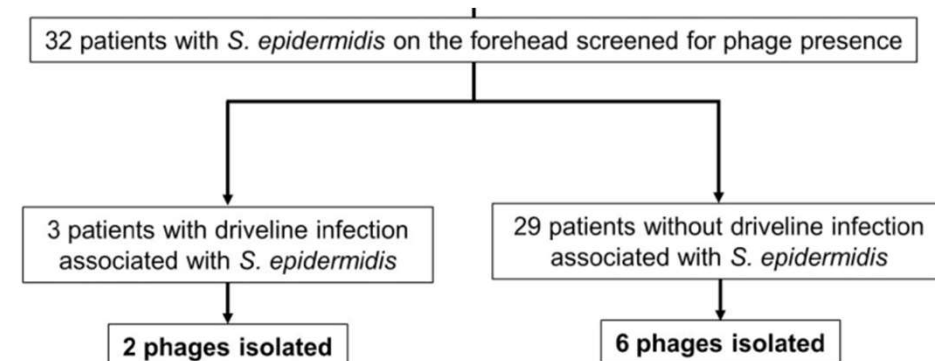
Ongoing



# Targeting Chronic Biofilm Infections With Patient-derived Phage



18 pts with DLI



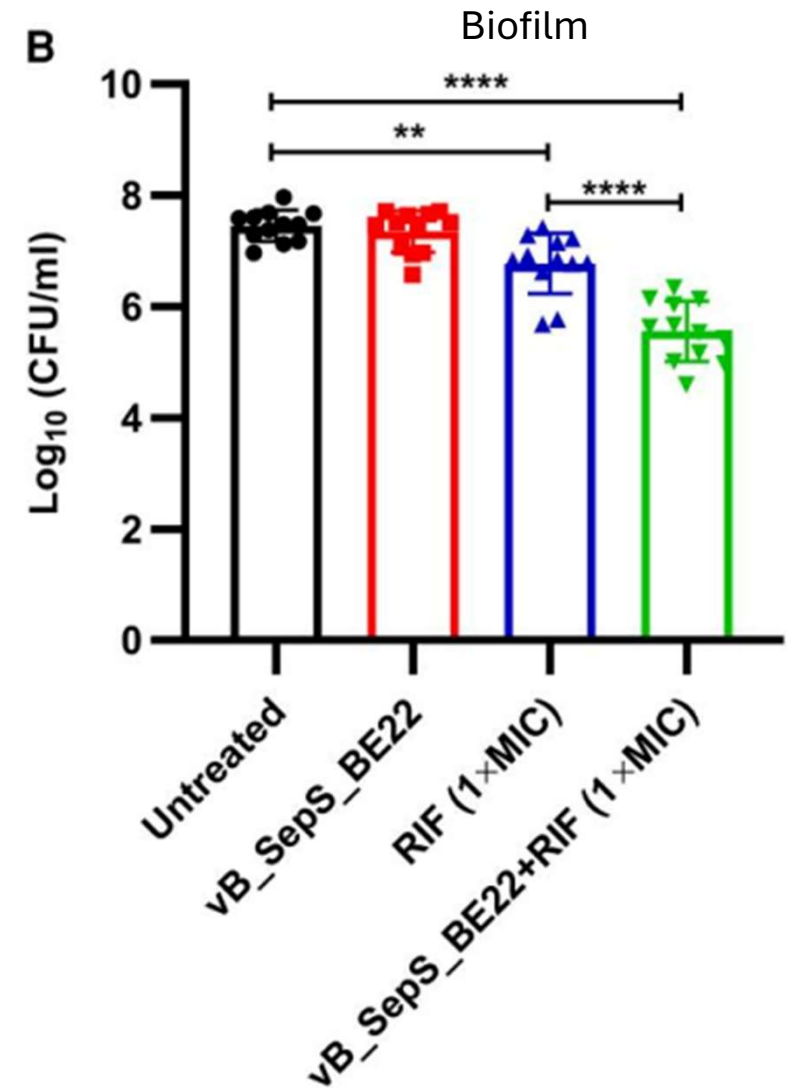
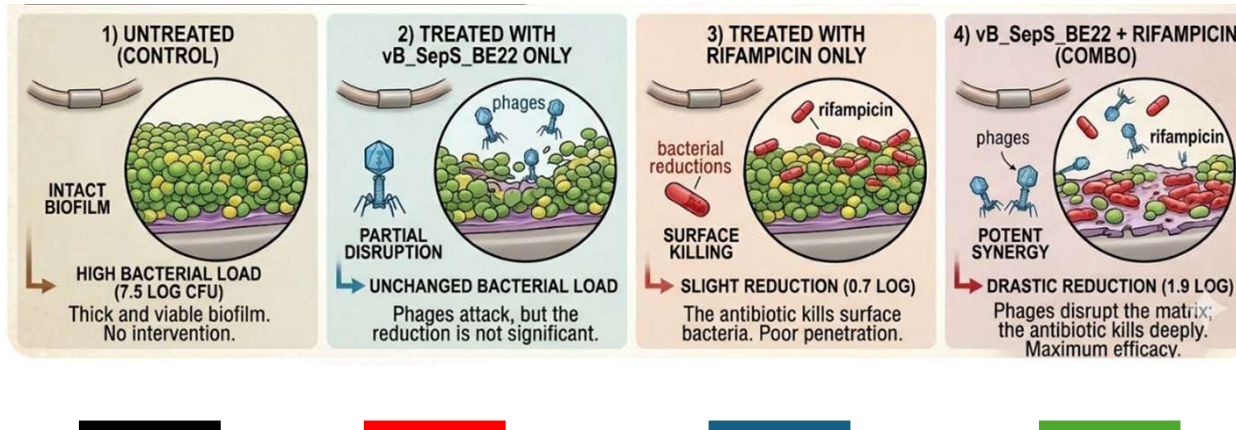
vB\_SepS\_BE22

- Phages infected between 19-52% of the isolated strains.
  - Narrow host range!!!



## Results

Planktonic cultures in vitro



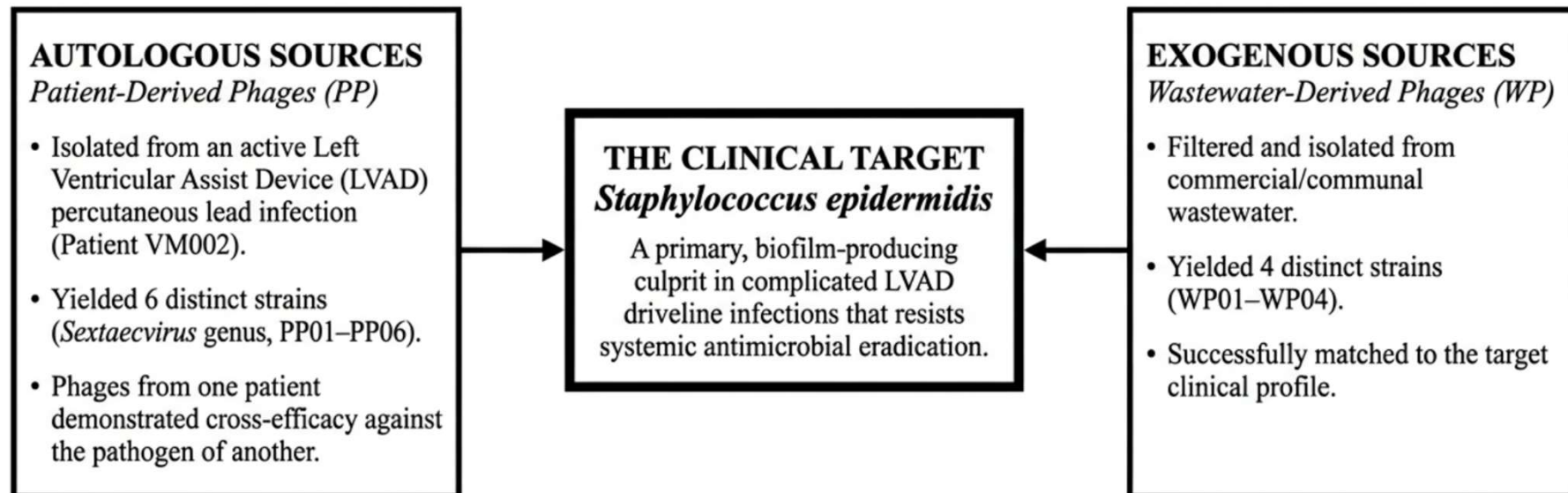
**5. Bacteriophages are promising in the treatment of LVAD-associated infections**

## Take Home Messages

1. Technological advances and a decrease in the infectious burden characterize the most recent devices.
2. Gram-positive bacteria, followed by *P. aeruginosa* are the most relevant pathogens in LVAD-specific infections
3. The Biofilm justifies prolonged treatments and the high recurrence rate of infectious complications (LVAD-DT).
4. Post-VAD placement infections, including nosocomial and community-acquired, especially those affecting the DL, do not reduce post-Tx mortality
5. switch from multidisciplinary to interdisciplinary management

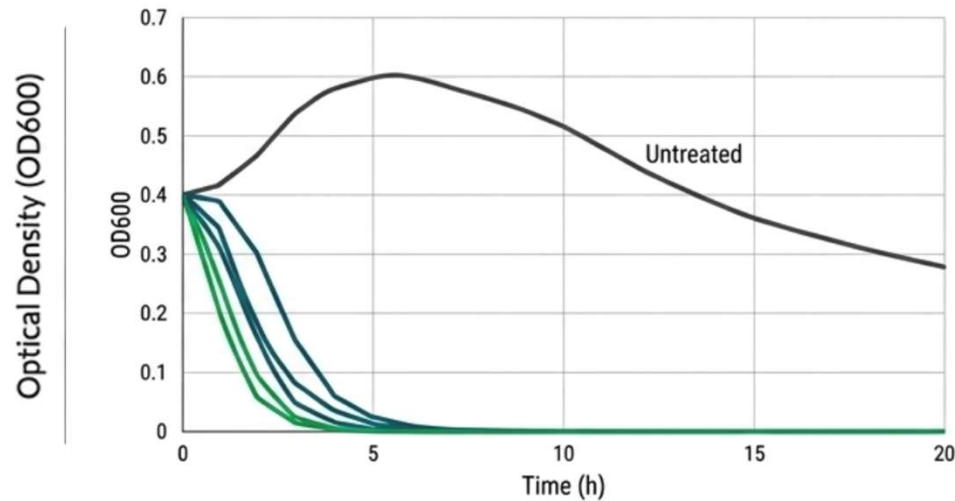


# Isolation of Bacteriophages with Lytic Activity from Biological Samples of Left Ventricular Assist Device Patients



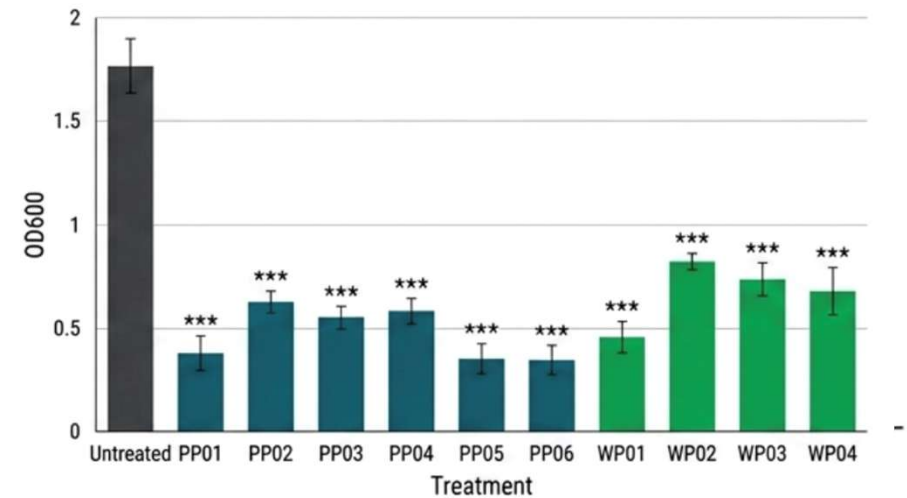


### Rapid Time-Kill Kinetics



- **Complete Eradication:** All isolated phages completely eliminated up to  $10^8$  CFU of *S. epidermidis* within 24 hours.
- **High Potency:** Efficacy was maintained even at highly diluted concentrations (Multiplicity of Infection [MOI] as low as 0.001).
- **Sustained Suppression:** Zero signs of bacterial regrowth over the continuous 20-hour spectrophotometer incubation period.

### Significant Biofilm Reduction



- **Structural Degradation:** Microtiter dish assays confirmed highly significant ( $p < 0.001$ ) biofilm disruption capabilities across all 10 tested phage strains.
- **Clinical Relevance:** Directly targets and overcomes the primary mechanism of antibiotic resistance in percutaneous LVAD cable infections.

