JN 23es Journées Nationales d'Infectiologie
Bordeaux
et la région Aquitaine
Palais des Congrès
du mercredi 15 juin 2022
au vendredi 17 juin 2022

Intérêt des scores dans le diagnostic des Endocardites infectieuses

Pr Xavier Duval
Hôpital Bichat Claude Bernard, Paris
xavier.duval@aphp.fr

Endocardite

- Maladie rare
- Présentation polymorphe
- Ex clinique: mauvaises sensibilité et spécificité diagnostiques
- Traitement spécifique (Abie, Chirurgie cardiaque)
- Maladie curable
- Pronostic dépend du délai thérapeutique

Endocardite

- **Examens diagnostiques de première ligne:**
  - Hémocultures répétées
  - Echocardiographie TT, TO

- **Suspicion** **Hémoculture** **Echocardiographie**

Ressources limitées

Diagnostic endocardite:

- **Suspicion** **Fièvre**

  AEG

  Souffle de régurgitation

  OAP

  Embolie ……

Diagnostic endocardite: 3 stratégies

- **Suspicion** → **Hémoculture**
  Echocardiographie

Chez tous

Diagnostic endocardite: 3 stratégies

- Suspicion → Hémoculture
  Echocardiographie
- **Suspicion → Hémoculture ⊕ → Echocardiographie**

Si hémoc pos

Staphylococcus aureus bacteremia Echocardiography indications

AEPEI

- *S. aureus* infective endocarditis: 8-15% of SAB

European Heart Journal
doi:10.1093/eurheartj/ehv319

2015 ESC Guidelines for the management of infective endocarditis

« **In patients with S. aureus bacteraemia, echocardiography is justified** in view of the frequency of IE in this setting, the virulence of this organism and its devastating effects once intracardiac infection is established. »

Infective Endocarditis in Adults: Diagnosis, Antimicrobial Therapy, and Management of Complications

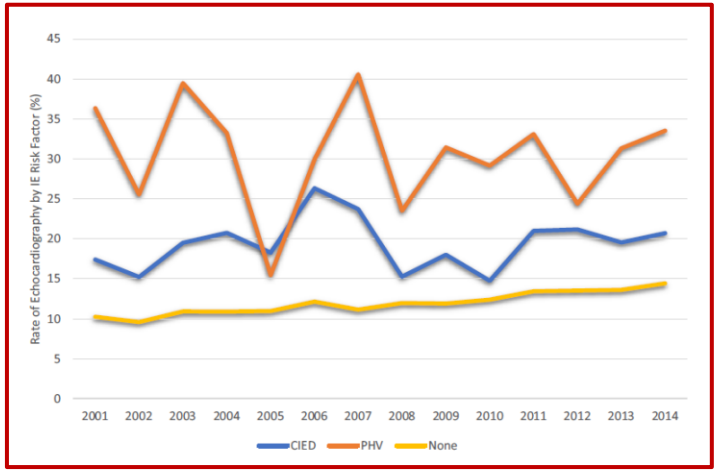
A Scientific Statement for Healthcare Professionals From the American Heart Association *Circulation*. 2015;132:

« Although cost-effectiveness calculations suggest that TEE should be the first examination in adults with suspected IE, **particularly in the setting of staphylococcal bacteremia, ……further work is needed to better define the subgroup of patients with bloodstream infection caused by S aureus who need only TTE to evaluate for IE »**

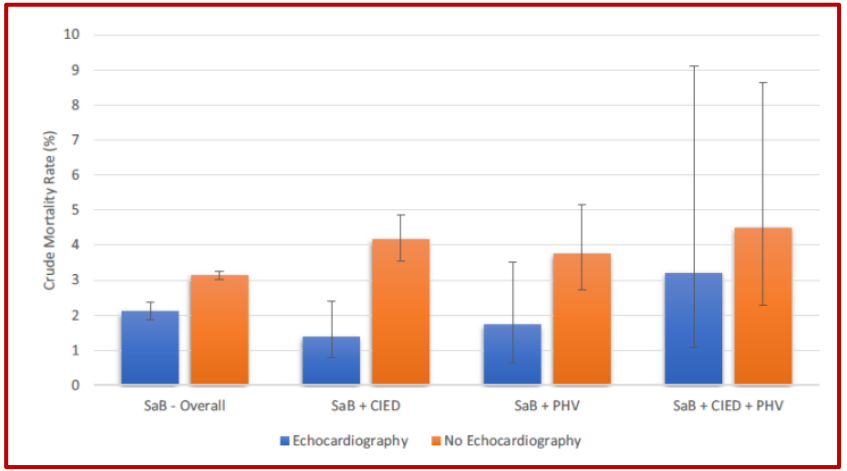
El Atrouni WI Clin Infect Dis 2009; 49:e130.
Rhee Y, Infect Control Hosp Epidemiol 2015; 36:1417.

Echocardiography in SAB patients: Clinical practice

- **668 423 hospitalizations with *S. aureus* bacteremia** (US National Inpatient Sample database (2001-2014)
- **86 387 (12.9%) had echocardiogram, from 11% in 2001 to 15% in 2014**
-



Trends in the rate of echocardiography



Crude mortality rates

Urja Echocardiography 2019 Sep;36(9):1625-1632

Diagnostic endocardite: 3 stratégies

- Suspicion → Hémoculture
  Echocardiographie
- Suspicion → Hémoculture ⊕ → Echocardiographie
- **Suspicion → Hémoculture ⊕ +/- → Echocardiographie**

Chez certains pts avec hémoc pos

Diagnostic endocardite

Raisonnement clinique

SCORES

- Suspicion → Hémoculture → Echocardiographie
- Suspicion → Hémoculture + +/- Echocardiographie

SCORES

Individually, most non obvious factors are poorly discriminant

S. aureus bacteremia and Infective endocarditis

Factor	OR	Se	Sp	LR+	LR-
Community-acquired	3.1	52%	73%	2.0	0.65
Haemodialysis	1.5	13%	91%	1.4	0.96
Unknown source of infection	2.1	45%	72%	1.6	0.77
Not catheter-related	3.1	86%	26%	1.2	0.57
Osteomyelitis	1.9	1%	100%	1.9	1.00
Prolonged bacteraemia > 48h	3.9	44%	83%	2.6	0.67
Prolonged bacteraemia > 72h	5.3-17.3	73-80%	57-87%	1.9-5.4	0.3-0.3
Prolonged bacteraemia > 96h	2.1-3.5	70-85%	38-48%	1.3-1.4	0.4-0.64

Bai CMI 2017

Individually, most non obvious factors are poorly discriminant

Factor	OR	Se	Sp	LR+	LR-
Community-acquired	3.1	52%	73%	2.0	0.65
Haemodialysis	1.5	13%	91%	1.4	0.96
Unknown source of infection	2.1	45%	72%	1.6	0.77
Not catheter-related	3.1	86%	26%	1.2	0.57
Osteomyelitis	1.9	1%	100%	1.9	1.00
Prolonged bacteraemia > 48h	3.9	44%	83%	2.6	0.67
Prolonged bacteraemia > 72h	5.3-17.3	73-80%	57-87%	1.9-5.4	0.3-0.3
Prolonged bacteraemia > 96h	2.1-3.5	70-85%	38-48%	1.3-1.4	0.4-0.64

SCORES: combinaison de critères

Bai AD , CMI 2017

RESEARCH METHODS & REPORTING

Prognosis and prognostic research: application and impact of prognostic models in clinical practice

Karel G M Moons,[1] Douglas G Altman,[2] Yvonne Vergouwe,[1] Patrick Royston[3]

An accurate prognostic model is of no benefit if it is not generalisable or doesn't change behaviour. In the last article in their series **Karel Moons and colleagues** discuss how to determine the practical value of models

BMJ | 20 JUNE 2009 | VOLUME 338

Modèles diagnostiques

Consecutive stages to produce a usable multivariable prognostic model

- *Development studies*[5 6]—Development of a multivariable prognostic model, including identification of the important predictors, assigning the relative weights to each predictor, and estimating the model's predictive performance (eg, calibration and discrimination) adjusted if necessary for overfitting

Modèles diagnostiques

Consecutive stages to produce a usable multivariable prognostic model

- *Development studies*[5 6]—Development of a multivariable prognostic model, including identification of the important predictors, assigning the relative weights to each predictor, and estimating the model's predictive performance (eg, calibration and discrimination) adjusted if necessary for overfitting

Risque de tautologie: Critères du score = critères du gold standard

Critères du scores = critères de Duke

Modèles diagnostiques

Consecutive stages to produce a usable multivariable prognostic model

- *Development studies*[5 6]—Development of a multivariable prognostic model, including identification of the important predictors, assigning the relative weights to each predictor, and estimating the model's predictive performance (eg, calibration and discrimination) adjusted if necessary for overfitting
- *Validation studies*[7] --Validating or testing the model's predictive performance in new subjects, preferably from different centres, with a different case mix or using (slightly) different definitions and measurements of predictors and outcomes