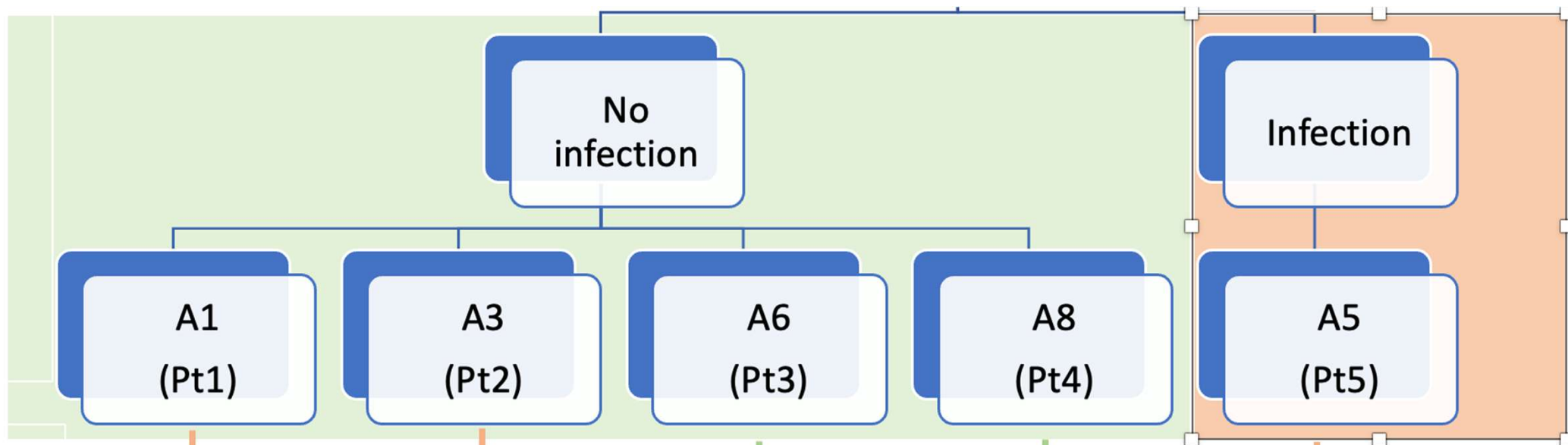




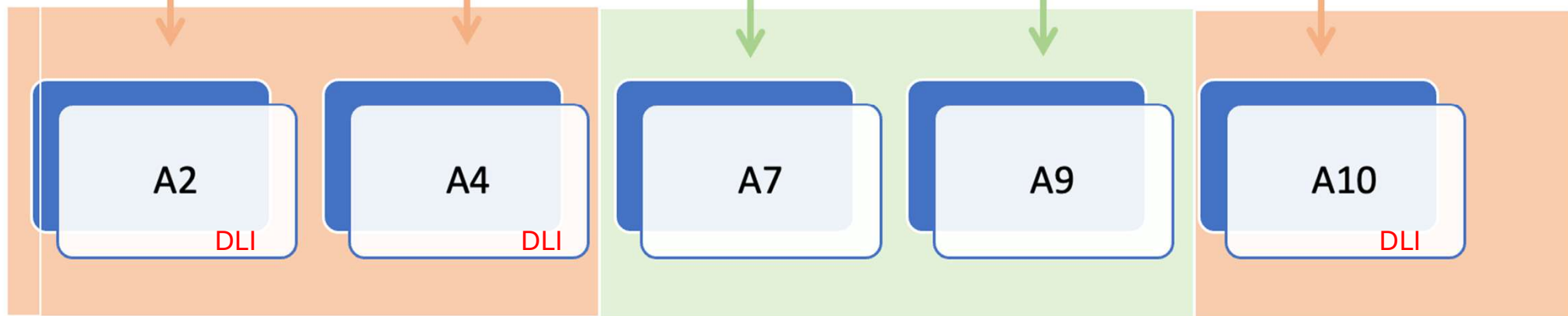
## Skin Microbiome in LVAD Patients



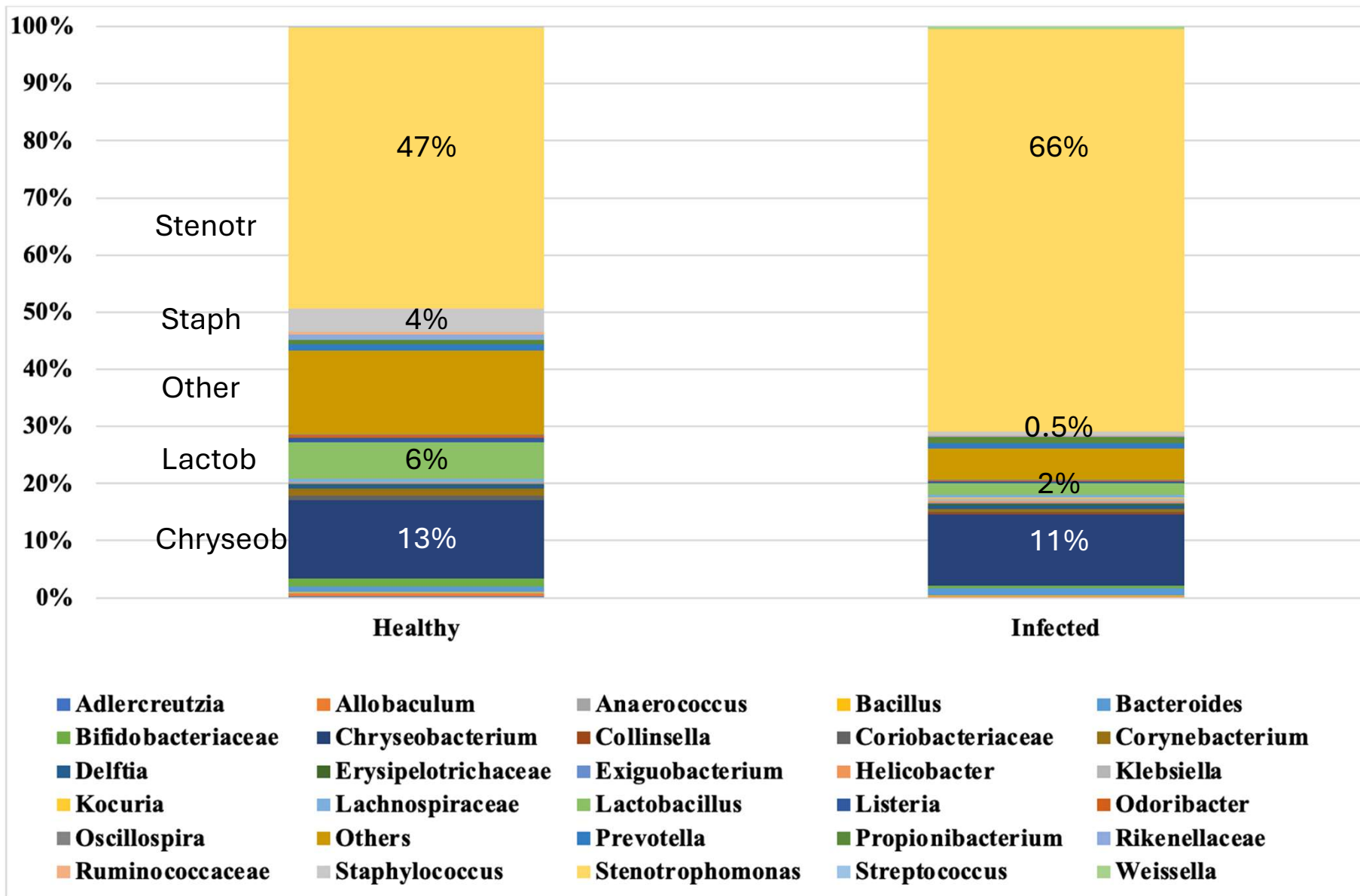
**BASELINE (T0)**

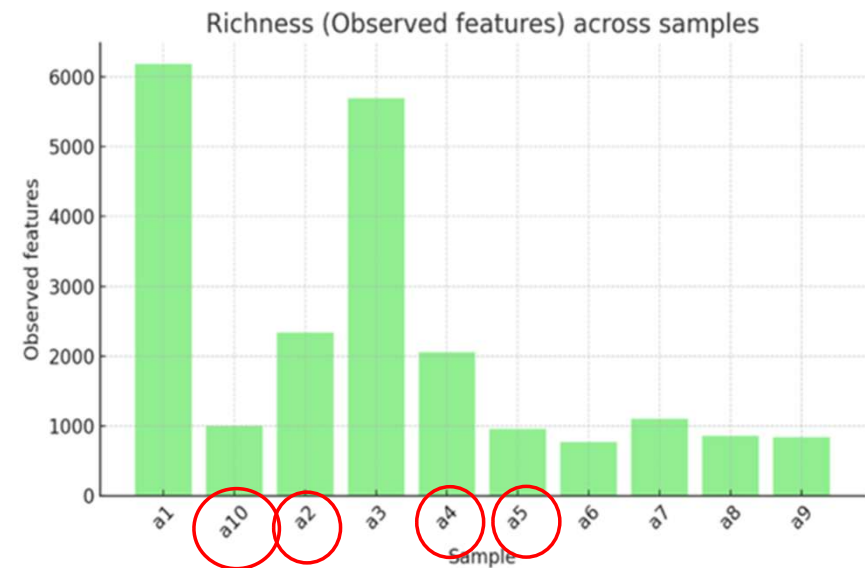
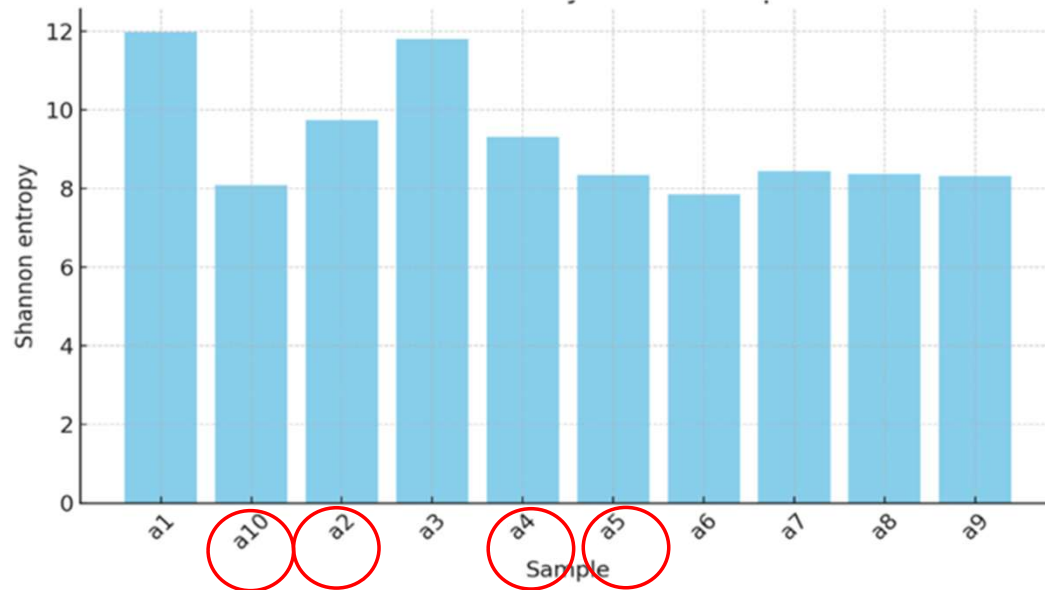


**CONTROL (T4)**



ASV's

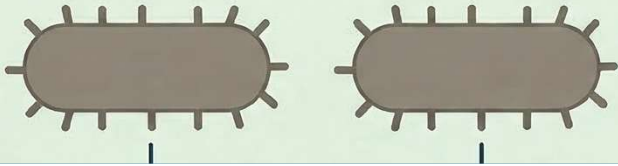




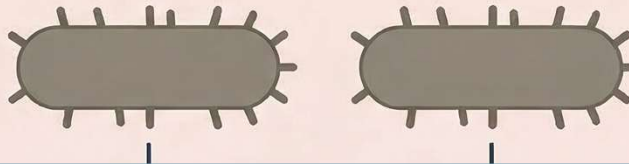
- ✓ mean Shannon infected = 8.86 vs Shannon non-infected = 9.46;
- ✓ mean richness infected = 1,587.5 vs richness non-infected = 2,573.7)

Welch's t-tests was not significant  $p > 0.4$  in each case

### SCENARIO 1: HARMLESS COLONIZATION



### SCENARIO 2: EXACERBATED DISEASE



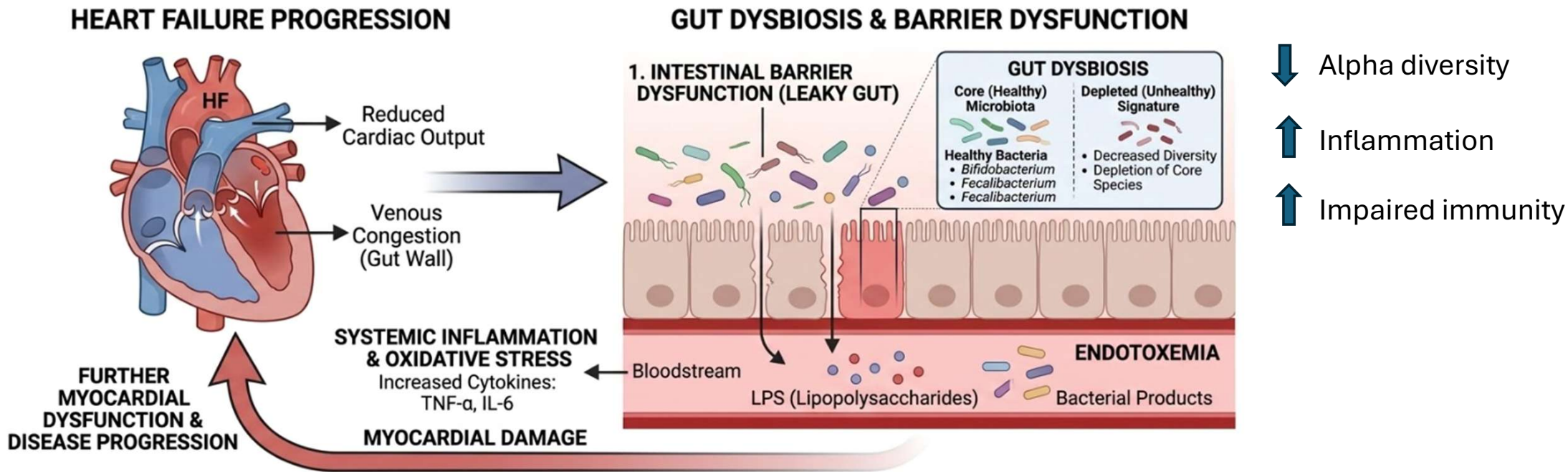
### Taxonomy (Who is?)