Modèles diagnostiques

Consecutive stages to produce a usable multivariable prognostic model

- *Development studies*[5 6]—Development of a multivariable prognostic model, including identification of the important predictors, assigning the relative weights to each predictor, and estimating the model's predictive performance (eg, calibration and discrimination) adjusted if necessary for overfitting
- *Validation studies*[7]—Validating or testing the model's predictive performance in new subjects, preferably from different centres, with a different case mix or using (slightly) different definitions and measurements of predictors and outcomes
- *Impact studies*—Quantifying whether use of a prognostic model in daily practice improves decision making and, ultimately, patient outcome using a comparative design

Scores et endocardite

- Maladie rare
- Maladie curable
- Diagnostic précoce améliore le pronostic

Scores et endocardite

- Maladie rare
- Maladie curable
- Diagnostic précoce améliore le pronostic

- **Test sensible**

Scores et endocardite

- Maladie rare
- Maladie curable
- Diagnostic précoce améliore le pronostic

- **Test sensible**

Valeurs intrinsèques du test

Sensibilité / Spécificité / Likelihood ratio (rapport de vraisemblance) un individu malade ayant RV+ fois plus de chance d'avoir un test positif qu'un individu sain

Valeurs extrinsèques

VPP, VPN (dépendent de la prévalence de la maladie)

Scores et endocardite

- Maladie rare
- Maladie curable
- Diagnostic précoce améliore le pronostic

- **Test sensible**

Valeurs intrinsèques du test

Sensibilité : 100%

Likelihood ratio -: → 0

Valeurs extrinsèques

VPN: 100%

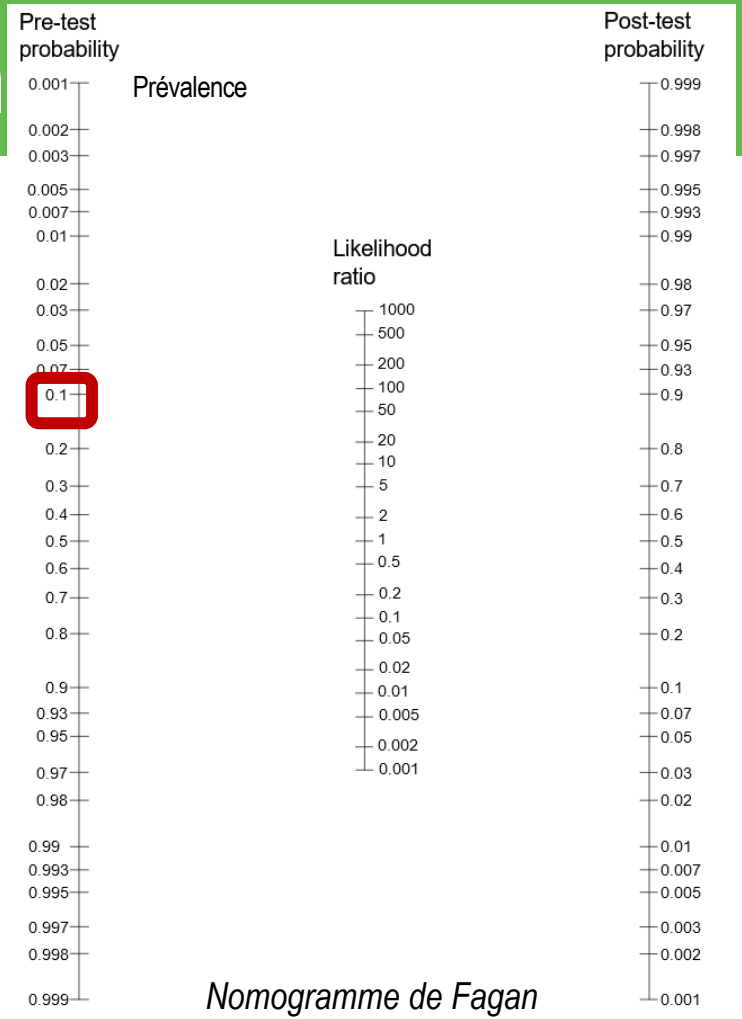
Scores et endocardite

Prévalence de la maladie dans la population: **10%** d'EI en cas de bactériémie à *S. aureus*

Scores et en

Prévalence de la maladie dans la population: **10%**
d'EI en cas de bactériémie à S. aureus

- **RV+ = Se / (1-Sp)**
- **RV- = 1-Se / Sp**

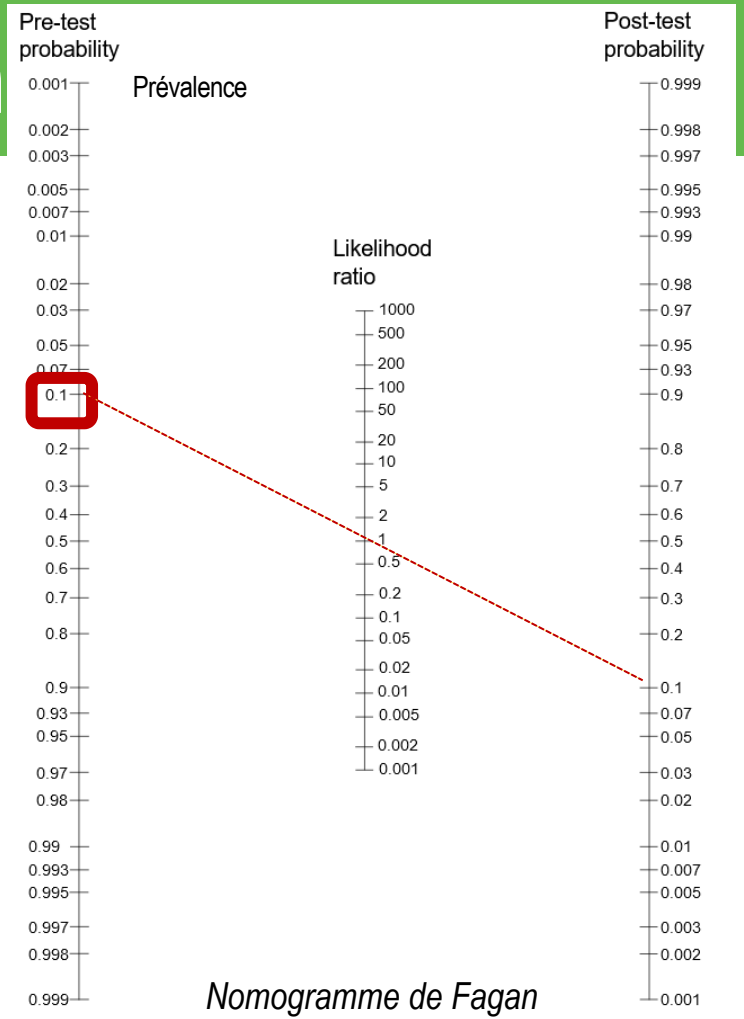


Nomogramme de Fagan

Scores et en

Prévalence de la maladie dans la population: **10%**
d'EI en cas de bactériémie à S. aureus

- **RV+ = Se / (1-Sp)**
- **RV- = 1-Se / Sp**



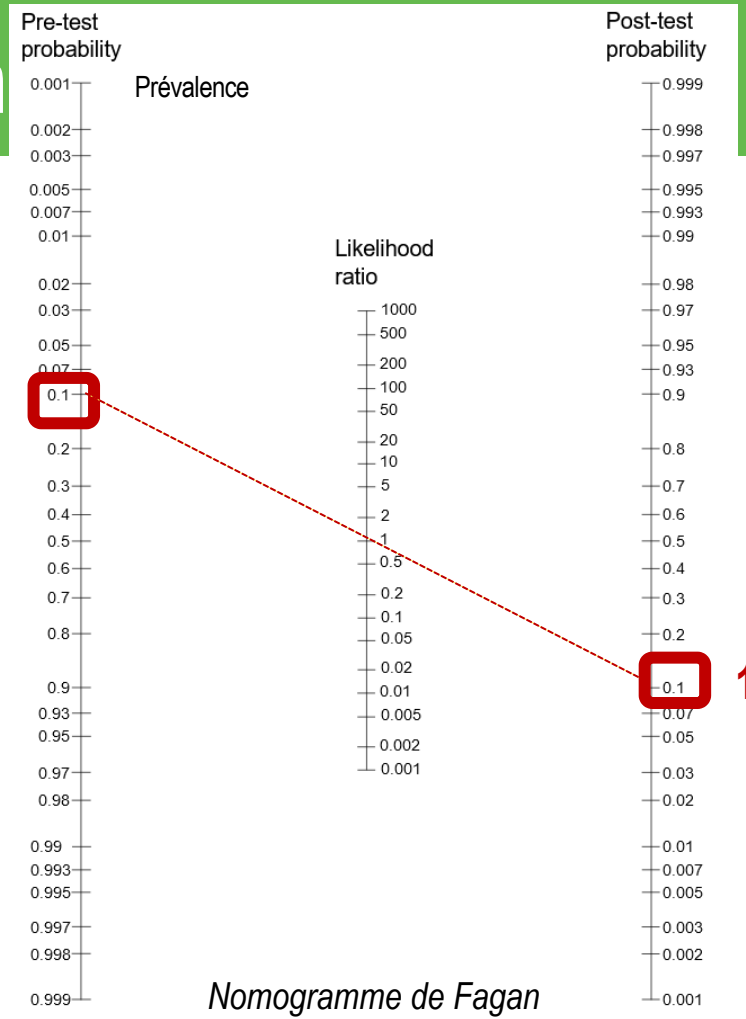
Nomogramme de Fagan

RV-	Apport diagnostique
1	

Scores et en

Prévalence de la maladie dans la population: **10%**
d'EI en cas de bactériémie à S. aureus