- Culture
- Molecular microbiology

Personal opinion

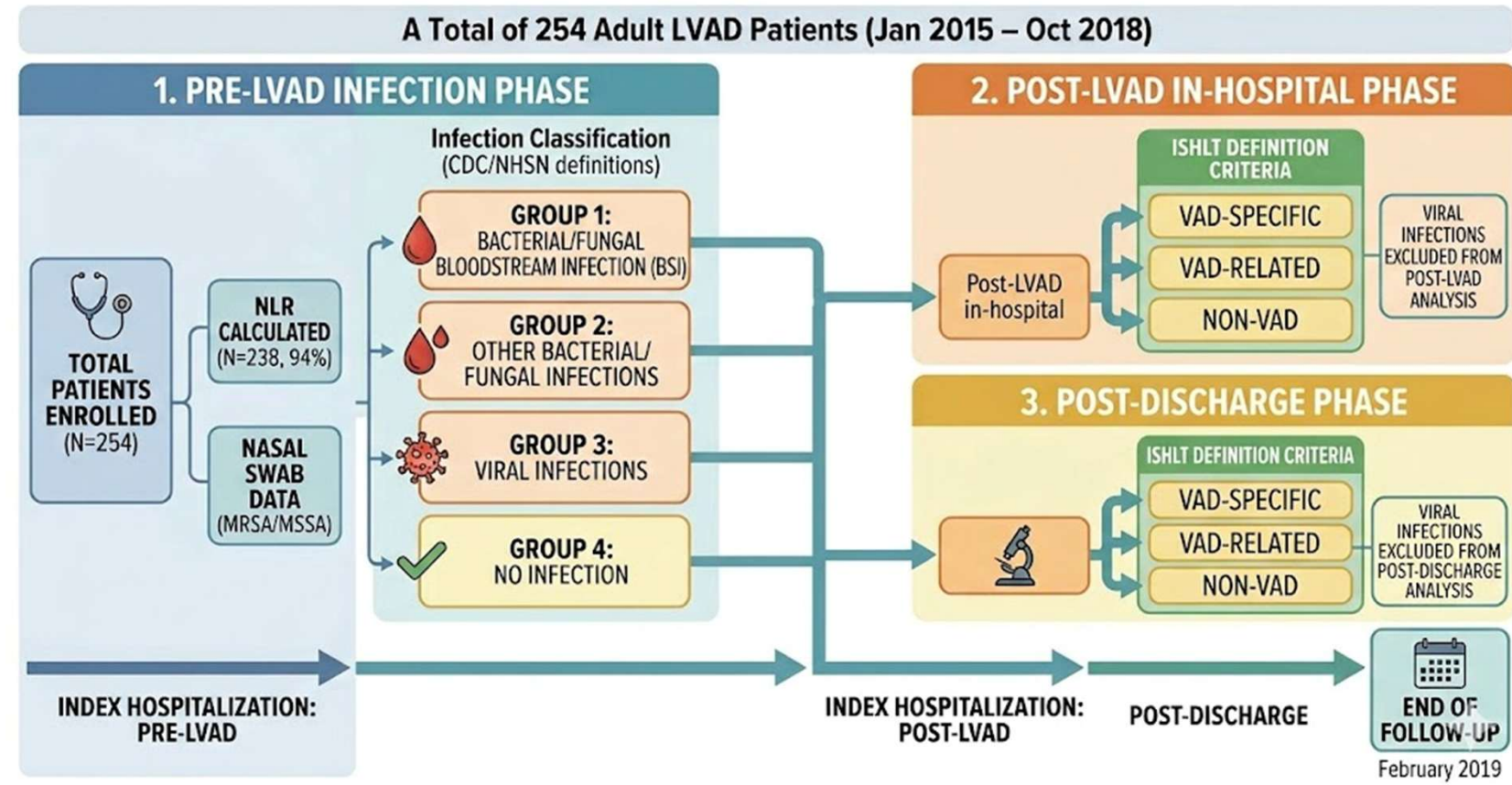


# Gut- Heart Axis

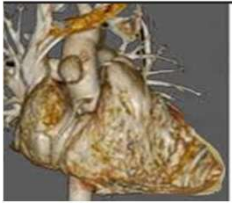


**But which is the impact of gut dysbiosis on the risk of post operative infections in patients receiving LVAD??**

J Am Coll Cardiol 2018;71:1184–1186  
ESC Heart Fail 2017;4:282–290  
J Heart Lung Transplant 2020;39:880–89



- 1) Describe prevalence and type of infections in LVAD pts.
- 2) Impact of preVAD infections on outcome.
- 3) Explore association among SA colonization, gut dysbiosis and inflammation



**PRE-VAD**

**29.5% (75 pts) events**

- **BSI 29.3% (G1)**
- **Other 54.6% (G2)**
- **16% Viral (G3)**

**70.5% (179) no Infections**

46.7% Gram-positive.

Median admission-infection Time: 8d

Median treatment length: 13d

**Results:  
254 pts**



**Post-VAD**

**38.0% (96 pts) events**

- **Median 48d**
- **Pneumonia and UTI  
(73%)**

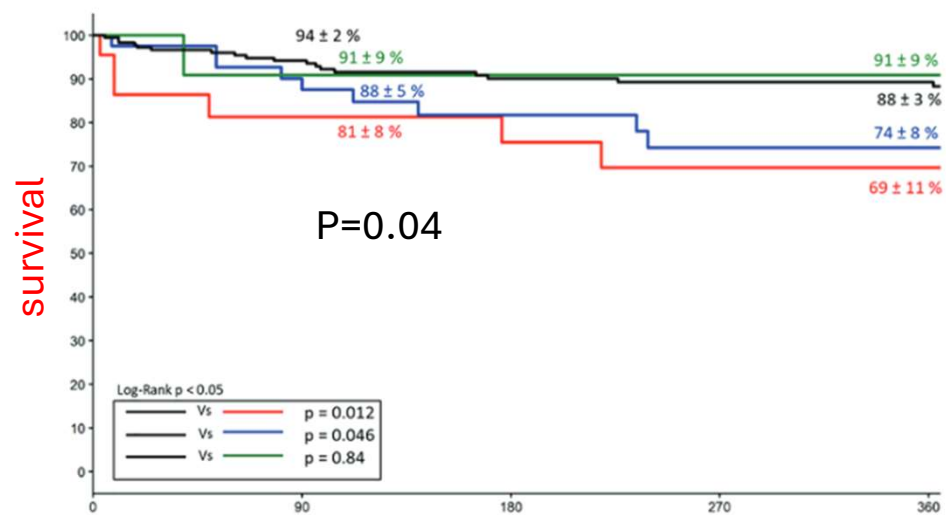


**Post-Discharge**

**31.0% (79 pts) events**

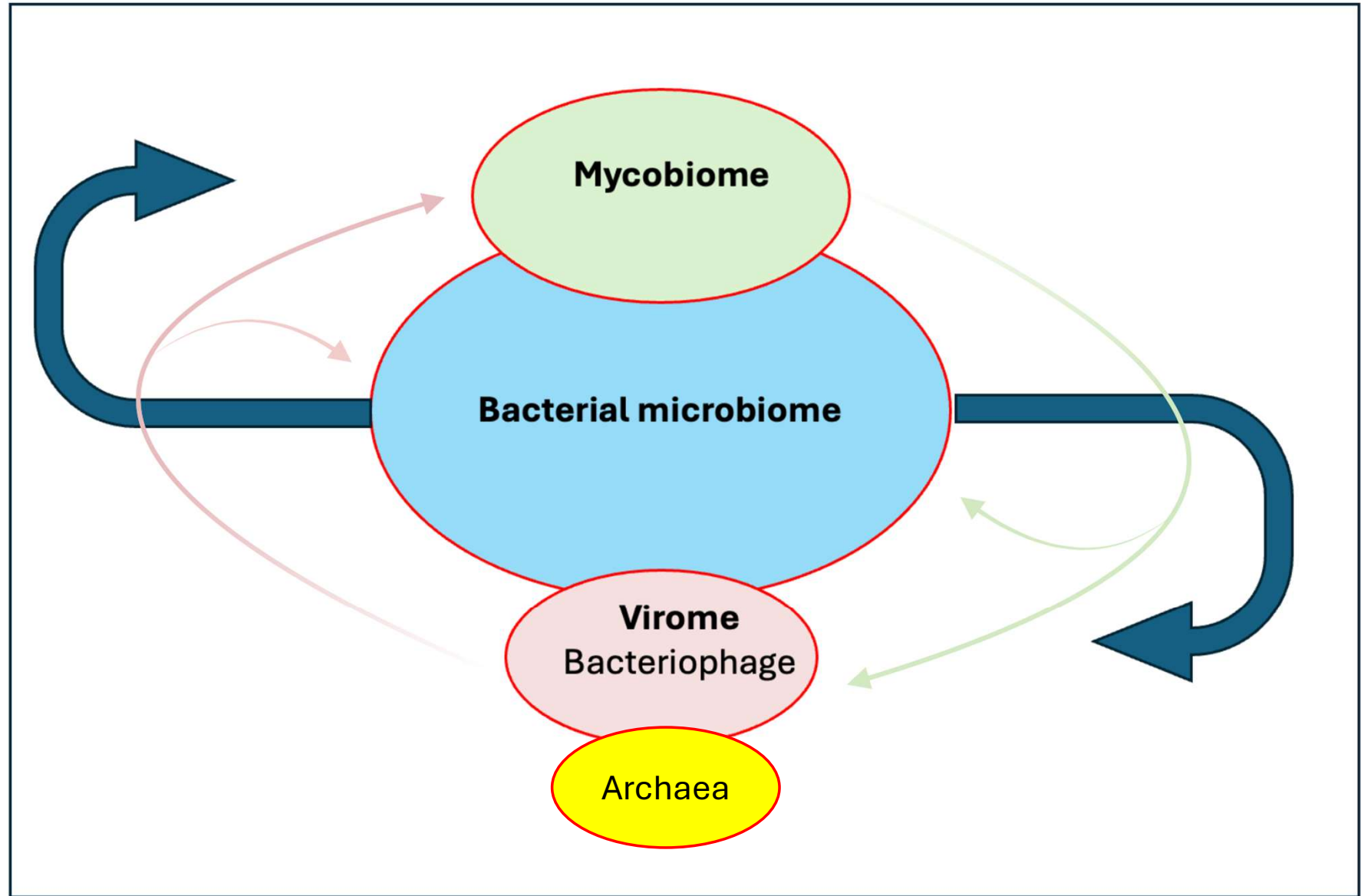
- **Median 597d**
- **VAD specific**

50% Gram-positive.



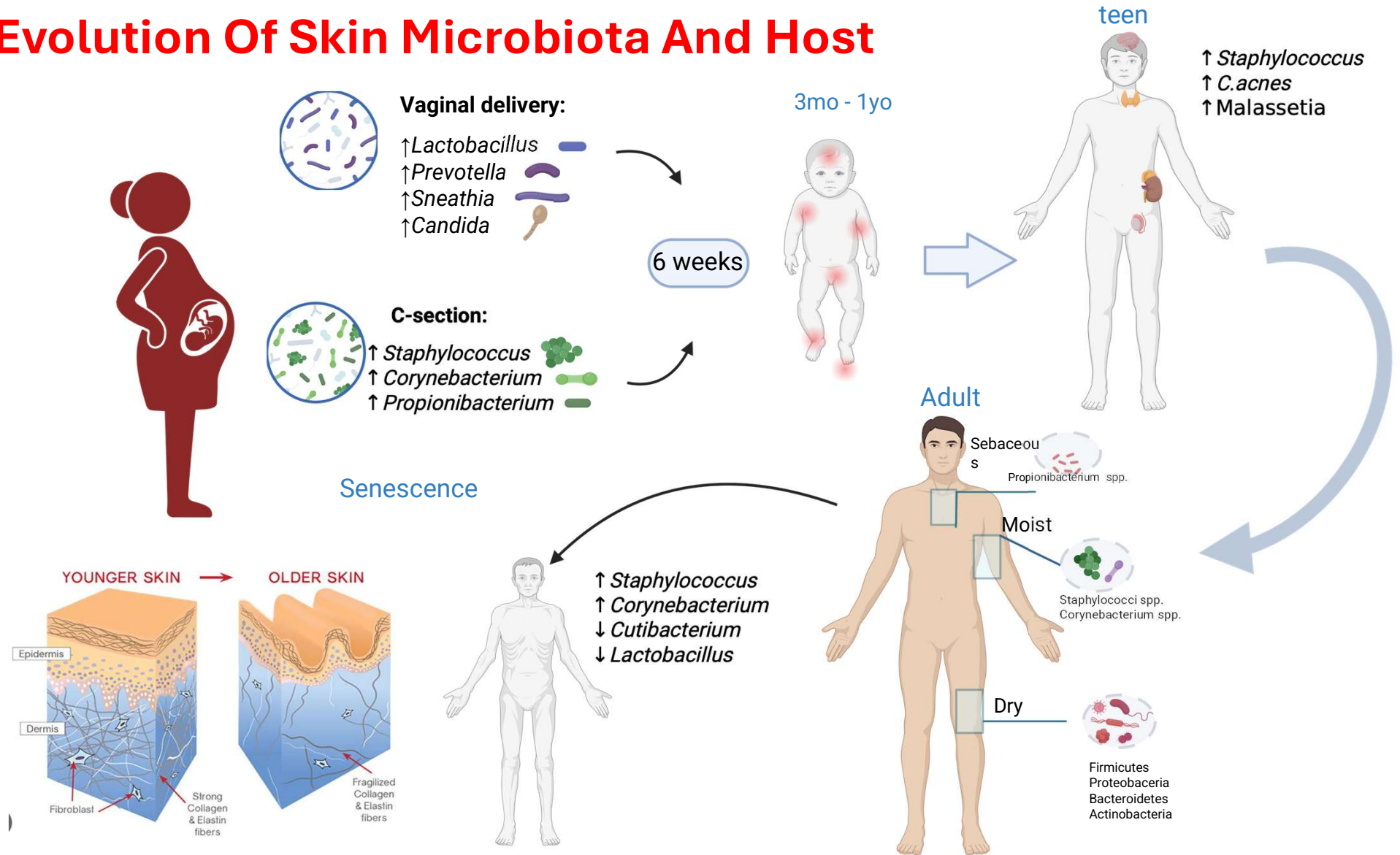
Group 1= BSI  
Group 2= Other  
Group 3= Viral  
Group 4= No infect.

# The W

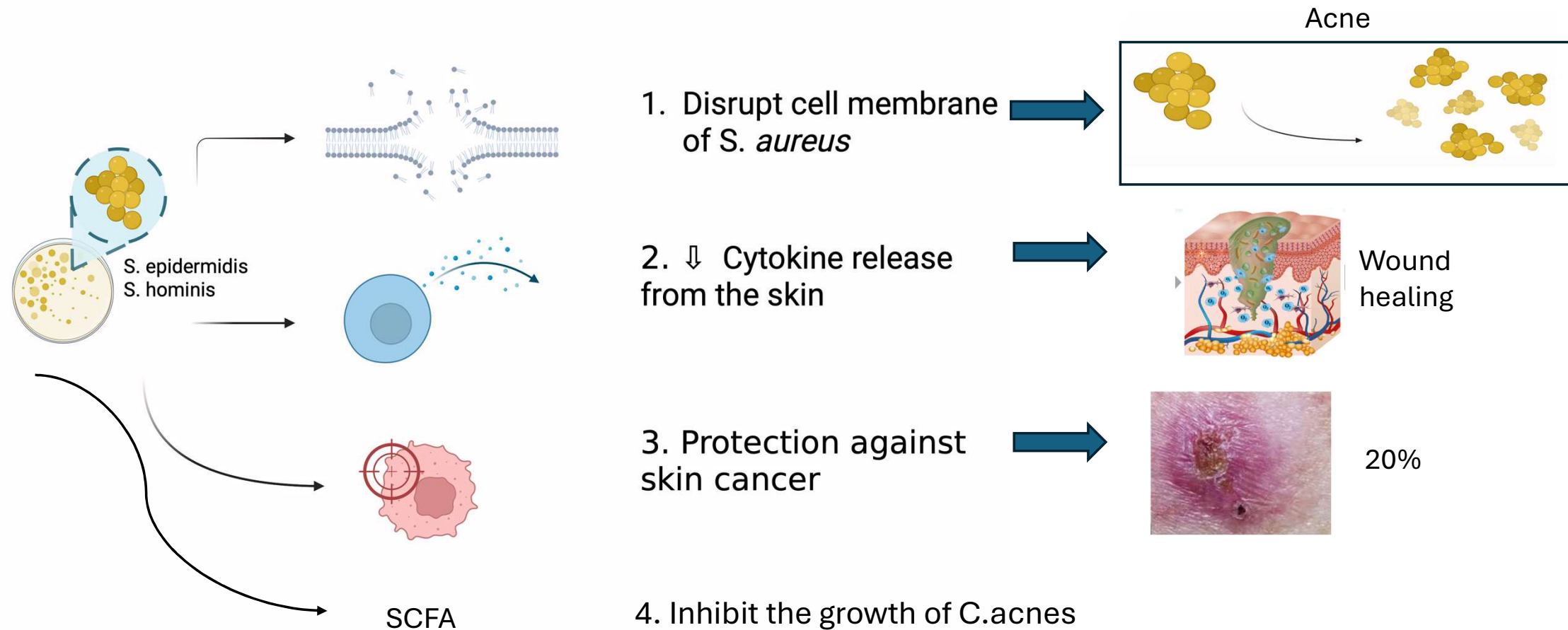




# Evolution Of Skin Microbiota And Host

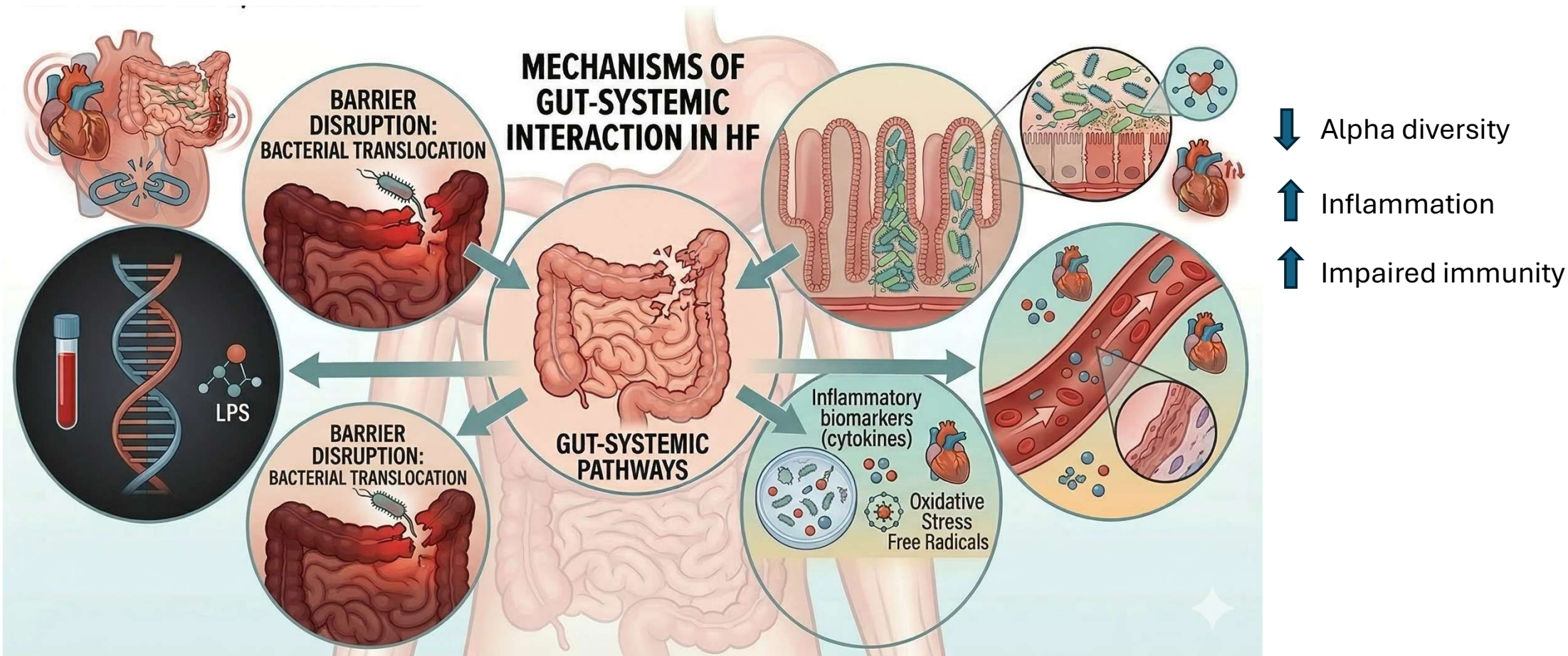


# Beneficial microbe-host interactions



*Nature Med Dec. 2009*  
*Sci. Adv. Vol 4 n 2, 2018.*

# Gut- Heart Axis



**How it change Gut microbiota communities across HF progression??**

J Am Coll Cardiol 2018;71:1184–1186

ESC Heart Fail 2017;4:282–290

J Heart Lung Transplant 2020;39:880–89



# Gut microbiota, endotoxemia, inflammation, and oxidative stress in patients with heart failure, left ventricular assist device, and transplant

## Study Population & Recruitment

**Sample Size:** 452 patients enrolled between June 2016 and February 2019 at Columbia University Irving Medical Center.

**Participants:** Adults ( $\geq 18$  years) with **systolic Heart Failure (HF)** across various stages of progression (**6 Groups**):

- HF NYHA Classes I, II, III, and IV.
- Post-LVAD (Left Ventricular Assist Device) for  $\geq 3$  months.
- Post-HT (Heart Transplant) for  $\geq 6$  months.

## Biomarkers & Stool Analysis

**Endotoxemia:** LPS and sCD14.

**Inflammation:** CRP, IL-6, TNF- $\alpha$ , ET-1, and adiponectin.

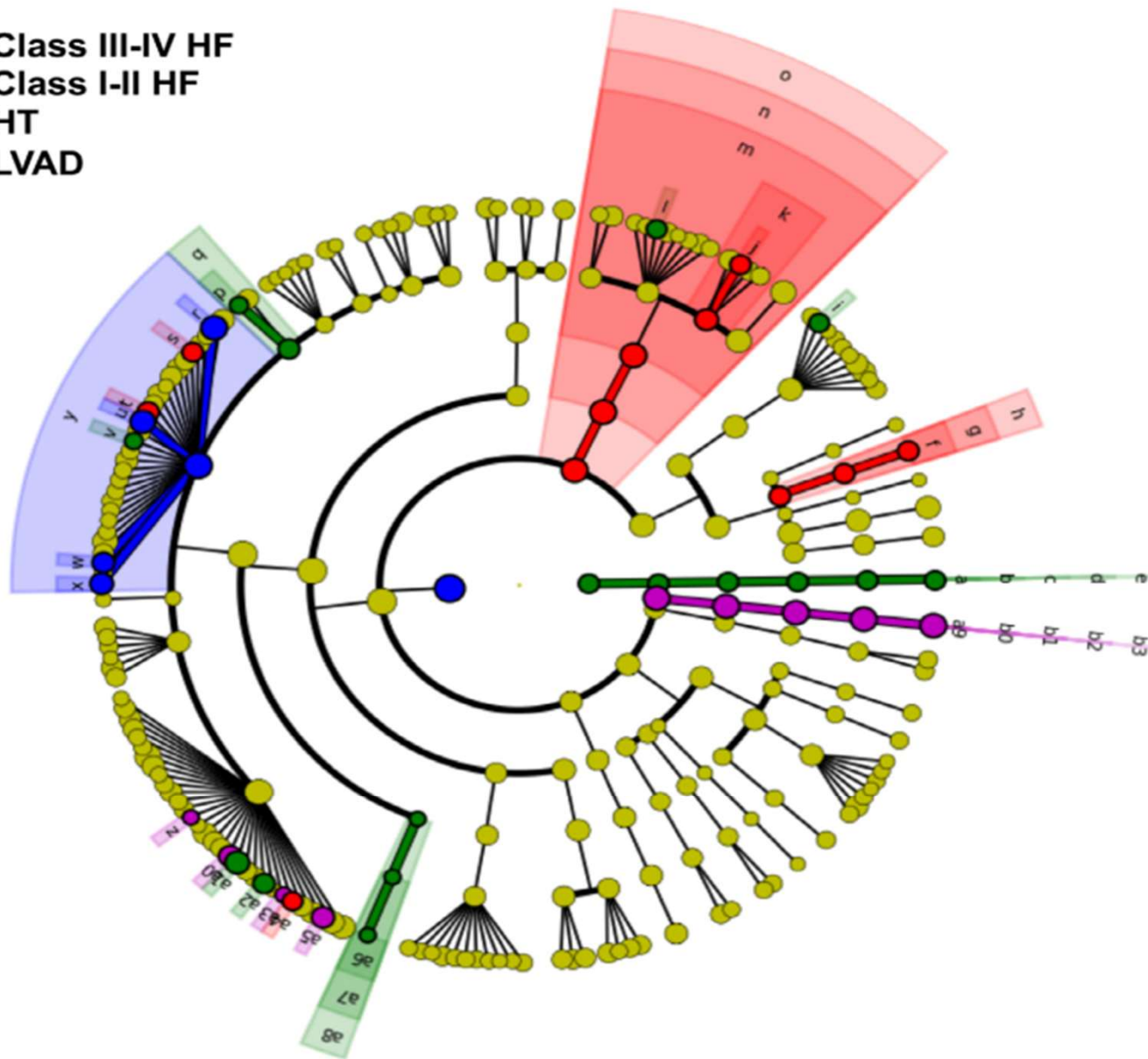
**Oxidative Stress:** Isoprostane.

## Stool Analysis:

DNA extraction and sequencing were performed to analyze the gut microbiome.



- Class III-IV HF
- Class I-II HF
- HT
- LVAD



- a: Methanobrevibacter
- b: Methanobacteriaceae
- c: Methanobacteriales
- d: Methanobacteria
- e: Euryarchaeota
- f: Rothia
- g: Micrococcaceae
- h: Micrococcales
- i: Senegalimassilia
- j: Odoribacter
- k: Porphyromonadaceae
- l: Prevotellaceae\_Ga6A1\_group
- m: Bacteroidales
- n: Bacteroidia
- o: Bacteroidetes
- p: Family\_XIII\_UCG\_001
- q: Family\_XIII
- r: Blautia
- s: Coprococcus\_2
- t: Hungatella
- u: Lachnoclostridium
- v: Lachnospiraceae\_FCS020\_group
- w: Tyzzerella
- x: Tyzzerella\_4
- y: Lachnospiraceae
- z: Ruminiclostridium
- a0: Ruminococcaceae\_NK4A214\_group
- a1: Ruminococcaceae\_UCG\_002
- a2: Ruminococcaceae\_UCG\_005
- a3: Ruminococcaceae\_UCG\_009
- a4: Ruminococcaceae\_UCG\_010
- a5: Ruminococcus\_1
- a6: Gelria
- a7: Thermoanaerobacteraceae
- a8: Thermoanaerobacterales
- a9: Akkermansia
- b0: Verrucomicrobiaceae
- b1: Verrucomicrobiales
- b2: Verrucomicrobiae
- b3: Verrucomicrobia



# The skin Microbiome

## Materials and Methods

- Single-center, longitudinal, pilot study
- Patients >18yo with end-stage heart failure admitted to our Centre with indication to LVAD implant regardless of indication (BTT, BTC,DT).
- The sample of this study foresees the enrolment of 100 patients with the above mentioned criteria.

Exclusion criteria: pregnancy, pts unable to provide informed consent.

**Main Aim:** Describe the skin microbiota in patients undergoing LVAD placement and evaluate any changes during a six-month period.

### **Secondary aims:**

- Analyze the skin communities isolated from the epidermis of patients with LVAD-specific infections to those of uninfected patients.
- Identify specific skin microbiome patterns associated with the development of LVAD specific infections
- Study the role of different antibiotic classes on skin microbiota changes.

TC  
LVAD im  
2023

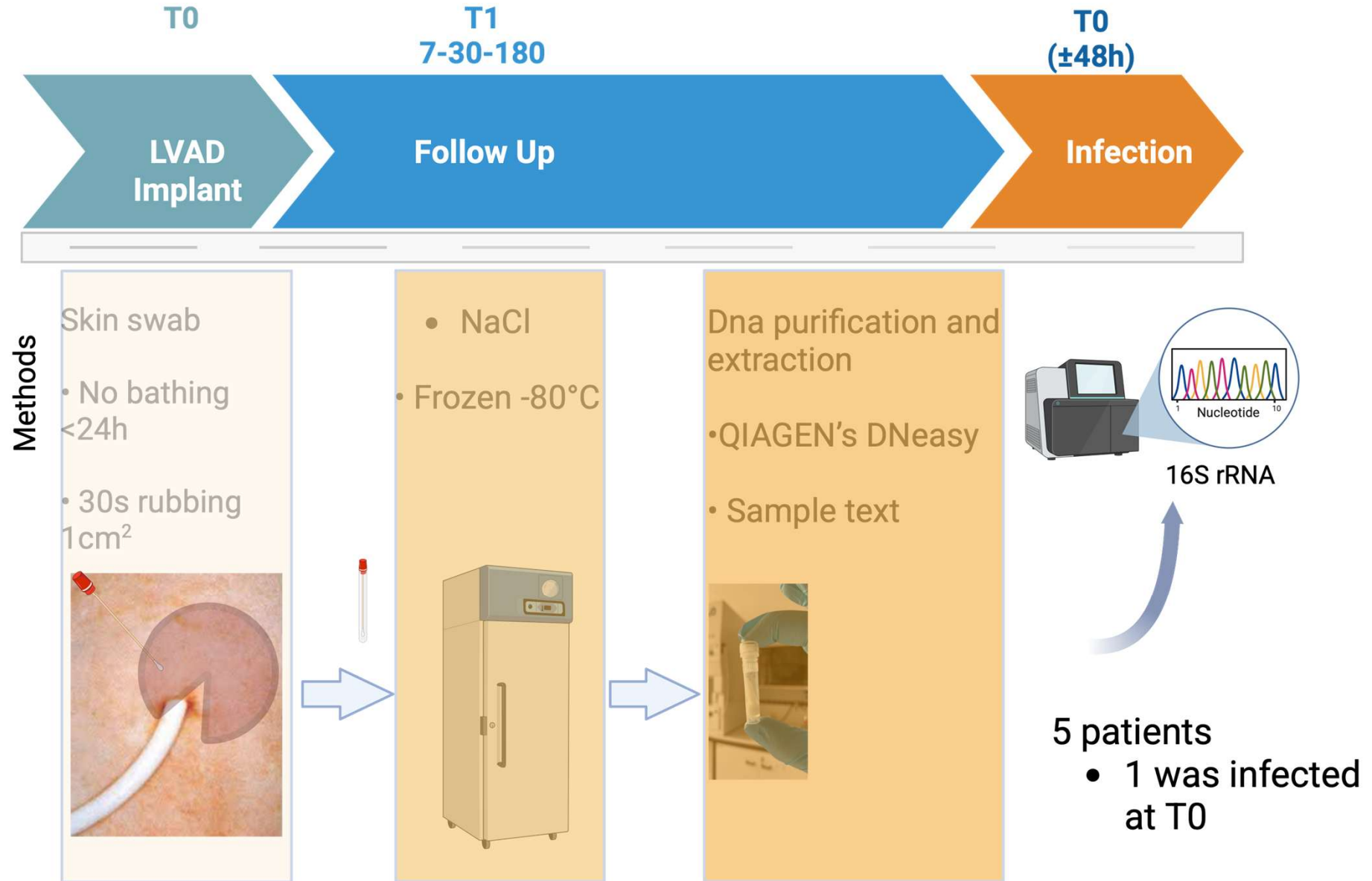
Exclusio  
- Unab  
- Pregr

	All patients				Infected patients	
	Day 0	Day 7	Day 30	Day 180	T0i	T30i
Timing	LVAD surgery				<7 days from <u>diagnosis</u>	30 days from <u>diagnosis</u>
<u>Enrollment</u>	X					
<u>Skin swab</u>	X	X	X	X	X	X
<u>Nasal swab</u>	X				X	
<u>Assessment medications and illnesses</u>	X	X	X	X	X	X
<u>Clinical data collection</u>	X	X	X	X	X	X