- **RV+ = Se / (1-Sp)**
- **RV- = 1-Se / Sp**



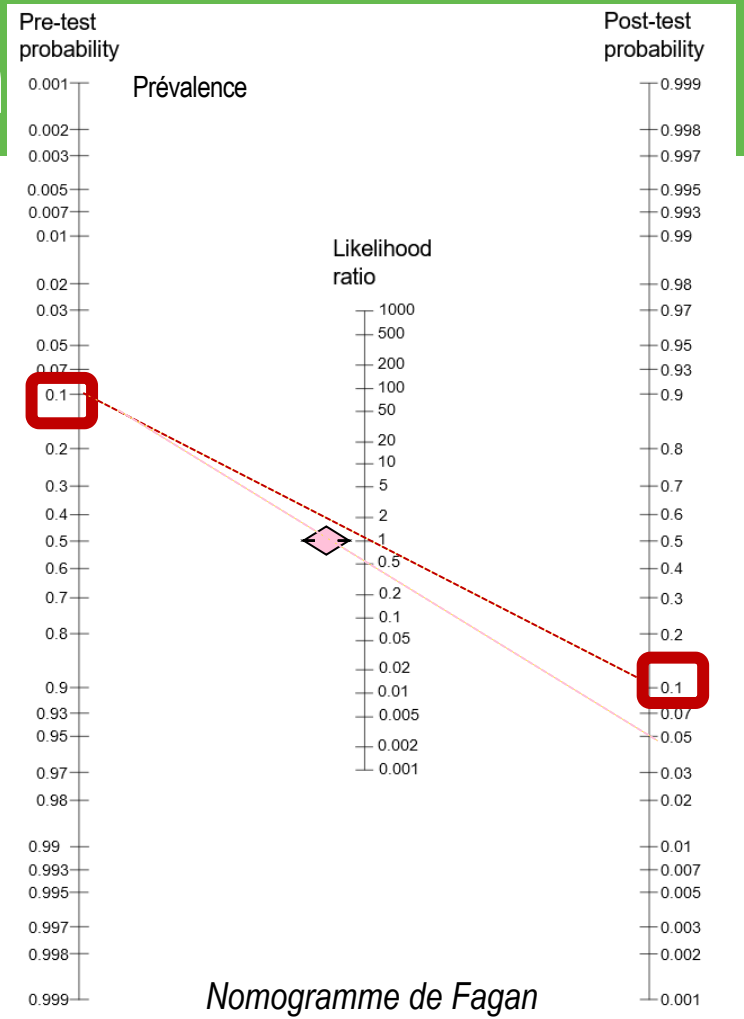
Nomogramme de Fagan

RV-	Apport diagnostique
1	Nul

Scores et en

Prévalence de la maladie dans la population: **10%**
d'EI en cas de bactériémie à S. aureus

- **RV+ = Se / (1-Sp)**
- **RV- = 1-Se / Sp**



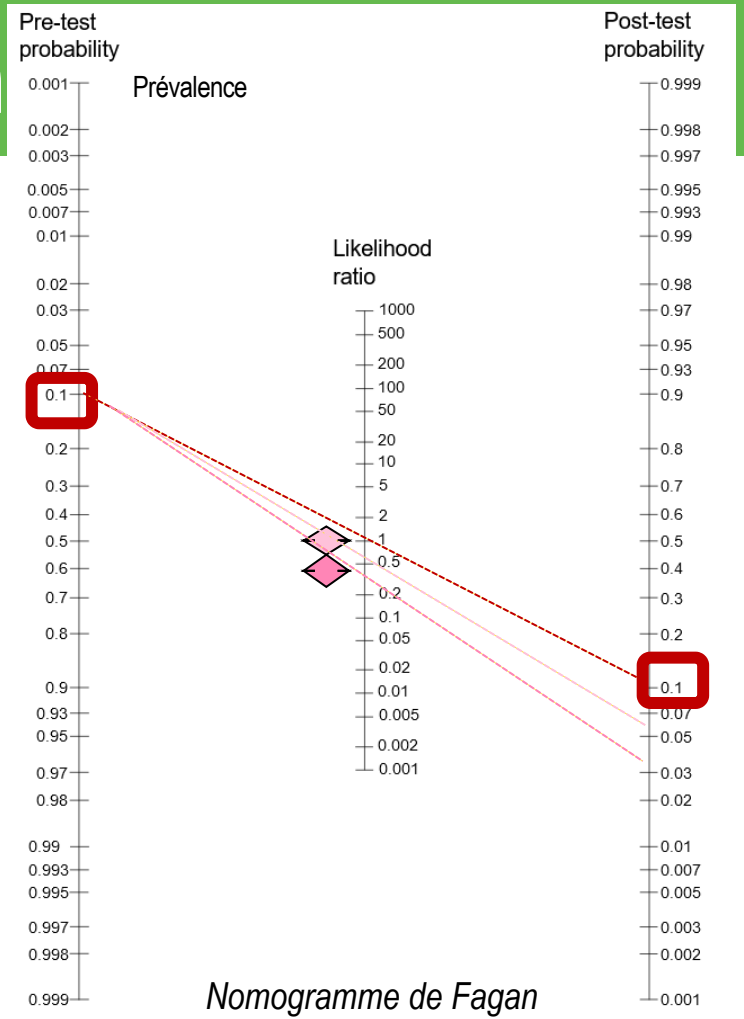
Nomogramme de Fagan

RV-	Apport diagnostique
0,5-1	Faible
1	Nul

Scores et en

Prévalence de la maladie dans la population: **10%**
d'EI en cas de bactériémie à S. aureus

- **RV+ = Se / (1-Sp)**
- **RV- = 1-Se / Sp**



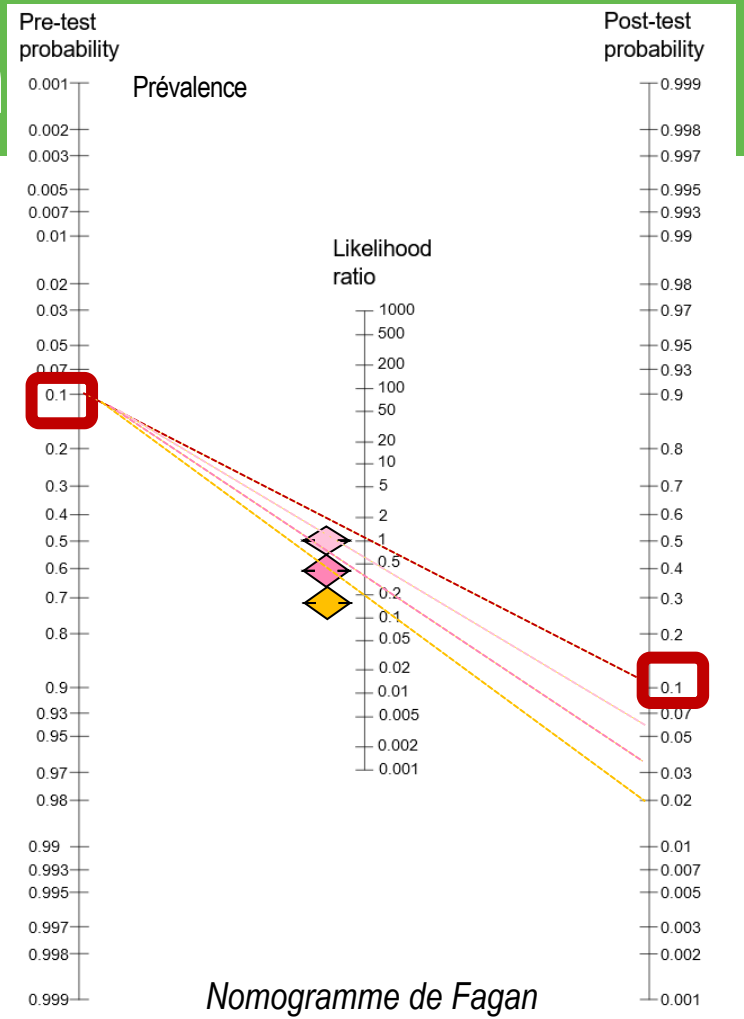
Nomogramme de Fagan

RV-	Apport diagnostique
0,2-0,5	Modéré
0,5-1	Faible
1	Nul

Scores et en

Prévalence de la maladie dans la population: **10%**
d'EI en cas de bactériémie à S. aureus