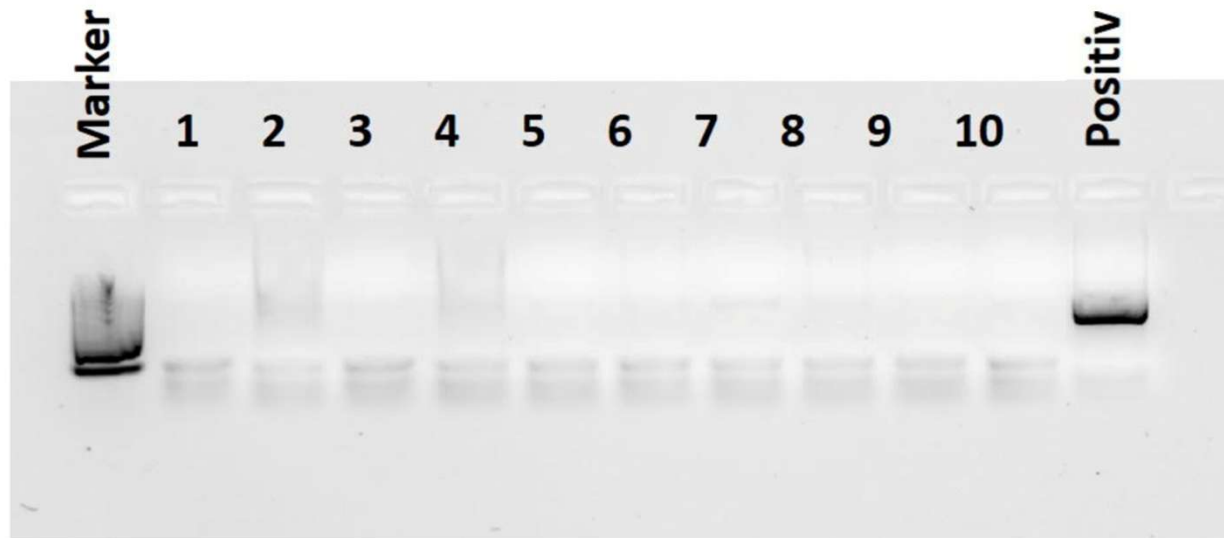
: 100 pts



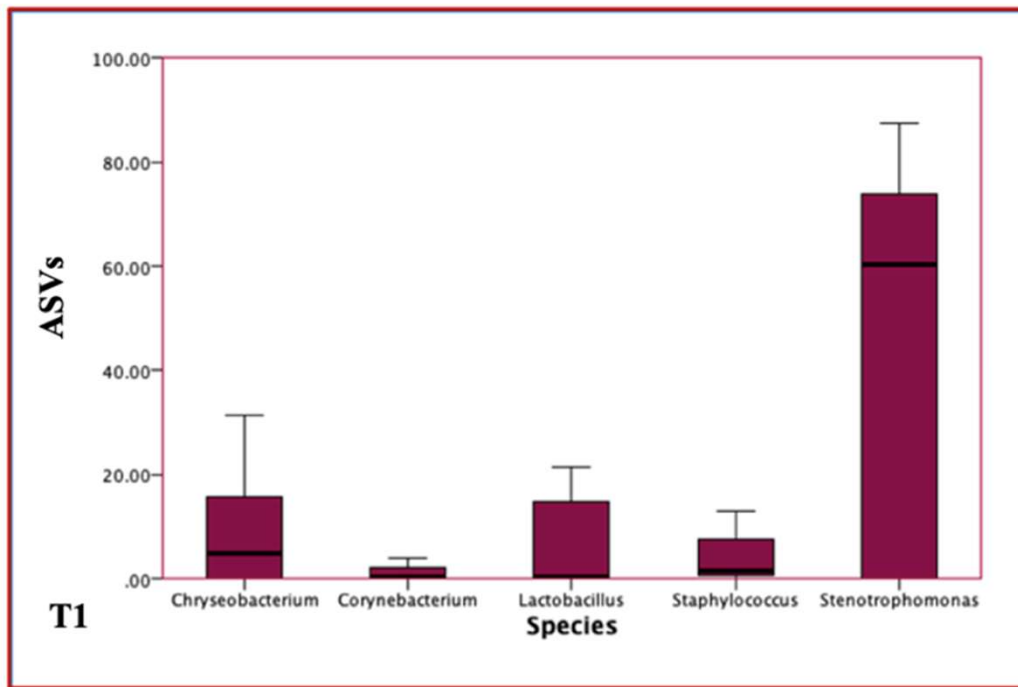
# SKIN SAMPLING



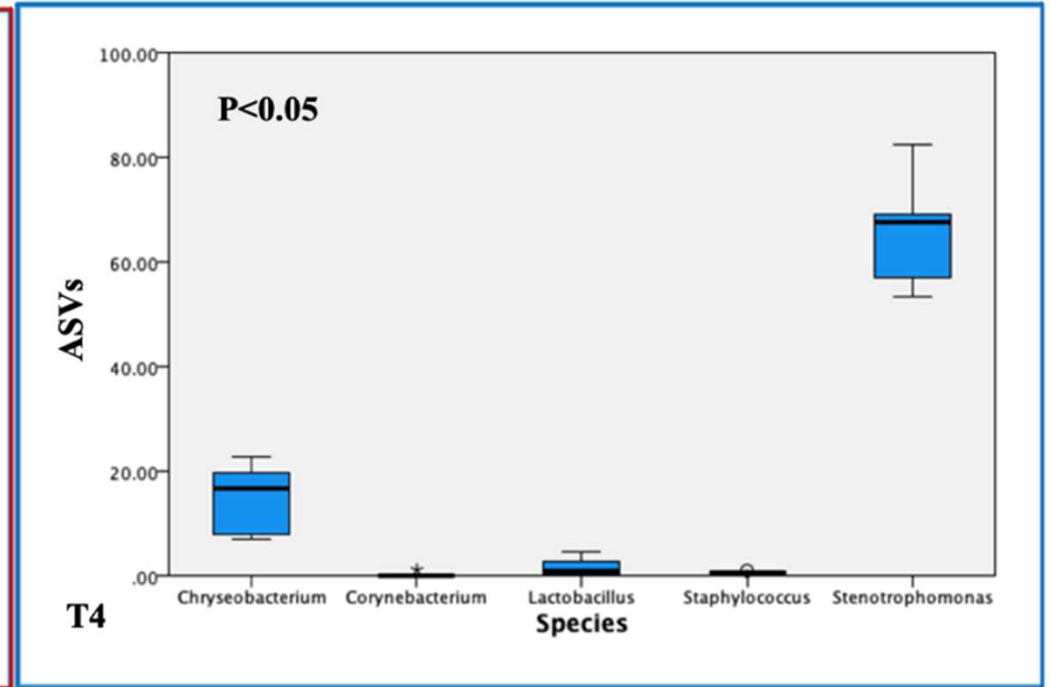
## Results: quantification of Skin Samples Biomasses



✓ Skin samples from dry areas are characterized by very low biomasses even doubling the number of swabs



Stenotrophomonas 47.5%  
 Cryseobacterium 13.8%  
 Lactobacillus 6.3%  
 Staphylococcus 3.9%  
 Corynebacterium 1.5%

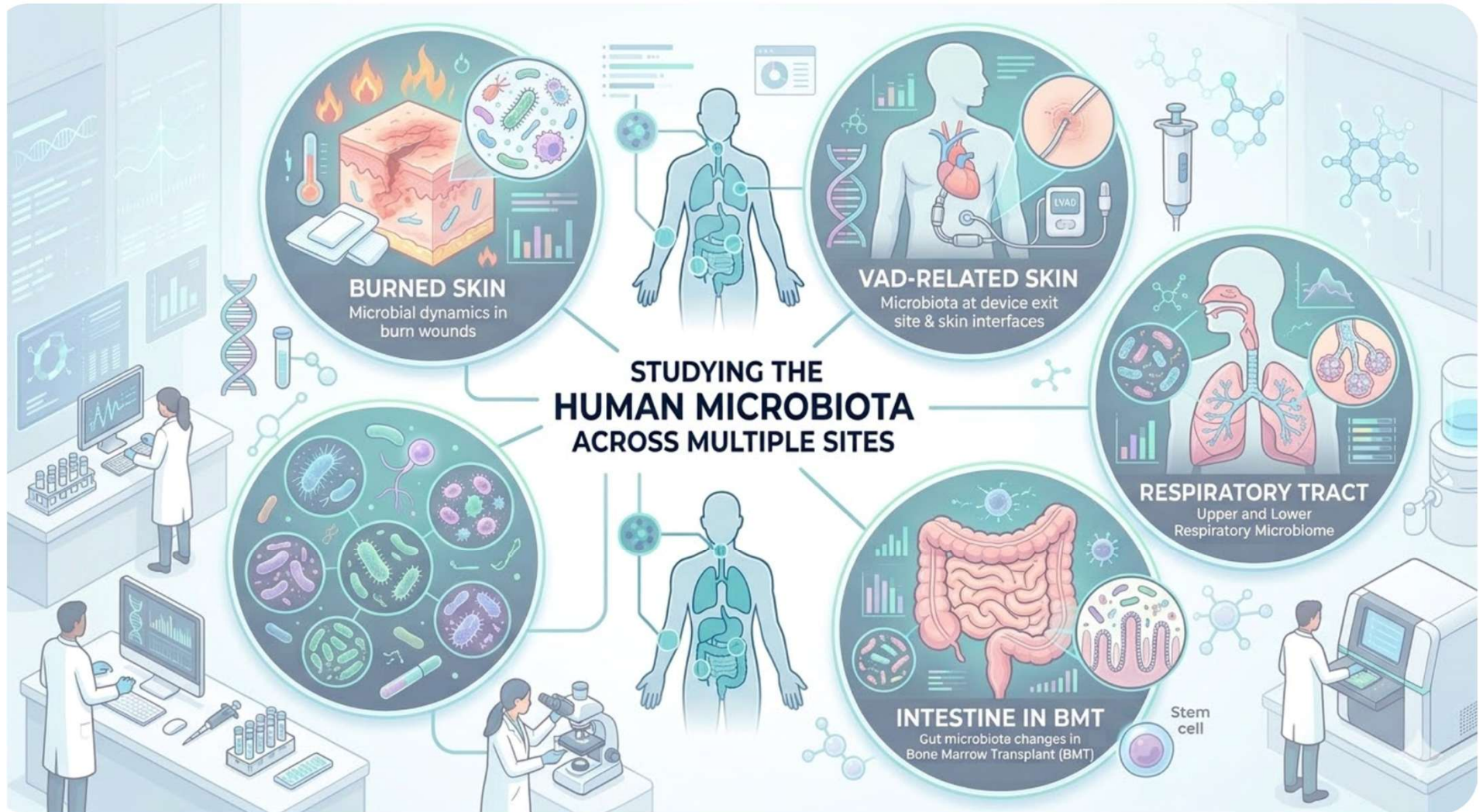


Stenotrophomonas 66.7%  
 Cryseobacterium 5.2%  
 Lactobacillus 2.0%  
 Staphylococcus 1.3%  
 Corynebacterium 0.8%





# Current studies



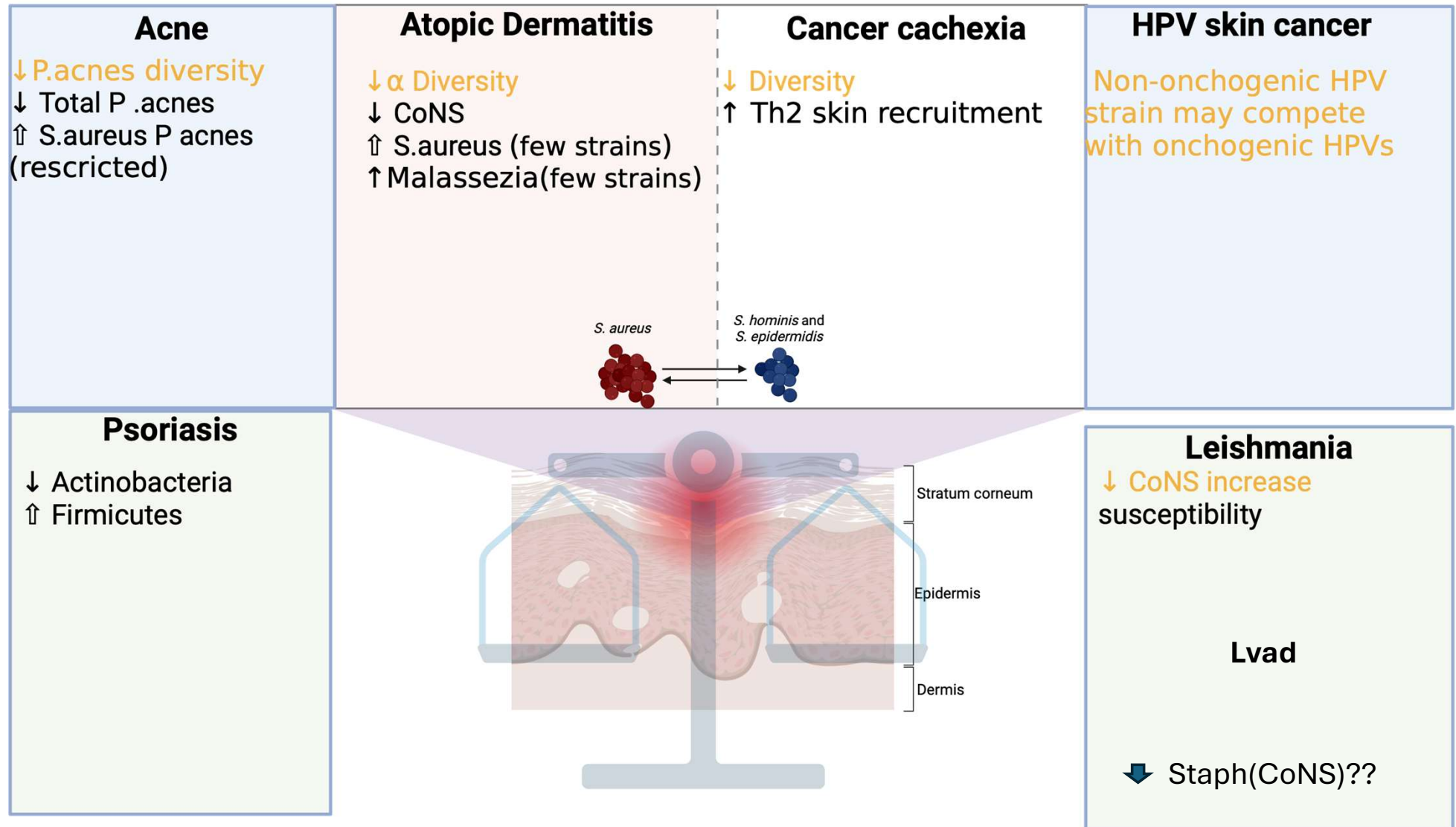
# Take Home Messages

- The skin microbiome is a complex balance of resident and transient species.
- Signaling among host-associated microbial communities is real
- A reduction in alpha-diversity has been observed in patients with heart failure, including those with LVAD and HT.
- Taxonomics should be coupled with other «omics» to understand how microbiota work.

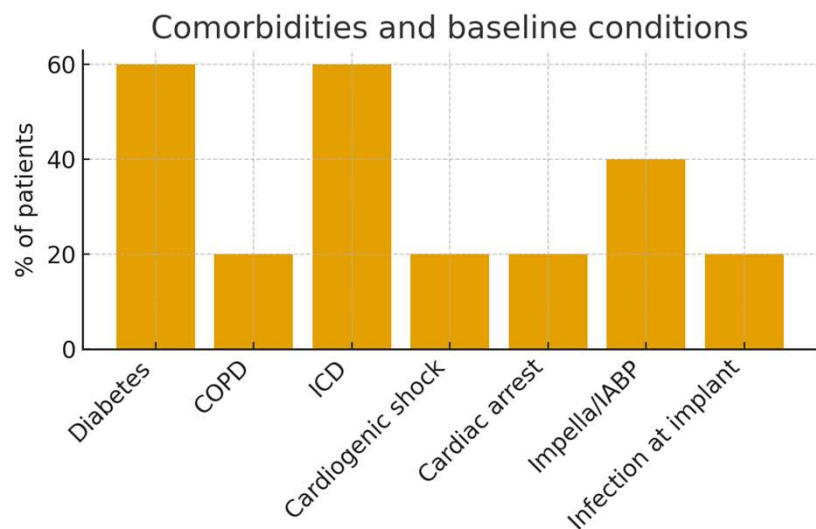
**The microbiota is not like Las Vegas:  
What happens on it doesn't stay on  
it.**

**Thanks for your attention**

# Commons skin microbiome features in pathological conditions







Sex (M/F: 4/1)

Median age: 59yo



LVAD type: HeartMate 3® (100%)



CEC time: median 137 min (range 115–168)



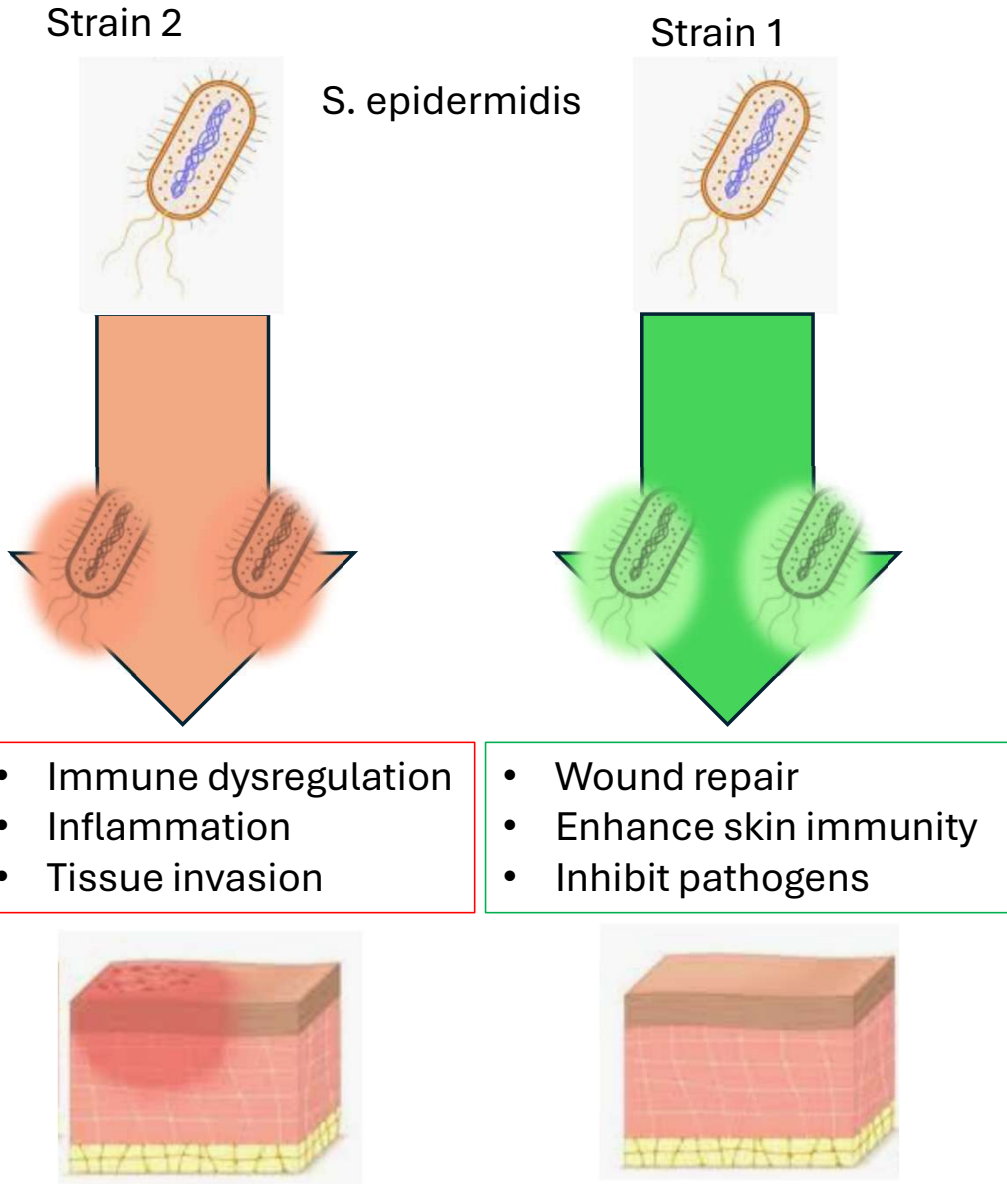
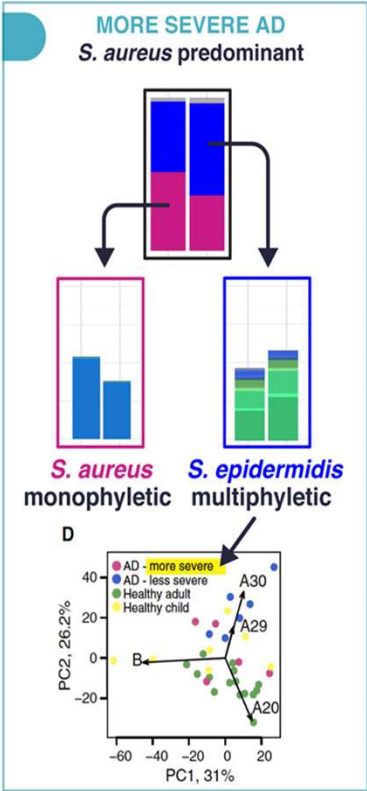
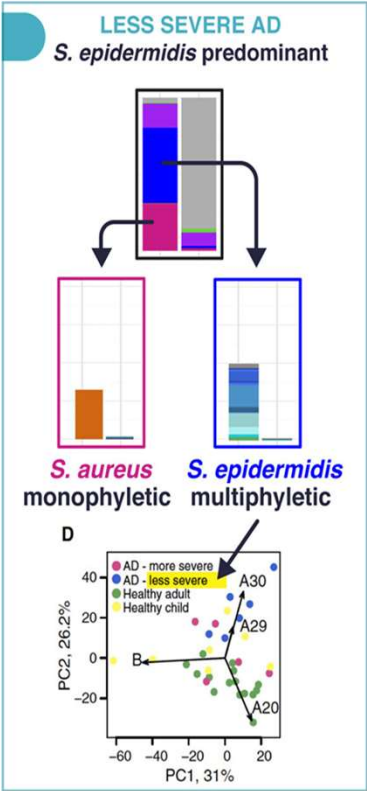
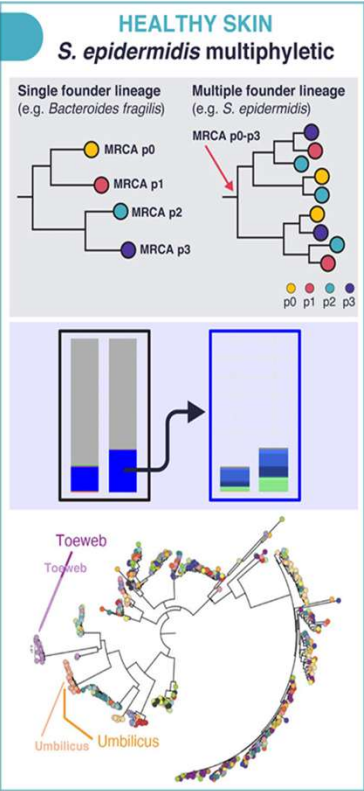
Recent antibiotics <30 days: 4 patients (80%)



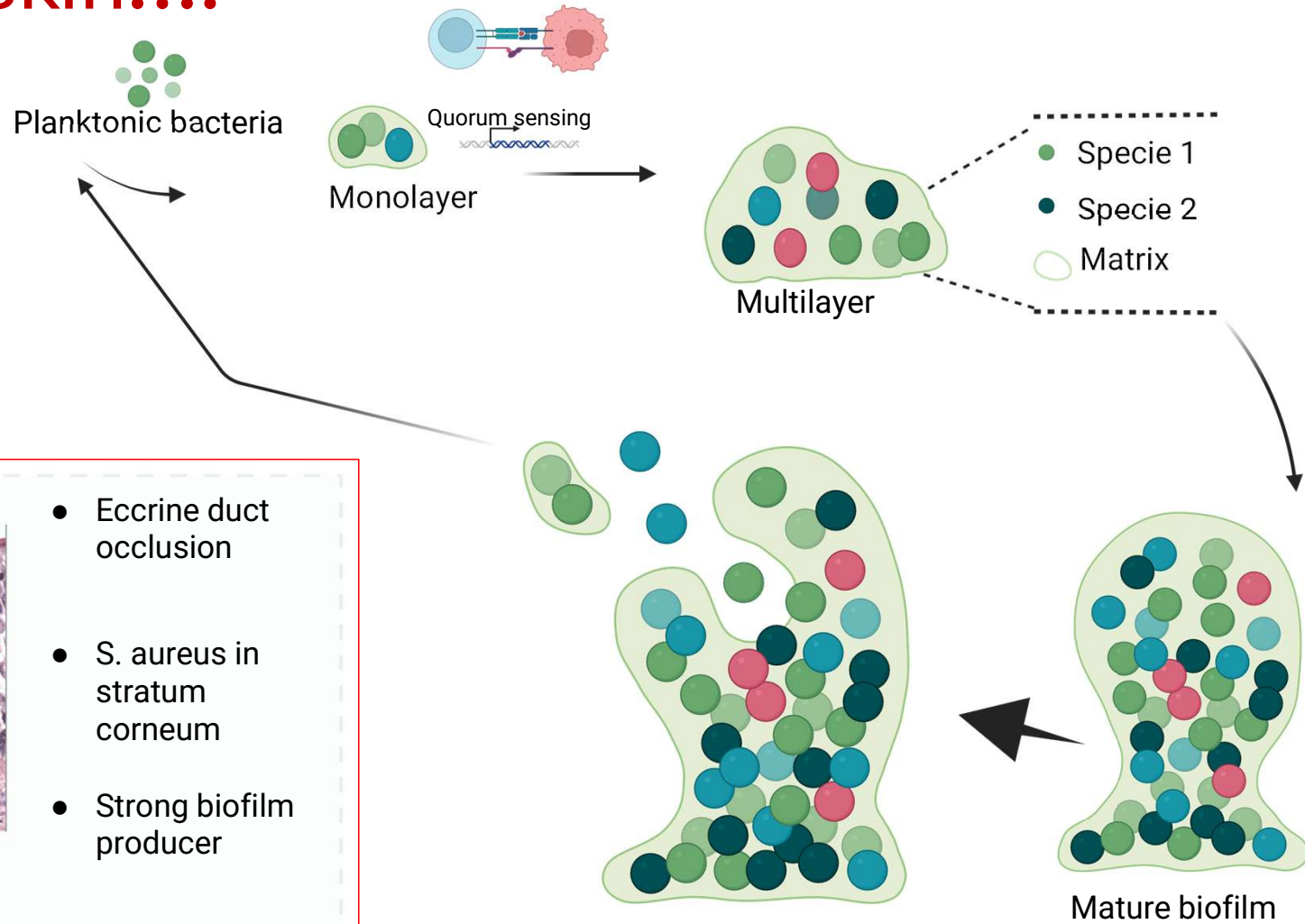
No MDRO gut colonization / No MRSA nasal colonization

Variable	n (%) / Details
Antibiotic therapy at baseline (T0)	3 patients (60%) broad spectrum (incl. anti-MRSA)
• Non-LVAD related infections	2 patients (40%) → 2 HAP/VAP; 1 BSI
• Suspected early DLI	1 patient (20%)
Infections documented at T4	1 MRSA DLI (daptomycin) 2 MRSE DLI (vancomycin) 1 MSSA DLI (piperacillin/tazobactam + vancomycin)
Patients infection-free at T4	2 patients (40%)

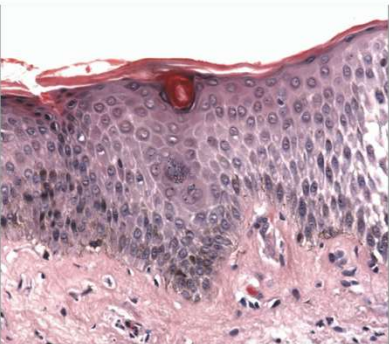




# Biofilm & skin....



## Atopic dermatitis

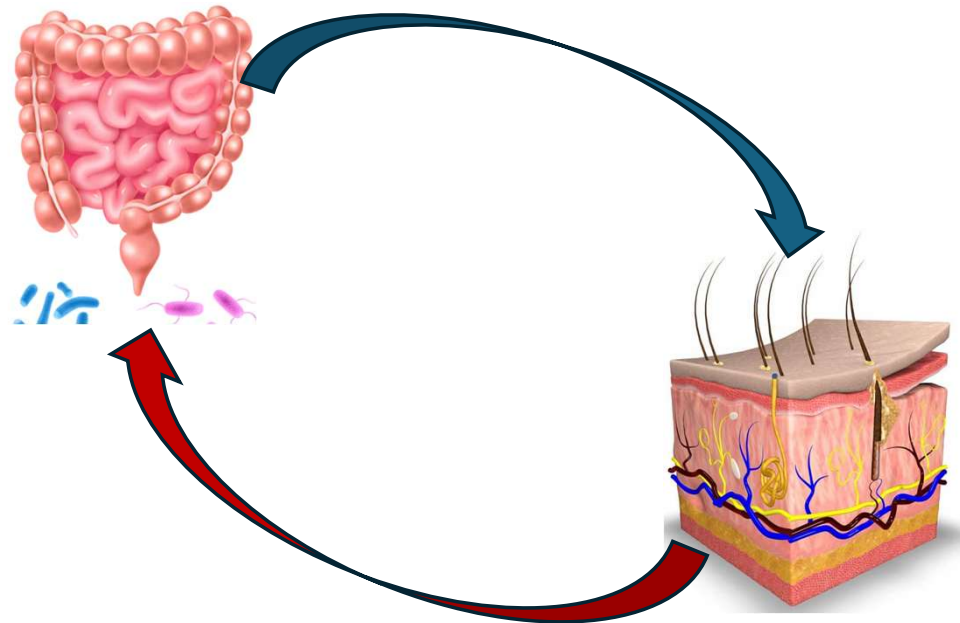


- Eccrine duct occlusion
- *S. aureus* in stratum corneum
- Strong biofilm producer

*JAMA Dermatol.* 150, 260–265 (2014).