- **RV+ = Se / (1-Sp)**
- **RV- = 1-Se / Sp**

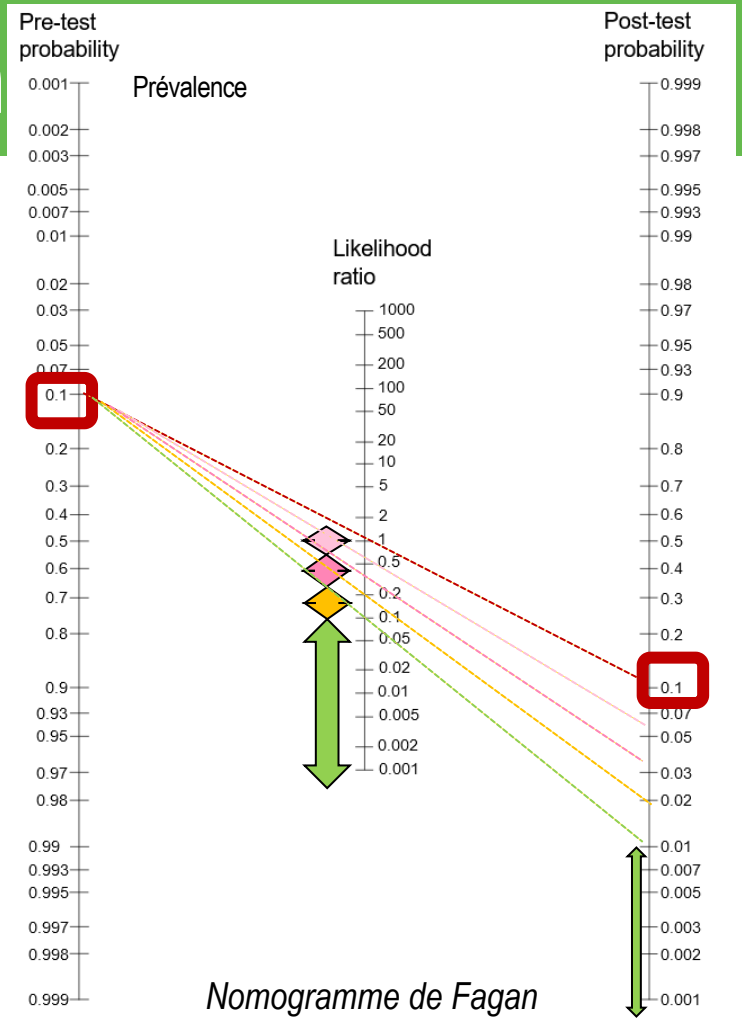


Nomogramme de Fagan

RV-	Apport diagnostique
0,1-0,2	Fort
0,2-0,5	Modéré
0,5-1	Faible
1	Nul

Scores et en

Prévalence de la maladie dans la population: **10%**
d'EI en cas de bactériémie à S. aureus



Nomogramme de Fagan

RV-	Apport diagnostique
<0,1	Très fort
0,1-0,2	Fort
0,2-0,5	Modéré
0,5-1	Faible
1	Nul

- **RV+ = Se / (1-Sp)**
- **RV- = 1-Se / Sp**

Très faible probabilité que le patient ait une EI si le test est négatif: VPP 1% à 0,1%

Diagnostic endocardite

- **Suspicion** → **Hémoculture**

Diagnostic endocardite

- **Suspicion → Hémoculture**

SCORES


RESEARCH METHODS & REPORTING

Prognosis and prognostic research: application and impact of prognostic models in clinical practice

Karel G M Moons,[1] Douglas G Altman,[2] Yvonne Vergouwe,[1] Patrick Royston[3]

An accurate prognostic model is of no benefit if it is not generalisable or doesn't change behaviour. In the last article in their series **Karel Moons and colleagues** discuss how to determine the practical value of models

Consecutive stages to produce a usable multivariable prognostic model

- *Development studies*[5 6]
- *Validation studies*[7]
- *Impact studies*

Development and assessment of a new early scoring system using non-specific clinical signs and biological results to identify children and adult patients with a high probability of infective endocarditis on admission

Hervé Richet[1], Jean-Paul Casalta[1], Franck Thuny[2], Julien Mérrien[1], Jean-Robert Harlé[3], Pierre-Jean Weiller[4], Gilbert Habib[2] and Didier Raoult[1]*

All patients with a suspicion of IE
IE: 402 of 2039 participants (19.7%)

J Antimicrob Chemother . 2008 Dec;62(6):1434-40

Development and assessment of a new early scoring system using non-specific clinical signs and biological results to identify children and adult patients with a high probability of infective endocarditis on admission

Hervé Richet[1], Jean-Paul Casalta[1], Franck Thuny[2], Julien Mérrien[1], Jean-Robert Harlé[3], Pierre-Jean Weiller[4], Gilbert Habib[2] and Didier Raoult[1]*

All patients with a suspicion of IE
IE: 402 of 2039 participants (19.7%)

Table 4. Multivariate analysis

Variable	Odds ratio	95% CI	*P*
Sex, male	2.5	1.7–3.6	<0.00001
Prior valvular damage	8.2	5–13.3	<0.00001
Fever	2.1	1.4–3	0.003
Stroke	4.3	2.2–8	<0.00001
Emboli	3.6	1.5–8.6	0.004
Finger clubbing	2.7	1.1–6.7	0.03
Splenomegaly	6	1.4–25	0.02
Leucocytosis	1.6	1.1–2.2	0.01
Thrombocytopenia	2.3	1.4–3.8	0.002
Erythrocyte sedimentation rate >50	1.9	1.3–2.7	0.0006

J Antimicrob Chemother . 2008 Dec;62(6):1434-40

Development and assessment of a new early scoring system using non-specific clinical signs and biological results to identify children and adult patients with a high probability of infective endocarditis on admission

Hervé Richet[1], Jean-Paul Casalta[1], Franck Thuny[2], Julien Mérrien[1], Jean-Robert Harlé[3], Pierre-Jean Weiller[4], Gilbert Habib[2] and Didier Raoult[1]*

All patients with a suspicion of IE
IE: 402 of 2039 participants (19.7%)

Table 4. Multivariate analysis

Variable	Odds ratio	95% CI	*P*
Sex, male	2.5	1.7–3.6	<0.00001
Prior valvular damage	8.2	5–13.3	<0.00001
Fever	2.1	1.4–3	0.003
Stroke	4.3	2.2–8	<0.00001
Emboli	3.6	1.5–8.6	0.004
Finger clubbing	2.7	1.1–6.7	0.03
Splenomegaly	6	1.4–25	0.02
Leucocytosis	1.6	1.1–2.2	0.01
Thrombocytopenia	2.3	1.4–3.8	0.002
Erythrocyte sedimentation rate >50	1.9	1.3–2.7	0.0006

Table 5. Predictive score of IE: overall cases

Score	Proportion of IE	PPV	NPV	Odds ratio
0	10 (4%)	0.04	0.93	baseline 1
1	30 (6.5%)	0.06	0.96	1.7
2	99 (18%)	0.2	0.93	5.4
3	113 (28%)	0.28	0.82	9.5
4	97 (44%)	0.44	0.72	19
5	43 (67%)	0.67	0.56	50
≥6	10 (83%)	0.83	0.32	123

PPV, positive predictive value; NPV, negative predictive value.
χ^2 for trend: $P < 0.0000001$.

J Antimicrob Chemother . 2008 Dec;62(6):1434-40

Development and assessment of a new early scoring system using non-specific clinical signs and biological results to identify children and adult patients with a high probability of infective endocarditis on admission

Hervé Richet[1], Jean-Paul Casalta[1], Franck Thuny[2], Julien Mérrien[1], Jean-Robert Harlé[3], Pierre-Jean Weiller[4], Gilbert Habib[2] and Didier Raoult[1]*

All patients with a suspicion of IE
IE: 402 of 2039 participants (19.7%)

Table 4. Multivariate analysis

Variable	Odds ratio	95% CI	*P*
Sex, male	2.5	1.7–3.6	<0.00001
Prior valvular damage	8.2	5–13.3	<0.00001
Fever	2.1	1.4–3	0.003
Stroke	4.3	2.2–8	<0.00001
Emboli	3.6	1.5–8.6	0.004
Finger clubbing	2.7	1.1–6.7	0.03
Splenomegaly	6	1.4–25	0.02
Leucocytosis	1.6	1.1–2.2	0.01
Thrombocytopenia	2.3	1.4–3.8	0.002
Erythrocyte sedimentation rate >50	1.9	1.3–2.7	0.0006

Table 5. Predictive score of IE: overall cases

Score	Proportion of IE	PPV	NPV	Odds ratio
0	10 (4%)	0.04	0.93	baseline 1
1	30 (6.5%)	0.06	0.96	1.7
2	99 (18%)	0.2	0.93	5.4
3	113 (28%)	0.28	0.82	9.5
4	97 (44%)	0.44	0.72	19
5	43 (67%)	0.67	0.56	50
≥6	10 (83%)	0.83	0.32	123

PPV, positive predictive value; NPV, negative predictive value.
χ^2 for trend: $P < 0.0000001$.