NPJ biofilm and Microbiomes, 2016

# The Gut-Skin Axis

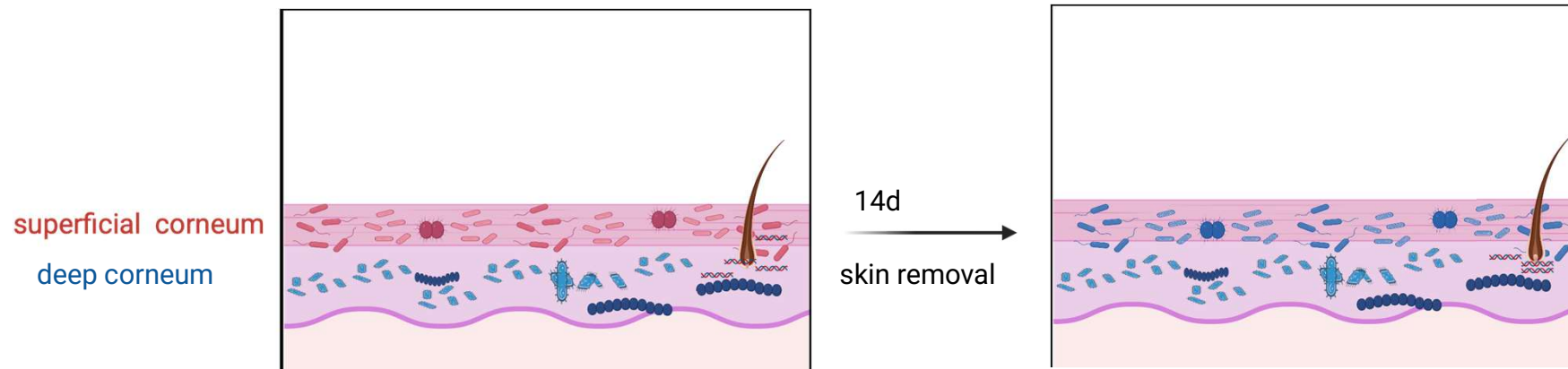


## AD

- Pts with AD have ↓ gut Bifidobacteria and increased Clostridioides
- High level of SCFA are protective against AD

- 7-11% of IBD pts has psoriasis
- High carbo diet is associated with acne vulgaris and dandruff
- A gut dysbiosis has been found in acne, AD, and rosacea
- **UVB and topical allergies influence the gut**

# Skin Microbiome Transplantation



Transfer dipteroides from armpit to forearm of the same subject produces malodour

*S. epidermidis* applied to the same subjects' facial skin during 4w increases lipid and water skin content and decrease water evaporation

Application of a mixture of different *C. acnes* species for 5 weeks in subject with acne resulted in reduction in lesion extension

# Brain function & skin microbiome: a pilot study

## Methods:

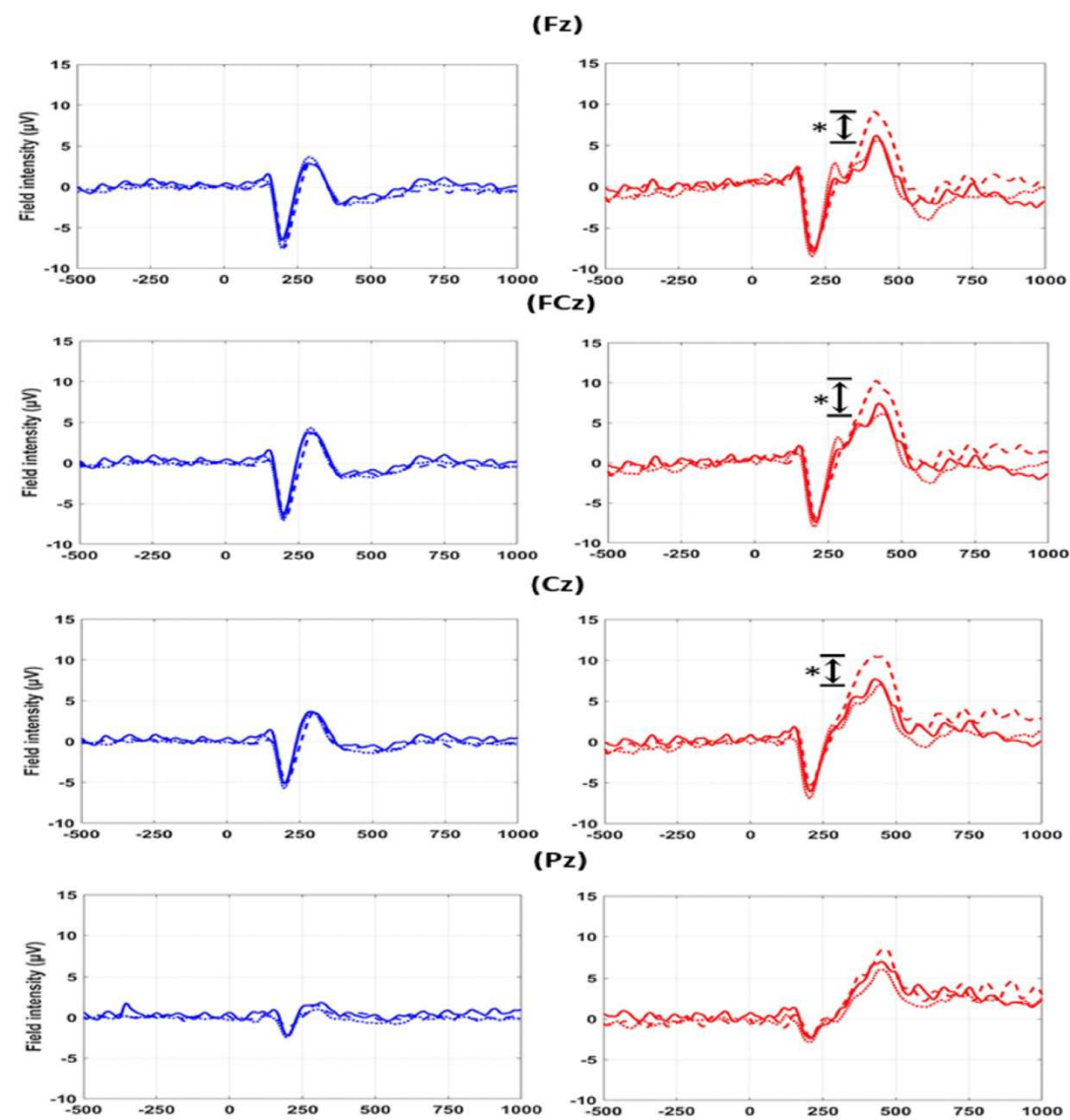
- 1) Manipulation of bacterial population of forehead of 24 healthy participants.
- 2) Task comprised 2 auditory stimuli with different frequencies (odd and high tone) presented randomly. Participants had to count only high tones.
- 3) Repeat 3 times; one for each bacterial manipulation of the forehead
- 3) Recording EEG during oddball tasks and examination of ERPs\*

Alcohol 75%

Distilled water (mimic natural skin growth)

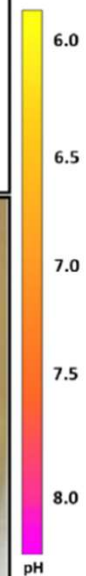
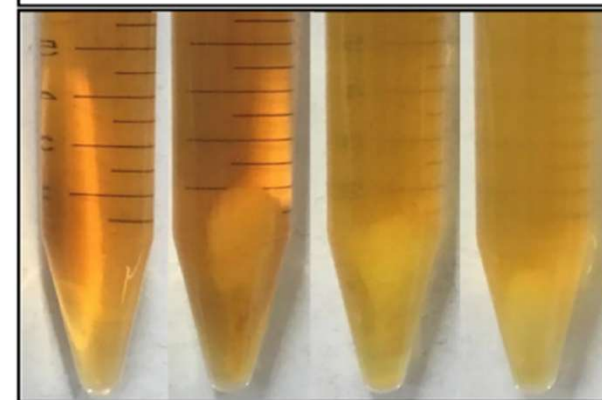
Glycerol 65%(nutrient for bacteria)

\*N200 and P300 were measured as an indicator of spatial and specific attention pathways.



Medium  
Bacteria  
Alcohol  
Water  
Glycerol

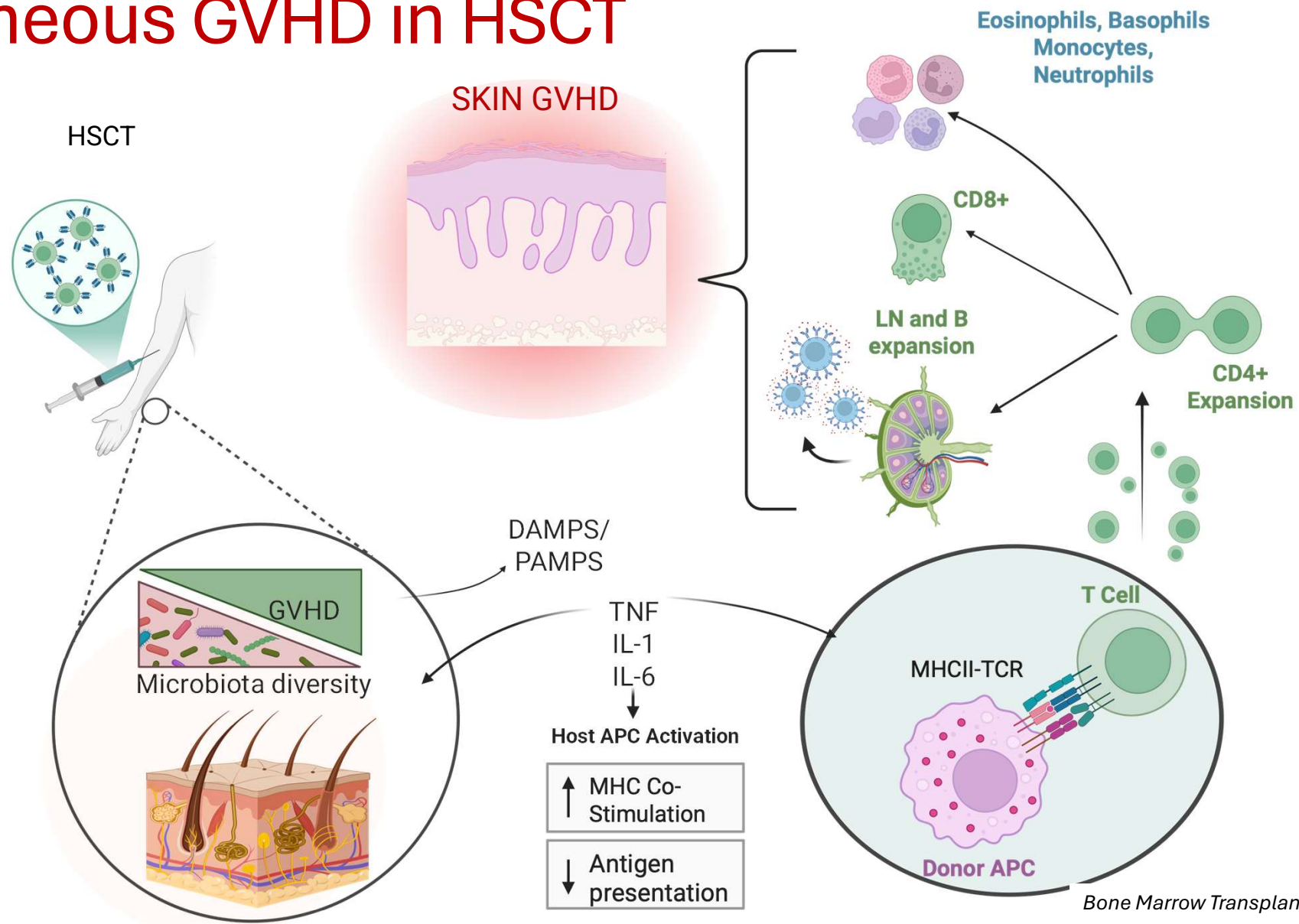
+	+	+	+
	+	+	+
	+		
		+	
			+



- - - Std\_alcohol      Std\_water      ..... Std\_glycerol  
 - - - Odd\_alcohol      Odd\_water      ..... Odd\_glycerol