Table 6. Predictive score of IE: score excluding PVD applied to patients with PVD

Score	Endocarditis in patients with prior valvular damage	PPV	NPV	Odds ratio
0	23 (9.5%)	0.045	0.9	baseline 1
1	81 (24%)	0.24	0.9	2.8
2	97 (32.7%)	0.32	0.76	4.6
3	95 (45.7%)	0.46	0.67	8
4	42 (67.7%)	0.68	0.5	20
≥5	10 (100%)	1	0.3	95

PPV, positive predictive value; NPV, negative predictive value.
χ^2 for trend: $P < 0.0000001$.

J Antimicrob Chemother . 2008 Dec;62(6):1434-40

European Journal of Clinical Microbiology & Infectious Diseases
https://doi.org/10.1007/s10096-017-3177-3

ORIGINAL ARTICLE

Marseille scoring system for empiric treatment of infective endocarditis

Frédérique Gouriet[1,2] · Hervé Tissot-Dupont[1,2] · Jean-Paul Casalta[1,2] · Sandrine Hubert[3] · Pierre-Edouard Fournier[1,2] · Sophie Edouard[1,2] · Alexis Theron[4] · Hubert Lepidi[1] · Dominique Grisoli[4] · Gilbert Habib[3] · Didier Raoult[1,2]

Prospective cohort study,
484 pts with PCC and
clinical suspicion of IE
2011 to 2013.

Definite IE in 123 pts (25%)
Possible IE in 107 pts

European Journal of Clinical Microbiology & Infectious Diseases
https://doi.org/10.1007/s10096-017-3177-3

ORIGINAL ARTICLE

Marseille scoring system for empiric treatment of infective endocarditis

Frédérique Gouriet[1,2] · Hervé Tissot-Dupont[1,2] · Jean-Paul Casalta[1,2] · Sandrine Hubert[3] · Pierre-Edouard Fournier[1,2] · Sophie Edouard[1,2] · Alexis Theron[4] · Hubert Lepidi[1] · Dominique Grisoli[4] · Gilbert Habib[3] · Didier Raoult[1,2]

Prospective cohort study,
484 pts with PCC
clinical suspicion of IE
2011 to 2013.

Definite IE in 123 pts (25%)
Possible IE in 107 pts

Table 3 Marseille score performance

Marseille score	≥ 1	≥ 2	≥ 3	≥ 4	≥ 5	6
Sensitivity (%)	99%	92%	73%	37%	9%	1%
Specificity (%)	10%	43%	68%	85%	97%	100%
Positive predictive value (%)	50%	59%	67%	69%	71%	100%
Negative predictive value (%)	89%	85%	73%	60%	54%	53%
LR-		0,10	0,19			

Diagnostic endocardite

- **Suspicion → Hémoculture**

SCORES


RESEARCH METHODS & REPORTING

Prognosis and prognostic research: application and impact of prognostic models in clinical practice

Karel G M Moons,[1] Douglas G Altman,[2] Yvonne Vergouwe,[3] Patrick Royston[4]

An accurate prognostic model is of no benefit if it is not generalisable or doesn't change behaviour. In the last article in their series, **Karel Moons and colleagues** discuss how to determine the practical value of models

Consecutive stages to produce a usable multivariable prognostic model

- *Development studies*[5 6] **OUI**
- *Validation studies*[7] **NON**
- *Impact studies* **NON**

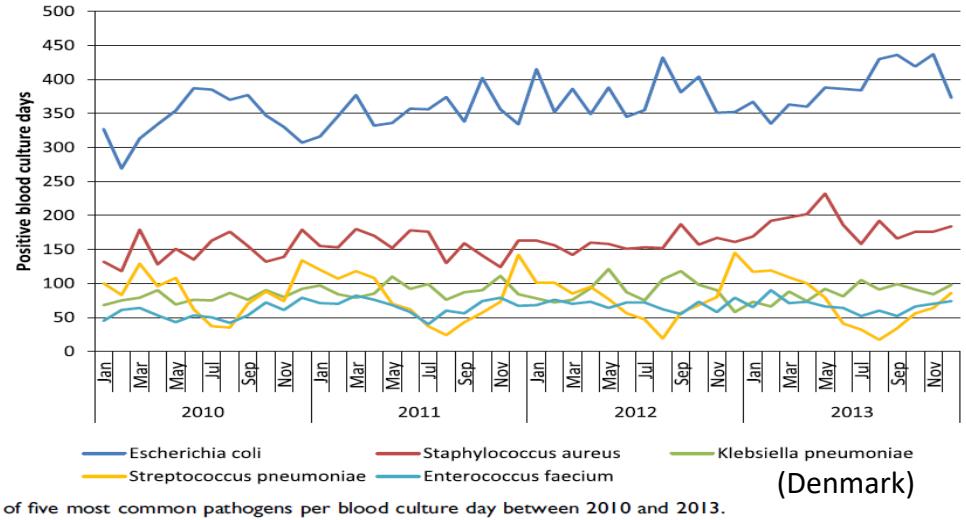
Diagnostic endocardite

- Suspicion → Hémoculture + → +/- Echocardiographie

↑ SCORES

Microbiologic aetiologies of bacteremia

- **Most common aetiologies** (Laupland, CMI 2013)
  - ***Escherichia coli*:** **35/100,000/year**
  - ***Staphylococcus aureus*:** ***25/100,000/year***
  - ***Streptococcus pneumoniae*:** ***10/100,000/year***
  - ***Enterococcus faecium*** ***< 10/100,000/year***



of five most common pathogens per blood culture day between 2010 and 2013. (Denmark)

IE exceptional

Clin Microbiol Infect 2014; ■: 1.e1–1.e9

Bactériémies et endocardite

- ***Staphylococcus aureus***
- ***Enterococcus***
- ***Streptococcus***

Staphylococcus aureus bacteremia Echocardiography indications

Consecutive stages to produce a usable multivariable prognostic model

- *Development studies*[5 6]

MAJOR ARTICLE

Predicting Risk of Endocarditis Using a Clinical Tool (PREDICT): Scoring System to Guide Use of Echocardiography in the Management of *Staphylococcus aureus* Bacteremia

Bharath Raj Palraj,[1] Larry M. Baddour,[1,2] Erik P. Hess,[3] James M. Steckelberg,[1] Walter R. Wilson,[1] Brian D. Lahr,[4] and M. Rizwan Sohail[1,2]

Divisions of [1]Infectious Diseases, and [2]Cardiovascular Diseases, Department of Medicine, [3]Department of Emergency Medicine and Center for Science of Healthcare Delivery, and [4]Department of Biomedical Statistics and Informatics, Mayo Clinic College of Medicine, Rochester, Minnesota

Staphylococcus aureus bacteremia Echocardiography indications

Consecutive stages to produce a usable multivariable prognostic model

- *Development studies*[5 6]

MAJOR ARTICLE

Predicting Risk of Endocarditis Using a Clinical Tool (PREDICT): Scoring System to Guide Use of Echocardiography in the Management of *Staphylococcus aureus* Bacteremia

Bharath Raj Palraj,[1] Larry M. Baddour,[1,2] Erik P. Hess,[3] James M. Steckelberg,[1] Walter R. Wilson,[1] Brian D. Lahr,[4] and M. Rizwan Sohail[1,2]

Divisions of [1]Infectious Diseases, and [2]Cardiovascular Diseases, Department of Medicine, [3]Department of Emergency Medicine and Center for Science of Healthcare Delivery, and [4]Department of Biomedical Statistics and Informatics, Mayo Clinic College of Medicine, Rochester, Minnesota

Journal of Infection (2016) 72, 544–553

ELSEVIER www.elsevierhe

The VIRSTA score, a prediction score to estimate risk of infective endocarditis and determine priority for echocardiography in patients with *Staphylococcus aureus* bacteremia

Sarah Tubiana [a,b], Xavier Duval [a,b,*], François Alla [c,d,e], Christine Selton-Suty [f], Pierre Tattevin [g], François Delahaye [h], Lionel Piroth [i], Catherine Chirouze [j], Jean-Philippe Lavigne [k], Marie-Line Erpelding [d,f], Bruno Hoen [l,m], François Vandenesch [n], Bernard Iung [o,p], Vincent Le Moing [q], the VIRSTA/AEPEI Study Group

Staphylococcus aureus bacteremia Echocardiography indications

Consecutive stages to produce a usable multivariable prognostic model

- *Development studies*[5 6]

MAJOR ARTICLE

Predicting Risk of Endocarditis Using a Clinical Tool (PREDICT): Scoring System to Guide Use of Echocardiography in the Management of *Staphylococcus aureus* Bacteremia

Bharath Raj Palraj,[1] Larry M. Baddour,[1,2] Erik P. Hess,[3] James M. Steckelberg,[1] Walter R. Wilson,[1] Brian D. Lahr,[4] and M. Rizwan Sohail[1,2]

Divisions of [1]Infectious Diseases, and [2]Cardiovascular Diseases, Department of Medicine, [3]Department of Emergency Medicine and Center for Science of Healthcare Delivery, and [4]Department of Biomedical Statistics and Informatics, Mayo Clinic College of Medicine, Rochester, Minnesota

Journal of Infection (2016) 72, 544–553

ELSEVIER www.elsevierhe

The VIRSTA score, a prediction score to estimate risk of infective endocarditis and determine priority for echocardiography in patients with *Staphylococcus aureus* bacteremia

Sarah Tubiana [a,b], Xavier Duval [a,b,*], François Alla [c,d,e], Christine Selton-Suty [f], Pierre Tattevin [g], François Delahaye [h], Lionel Piroth [i], Catherine Chirouze [j], Jean-Philippe Lavigne [k], Marie-Line Erpelding [d,f], Bruno Hoen [l,m], François Vandenesch [n], Bernard Iung [o,p], Vincent Le Moing [q], the VIRSTA/AEPEI Study Group

Clinical Microbiology and Infection xxx (xxxx) xxx

Contents lists available at ScienceDirect

Clinical Microbiology and Infection

journal homepage: www.clinicalmicrobiologyandinfection.com

ELSEVIER

CMI CLINICAL MICROBIOLOGY AND INFECTION ESCMID

Original article

Time to blood culture positivity in *Staphylococcus aureus* bacteraemia to determine risk of infective endocarditis*

Fredrik Kahn [1,2,†], Fredrik Resman [1,6,†], Sissela Bergmark [1], Peter Filiptsev [1], Bo Nilson [5,3], Patrik Gilje [1,4], Magnus Rasmussen [1,2,*]

Staphylococcus aureus bacteremia Echocardiography indications

Table 1. Overview of POSITIVE, PREDICT, and VIRSTA Scores

POSITIVE Cutoff: >4		PREDICT Cutoff: ≥2 (for Day 5 Score)		VIRSTA Cutoff: ≥3	
Item	Points Assigned	Item	Points Assigned	Item	Points Assigned
TTP <9 h	5	ICD	2	Cerebral or peripheral emboli	5
TTP 9–11 h	3	Permanent pacemaker	3	Meningitis	5
TTP 11–13 h	2	Community acquisition	2	Permanent intracardiac device or previous IE	4
IV drug use	3	Healthcare acquisition	1	Preexisting native valve disease[a]	3
Vascular phenomena[b]	6	Positive culture after 72 h	2	IV drug use	4
Predisposing heart disease[c]	5			Positive culture after 48 h	3
				Community or non-nosocomial health care associated acquisition	2
				Severe sepsis or septic shock	1
				C-reactive protein >190 mg/L	1

POSITIVE	PREDICT	VIRSTA
N=465 SAB	N=678 SAB	N=2 008 SAB
EI rate: 8.2%	12%	11%
VPN: ?	98.5%	98.8%

Staphylococcus aureus bacteremia Echocardiography indications

Consecutive stages to produce a usable multivariable prognostic model

- *Development studies*[5 6]

Staphylococcus aureus bacteremia Echocardiography indications

Consecutive stages to produce a usable multivariable prognostic model

- *Development studies*[5 6]

- *Validation studies*[7]

Staphylococcus aureus bacteremia Echocardiography indications

Clinical Infectious Diseases

MAJOR ARTICLE

IDSA Infectious Diseases Society of America · hivma hiv medicine association · OXFORD

Prediction Rules for Ruling Out Endocarditis in Patients With *Staphylococcus aureus* Bacteremia

Thomas W. van der Vaart,[1,2] Jan M. Prins,[2] Robin Soetekouw,[3] Gitte van Twillert,[4] Jan Veenstra,[5] Bjorn L. Herpers,[6] Wouter Rozemeijer,[7] Rogier R. Jansen,[8] Marc J. M. Bonten,[1,9] and Jan T. M. van der Meer[2]

Results. Of 477 SAB patients enrolled, 33% had community-acquired SAB, 8% had a prosthetic valve, and 11% a cardiac implantable electronic device. Echocardiography was performed in 87% of patients, and 42% received transesophageal echocardiography (TEE). Eighty-seven (18.2%) had definite endocarditis. Sensitivity was 77.6% (65.8%–86.9%), 85.1% (75.8%–91.8%), and 98.9% (95.7%–100%) for the POSITIVE (n = 362), PREDICT, and VIRSTA scores, respectively. NPVs were 92.5% (87.9%–95.8%), 94.5% (90.7%–97.0%), and 99.3% (94.9%–100%). For the POSITIVE, PREDICT, and VIRSTA scores, 44.5%, 50.7%, and 70.9% of patients with SAB, respectively, were classified as at high risk for endocarditis.

Conclusions. Only the VIRSTA score had an NPV of at least 98%, but at the expense of a high number of patients classified as high risk and thus requiring TEE.

Clin infect Dis 2021

Staphylococcus aureus bacteremia Echocardiography indications

Clinical Infectious Diseases

MAJOR ARTICLE

Validation of VIRSTA and Predicting Risk of Endocarditis Using a Clinical Tool (PREDICT) Scores to Determine the Priority of Echocardiography in Patients With *Staphylococcus aureus* Bacteremia

Juan Sebastián Peinado-Acevedo,[1,2] Juan José Hurtado-Guerra,[2,3] Carolina Hincapié,[2,4] Juanita Mesa-Abad,[2] José Roberto Uribe-Delgado,[2] Santiago Giraldo-Ramírez,[5] Paula A. Lengerke-Diaz,[6] and Fabián Jaimes[2,3,7]

patients with SAB, respectively, were classified as at high risk for endocarditis.

Conclusions: In patients with negative VIRSTA, screening echocardiography may be unnecessary because of the low frequency of IE. In PREDICT-negative patients, despite the low frequency of IE, it is not safe to omit echocardiography.

high risk and thus requiring TEE.

Clin Infect Dis 2021

RV-	Apport Dc
<0,1	Très fort
0,1-0,2	Fort
0,2-0,5	Modéré
0,5-1	Faible
1	Nul

Validation studies

		PREDICT
	IE rate	**VPN** **LR –** AUC % population with score < cut off
JS Peinado-Acevedo (CID 2021) n=922	6.7%	95.1% (93.4%–96.9%) **0.7 (0.5–0.9)**
TW. van der Vaart (CID 2021) n=477	18.2%	94.5% (90.7%–97.0%) 0.250 0.79 55%
F Kahn POSITIVE (CMI 2020) n=465	8.2%	0.109
Omar Abu Saleh (CID 2020) n=199	11.6%	100.0 (93.7 to 100.0)
Caldreon-Parra J (J clin med 2022) n=404 pts	12.4	96.4 0.27
Simos PA (JAC 2022) n=106 pts	17%	95.8 (76.8–99.4) 0.2 (0.0–1.5)

RV-	Apport Dc
<0,1	Très fort
0,1-0,2	Fort
0,2-0,5	Modéré
0,5-1	Faible
1	Nul

Validation studies

		PREDICT	VIRSTA
	IE rate	**VPN** **LR –** AUC % population with score < cut off	**VPN** **LR-** AUC % pop with score < cut off
JS Peinado-Acevedo (CID 2021) n=922	6.7%	95.1% (93.4%–96.9%) **0.7 (0.5–0.9)**	**99.5 %** (98.8%–100%) 0.06 (0.02–0.24)
TW. van der Vaart (CID 2021) n=477	18.2%	94.5% (90.7%–97.0%) 0.250 0.79 55%	**99.3%** (94.9%–100%) 0.031 0.89 30%
F Kahn POSITIVE (CMI 2020) n=465	8.2%	0.109	**100%** 0.00
Omar Abu Saleh (CID 2020) n=199	11.6%	100.0 (93.7 to 100.0)	ND
Caldreon-Parra J (J clin med 2022) n=404 pts	12.4	96.4 0.27	**97.8** 0.16
Simos PA (JAC 2022) n=106 pts	17%	95.8 (76.8–99.4) 0.2 (0.0–1.5)	97.1 (82.8–99.6) 0.2 (0.0–1.0)