# Cutaneous GVHD in HSCT



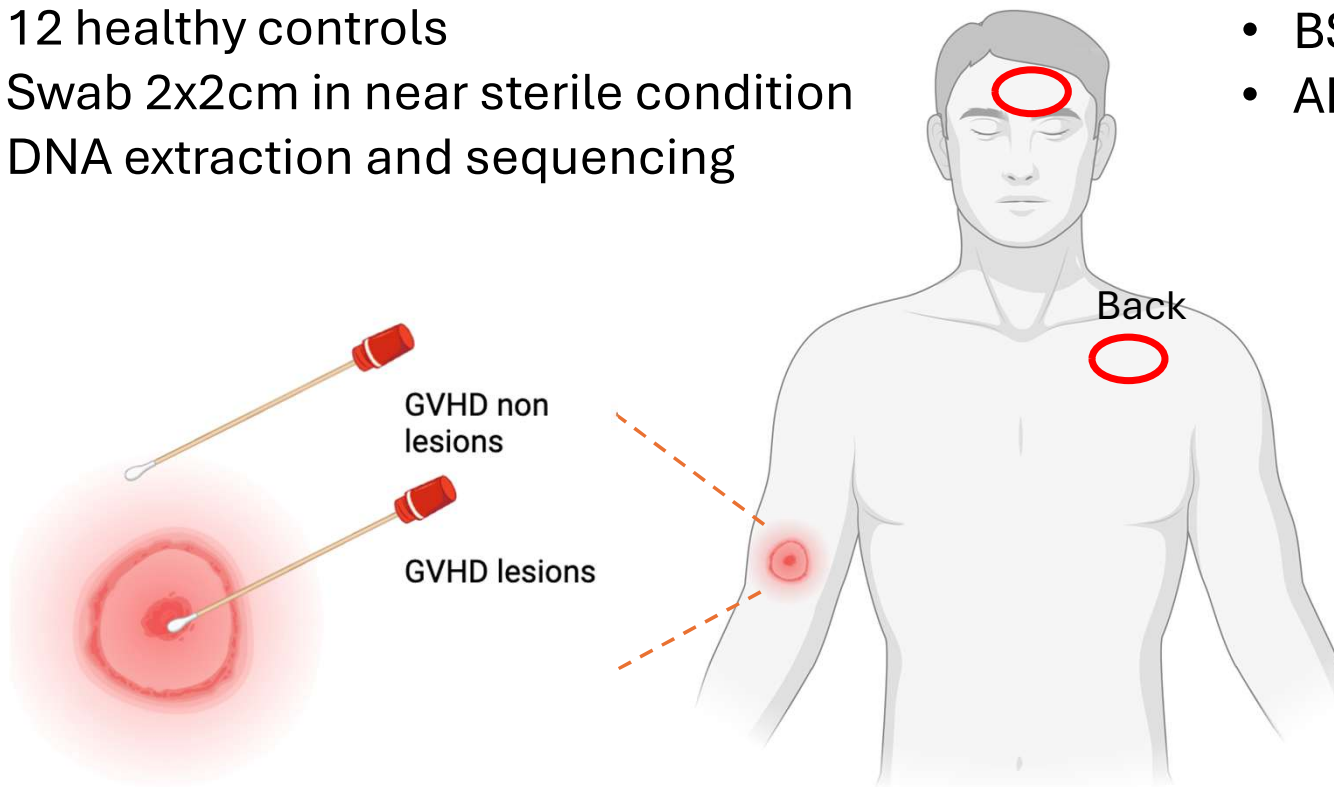
# Cutaneous GVHD in HSCT patients

## Population and Methods

- 12 Pts (AML, ALL) with skin GVHD
- 12 healthy controls
- Swab 2x2cm in near sterile condition
- DNA extraction and sequencing

## Exclusion

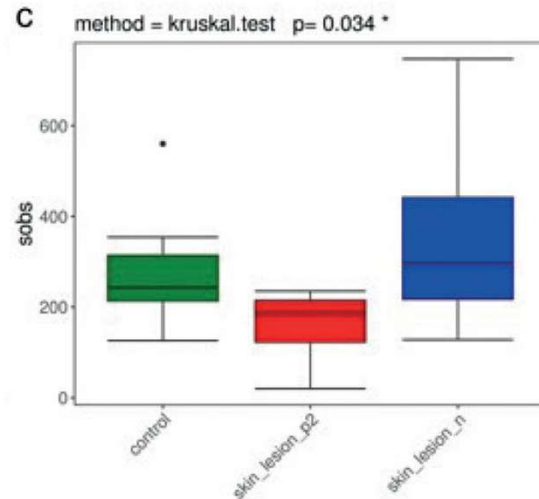
- Autoimmune disease
- BSI
- ABT treatment at least 4 weeks



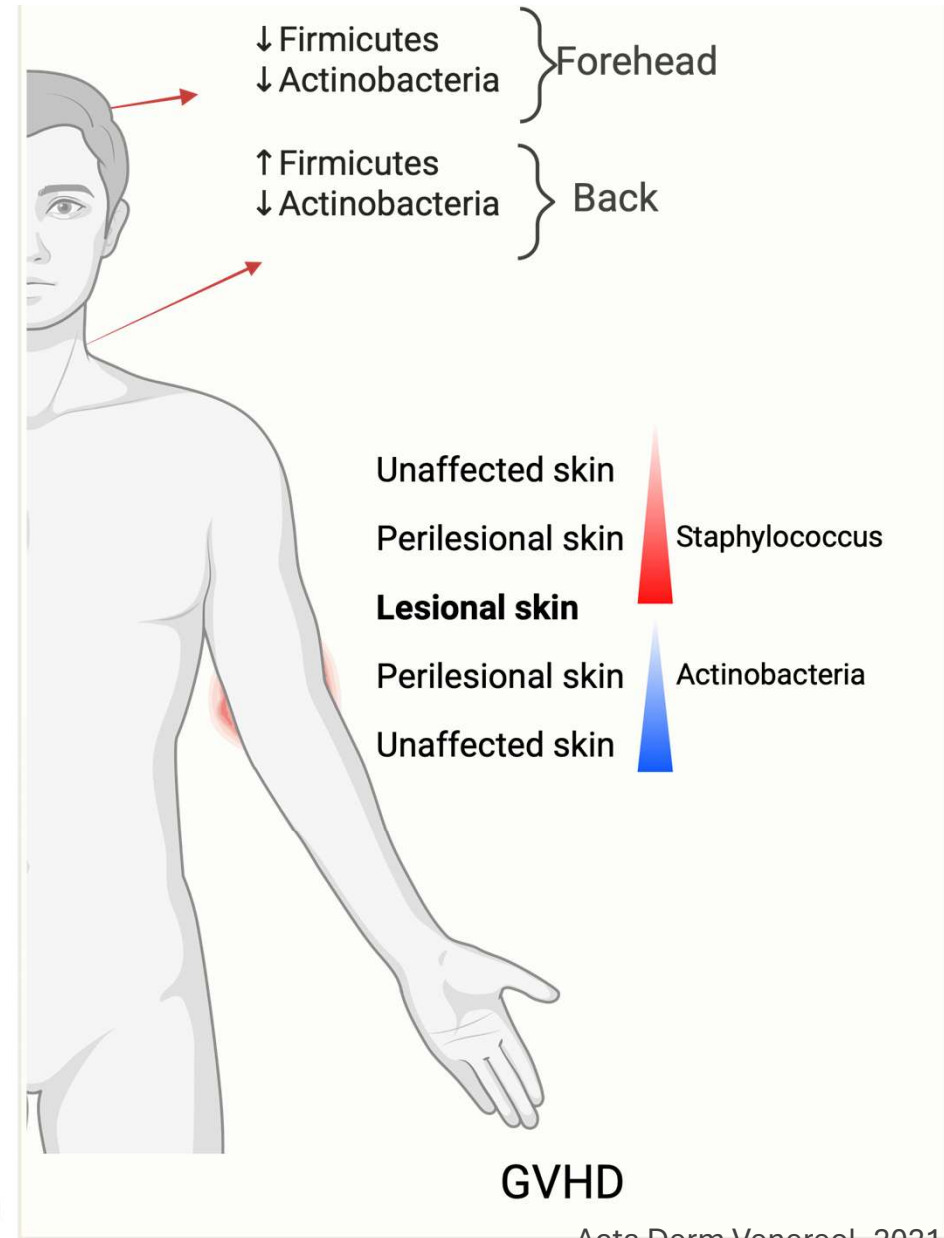
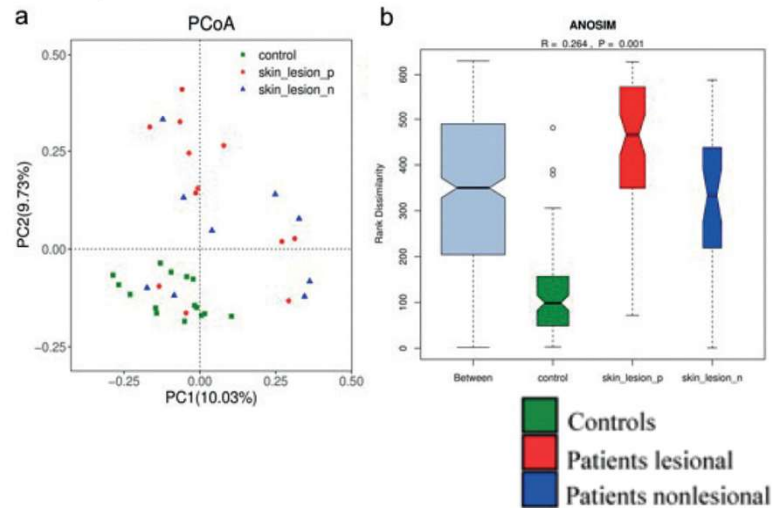
6 pts with Lichen Planus-like GVHD  
7 pts with atopid dermatitis-like GVHD

# Results

## $\alpha$ Diversity

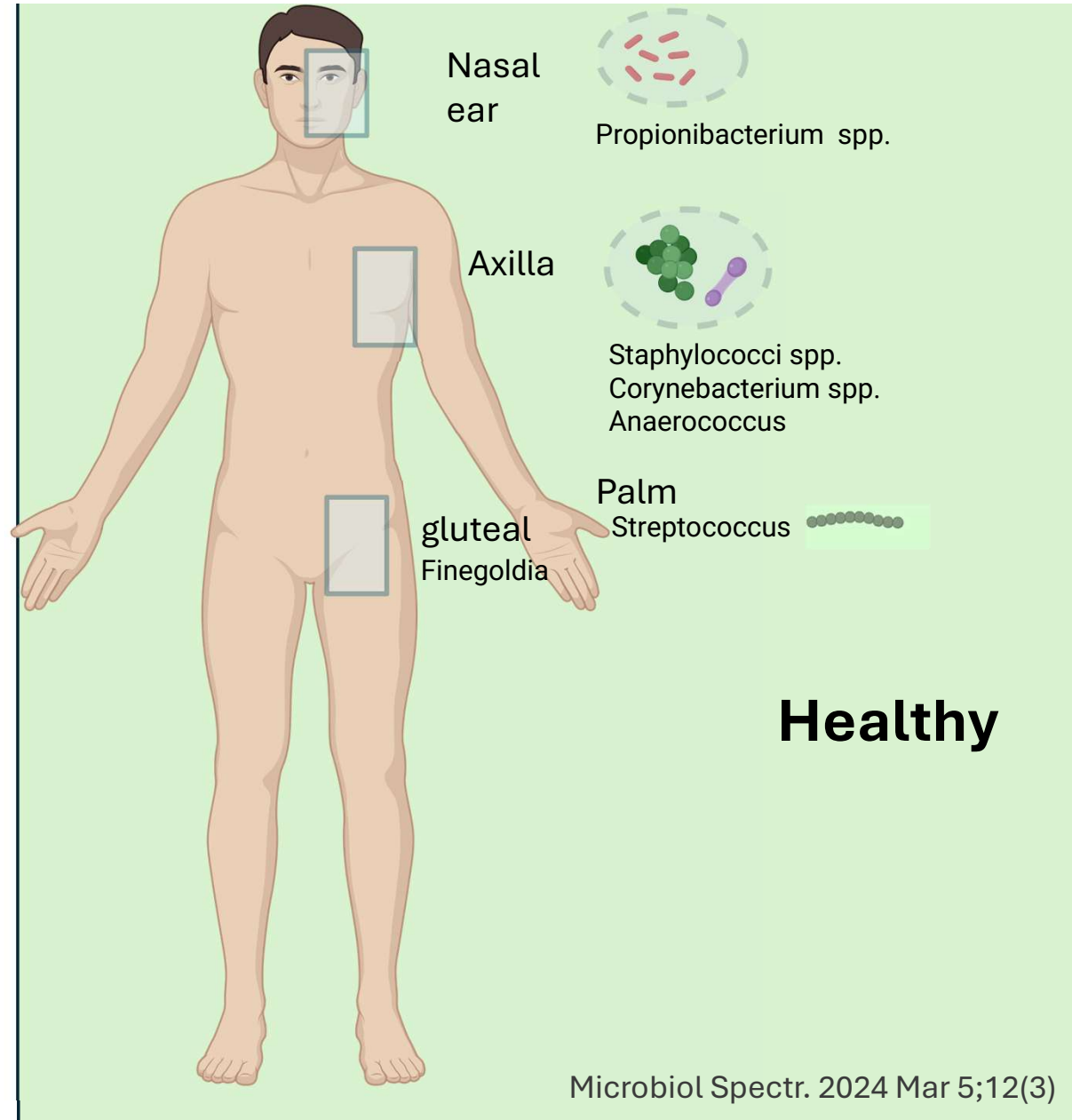
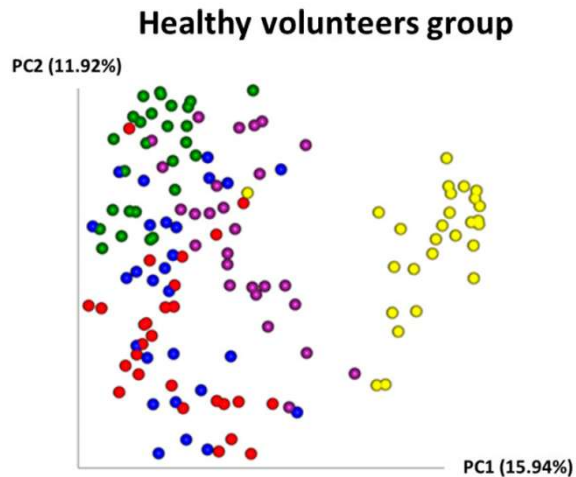


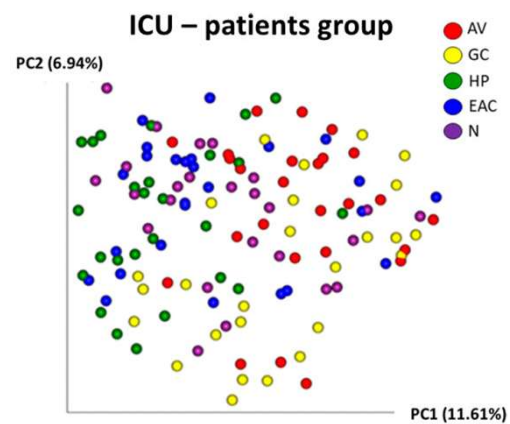
## $\beta$ Diversity



# Dysbiosis in Intensive Care Unit

- 265 skin sample from different areas
- 26 ICU pts vs 27 Healthy Volunteers
- At time of ICU admission





- Loss of site-dependent segregation
- Increase in typical gut microorganisms