RV-	Apport Dc
<0,1	Très fort
0,1-0,2	Fort
0,2-0,5	Modéré
0,5-1	Faible
1	Nul

Validation studies

		PREDICT	VIRSTA	POSITIVE
	IE rate	**VPN** **LR –**	**VPN** **LR-**	**VPN** **LR-**
JS Peinado-Acevedo (CID 2021) n=922	6.7%	95.1% (93.4%–96.9%) **0.7 (0.5–0.9)**	**99.5 %** (98.8%–100%) 0.06 (0.02–0.24)	ND
TW. van der Vaart (CID 2021) n=477	18.2%	94.5% (90.7%–97.0%) 0.250	**99.3%** (94.9%–100%) 0.031	92.5% (87.9%–95.8%) **0.355**
F Kahn POSITIVE (CMI 2020) n=465	8.2%	0.109	**100%** 0.00	0.10
Omar Abu Saleh (CID 2020) n=199	11.6%	100.0 (93.7 to 100.0)	ND	ND
Caldreon-Parra J (J clin med 2022) n=404 pts	12.4	96.4 0.27	**97.8** 0.16	95.1 0.37
Simos PA (JAC 2022) n=106 pts	17%	95.8 (76.8–99.4) 0.2 (0.0–1.5)	97.1 (82.8–99.6) 0.2 (0.0–1.0)	94.2 (87.2–97.5) **0.3 (0.1–0.7)**

Validation studies

		PREDICT
	IE rate	**VPN** **LR –** **AUC** **% population with score < cut off**
JS Peinado-Acevedo (CID 2021) n=922	6.7%	95.1% (93.4%–96.9%) **0.7 (0.5–0.9)** 0.64 67,5%
TW. van der Vaart (CID 2021) n=477	18.2%	94.5% (90.7%–97.0%) 0.250 0.79 55%
F Kahn POSITIVE (CMI 2020) n=465	8.2%	 0.109 0.77 ND
Omar Abu Saleh (CID 2020) n=199	11.6%	100.0 (93.7 to 100.0)
Caldreon-Parra J (J clin med 2022) n=404 pts	12.4	96.4 0.27 0.69 34%
Simos PA (JAC 2022) n=106 pts	17%	95.8 (76.8–99.4) 0.2 (0.0–1.5) 0.59 ND

Validation studies

		PREDICT	VIRSTA
	IE rate	**VPN** **LR –** **AUC** **% population with score < cut off**	**VPN** **LR-** **AUC** **% pop with score < cut off**
JS Peinado-Acevedo (CID 2021) n=922	6.7%	95.1% (93.4%–96.9%) **0.7 (0.5–0.9)** 0.64 67,5%	**99.5 %** (98.8%–100%) 0.06 (0.02–0.24) 0.86 49,2%
TW. van der Vaart (CID 2021) n=477	18.2%	94.5% (90.7%–97.0%) 0.250 0.79 55%	**99.3%** (94.9%–100%) 0.031 0.89 30%
F Kahn POSITIVE (CMI 2020) n=465	8.2%	 0.109 0.77 ND	**100%** 0.00 0.89 ND
Omar Abu Saleh (CID 2020) n=199	11.6%	100.0 (93.7 to 100.0)	ND
Caldreon-Parra J (J clin med 2022) n=404 pts	12.4	96.4 0.27 0.69 34%	**97.8** 0.16 0.84 46%
Simos PA (JAC 2022) n=106 pts	17%	95.8 (76.8–99.4) 0.2 (0.0–1.5) 0.59 ND	97.1 (82.8–99.6) 0.2 (0.0–1.0) 0.83 ND

Validation studies

		PREDICT	VIRSTA	POSITIVE
	IE rate	**VPN** **LR –** **AUC** **% population with score < cut off**	**VPN** **LR-** **AUC** **% pop with score < cut off**	**VPN** **LR-** **AUC** **% pop with score < cut off**
JS Peinado-Acevedo (CID 2021) n=922	6.7%	95.1% (93.4%–96.9%) **0.7 (0.5–0.9)** 0.64 67,5%	**99.5 %** (98.8%–100%) 0.06 (0.02–0.24) 0.86 49,2%	ND
TW. van der Vaart (CID 2021) n=477	18.2%	94.5% (90.7%–97.0%) 0.250 0.79 55%	**99.3%** (94.9%–100%) 0.031 0.89 30%	92.5% (87.9%–95.8%) **0.355** 0.78 49%
F Kahn POSITIVE (CMI 2020) n=465	8.2%	 0.109 0.77 ND	**100%** 0.00 0.89 ND	 0.10 0.92 ND
Omar Abu Saleh (CID 2020) n=199	11.6%	100.0 (93.7 to 100.0)	ND	ND
Caldreon-Parra J (J clin med 2022) n=404 pts	12.4	96.4 0.27 0.69 34%	**97.8** 0.16 0.84 46%	95.1 0.37 0.77 60%
Simos PA (JAC 2022) n=106 pts	17%	95.8 (76.8–99.4) 0.2 (0.0–1.5) 0.59 ND	97.1 (82.8–99.6) 0.2 (0.0–1.0) 0.83 ND	94.2 (87.2–97.5) **0.3 (0.1–0.7)** 0.89 ND

Staphylococcus aureus bacteremia Echocardiography indications

Consecutive stages to produce a usable multivariable prognostic model

- *Development studies*[5 6]

- *Validation studies*[7]

Staphylococcus aureus bacteremia Echocardiography indications

Consecutive stages to produce a usable multivariable prognostic model

- *Development studies*[5 6]

- *Validation studies*[7]

- *Impact studies*

Staphylococcus aureus bacteremia Echocardiography indications

Consecutive stages to produce a usable multivariable prognostic model

- *Development studies*[5 6]

- *Validation studies*[7]

- *Impact studies*

ASSISTANCE PUBLIQUE HÔPITAUX DE PARIS

RESEARCH PROTOCOL INVOLVING HUMAN PARTICIPANTS WITH MINIMAL RISKS AND BURDEN

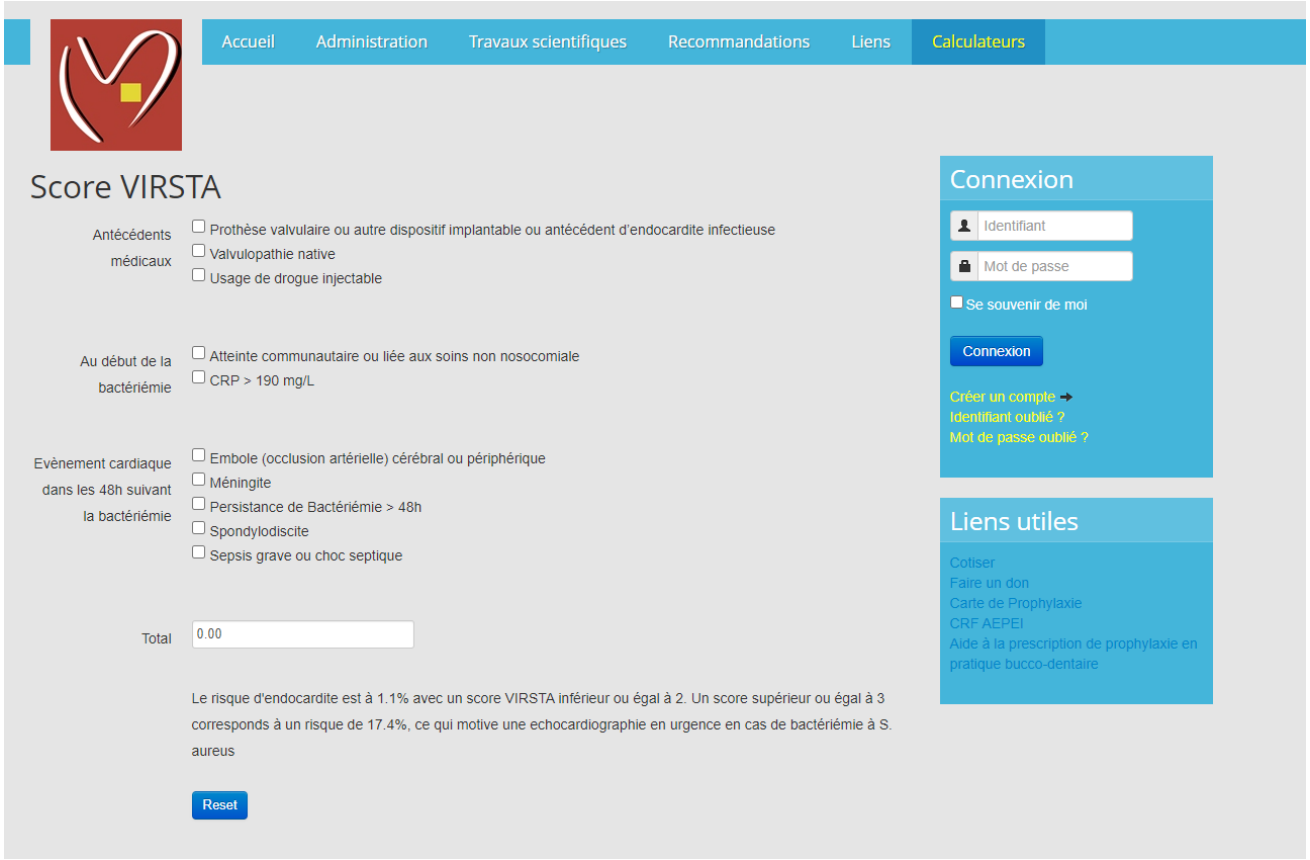
Project Code: / IDRCB no:

Echocardiography versus no echocardiography in individuals with *Staphylococcus aureus* bacteraemia and a VIRSTA score < 3: a non-inferiority randomized controlled trial

VIRSTA-VAL

Version N°1.0 dated 2022/02/28

Coordinating Investigator:	Pr. Xavier DUVAL Clinical Investigating Center Bichat Claude Bernard hospital, Paris, France Tel. 01 40 25 71 35 Email: xavier.duval@aphp.fr
Scientific Director	Pr. Vincent LE MOING Department of Infectious diseases Gui de Chauliac hospital, Montpellier, France Tel. 04 67 33 95 10 Email: v-le_moing@chu-montpellier.fr



https://endocardite.org/index.php/calculateurs/score-virsta

Enterococcal bacteremia

Twice as rare

Enterococcal bacteremia

- NOVA, 1515 bacteremia, 65 IE **(4%)**
  - score ≥4, **Se 100%,** Sp 29%

variables	points
Number of PBC (3/3 or majority if >3)	5
Unknown origin of bacteremia	4
Prior valve disease	2
Heart murmur	1

Bouza CID 2015;60:528 - Berge Infection. 2019;47:45 - Dahl JACC 2019;74:193-201

Enterococcal bacteremia

- NOVA, 1515 bacteremia, 65 IE (4%)
  - score ≥4, **Se 100%,** Sp 29%

variables	points
Number of PBC (3/3 or majority if >3)	5
Unknown origin of bacteremia	4
Prior valve disease	2
Heart murmur	1

- DENOVA score (397 pts, 11% IE)
  - = NOVA + emboli + symptoms >7 days
  - score ≥3 (each item = 1 point)
  - **Se 100%,** improved Sp (85%)

Bouza CID 2015;60:528 - Berge Infection. 2019;47:45 - Dahl JACC 2019;74:193-201

Enterococcal bacteremia

- NOVA, 1515 bacteremia, 65 IE (4%)
  - score ≥4, **Se 100%,** Sp 29%

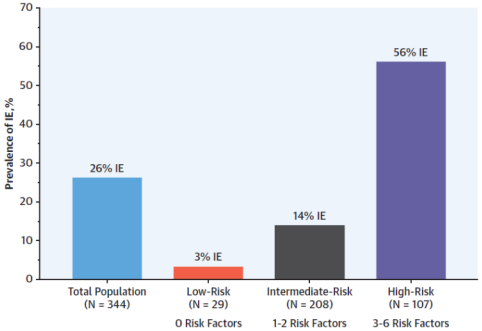
variables	points
Number of PBC (3/3 or majority if >3)	5
Unknown origin of bacteremia	4
Prior valve disease	2
Heart murmur	1

- DENOVA score (397 pts, 11% IE)
  - = NOVA + emboli + symptoms >7 days
  - score ≥3 (each item = 1 point)
  - **Se 100%,** improved Sp (85%)

Prospective Study with Systematic TTE

- ± TEE (74%) in 344 patients with *E faecalis* bacteremia
  - prevalence of IE = 26%

variables	OR
Prosthetic heart valve	3.93
Number of PBC >3	3.69
Community acquired infection	3.35
Immunosuppression	2.82
Monomicrobial infection	2.73
Unknown origin of infection	2.36



Bouza CID 2015;60:528 - Berge Infection. 2019;47:45 - Dahl JACC 2019;74:193-201

Streptococcal bacteremia

 Sunnerhagen CID 2018;66:693-698 - Sunnerhagen Infect Dis (Lond). 2020 Jan;52(1):54-57

Streptococcal bacteremia

- HANDOC, 339 bacteremia, 26 IE (7.6%)
- score ≥ 3, **Se 100%,** Sp 76%

variables	points
Heart murmur or valvular disease	1
Aetiology	
S bovis, mutans, sanguinis	1
S anginosus	-1
Number of PBC (>1)	1
Duration of symptoms > 7 days	1
Only 1 species in BC	1
Community acquired infection	1

 Sunnerhagen CID 2018;66:693-698 - Sunnerhagen Infect Dis (Lond). 2020 Jan;52(1):54-57

Streptococcal bacteremia

- HANDOC, 339 bacteremia, 26 IE (7.6%)
- score ≥ 3, **Se 100%,** Sp 76%

variables	points
Heart murmur or valvular disease	1
Aetiology	
S bovis, mutans, sanguinis	1
S anginosus	-1
Number of PBC (>1)	1
Duration of symptoms > 7 days	1
Only 1 species in BC	1
Community acquired infection	1

External validation
68 bacteremia, 16 IE (24%)
score ≥ 3, **Se 100%,** Sp 62%

 Sunnerhagen CID 2018;66:693-698 - Sunnerhagen Infect Dis (Lond). 2020 Jan;52(1):54-57

Conclusions

- **Quand faut-il évoquer une endocardite ?**

Conclusions

- **Quand faut-il évoquer une endocardite ?**
- **Ressources limitées**

Conclusions

- Quand faut-il évoquer une endocardite ?
- Ressources limitées
- De plus en plus de scores diagnostiques
- Nécessité sensibilité très haute, LR - < 0,2

Conclusions

- Quand faut-il évoquer une endocardite ?
- Ressources limitées
- De plus en plus de scores diagnostiques
- Nécessité sensibilité très haute, LR - < 0,2
- Pas à ce jour d'étude randomisée de validation

Conclusions

- Quand faut-il évoquer une endocardite ?
- Ressources limitées
- De plus en plus de scores diagnostiques
- Nécessité sensibilité très haute, LR - < 0,2
- Pas à ce jour d'étude randomisée de validation
- Score < limite: ne veut pas dire « ne pas réévaluer » d'ici J14
- Aucun score ne remplace l'analyse fine du clinicien

Remerciements

- AEPEI
- Pr Vincent Le Moing, Pr Bruno Hoen
- Pr Bernard Iung, Dr Christine Selton-Suty, Pr F Delahaye
- Pr François Alla, Dr Sarah Tubiana
- Investigateurs VIRSTA et TEPSTAR

When does risk of TEE outweighs risk of neglecting IE ?

- **When considering mortality as the outcome, the utility of performing TEE outweighs that of not treating IE except in populations with a probability of IE < 1.1% (testing threshold)**

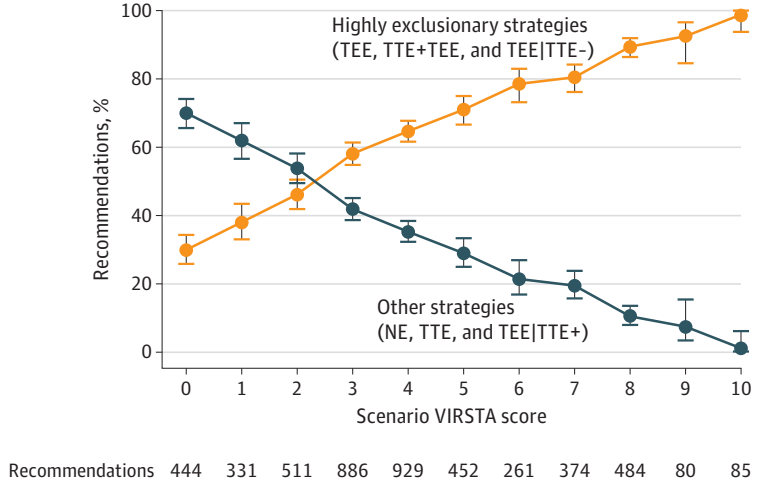
- **This is true even if:**
  - benefit of treating IE is as low as 7% (testing threshold = 2%)
  - excess mortality due to TEE is as high of 0.1%

Heriot G, Clin Microbiol Infect 2018

Clinicians use VIRSTA score without knowing

- 50 scénarios
- 656 clinicians (ID: 78%)
- Europeans more agressive

Figure. Recommendations in Favor of a Highly Exclusionary Echocardiography Strategy by Scenario VIRSTA Score



Heriot G, Jama Open Network 2020

- We also considered the usefulness of the negative likelihood ratio (NLR) to predict this risk, as previously reported [32].
- In accordance with the aforementioned studies, we predefined the following cutoff points:
  - 1—If the risk of IE was less than 1% and the NLR was less than 0.05, IE would be considered ruled out without the need for any echocardiographic assessment;
  - 2—If the risk of IE was between 1–2% and the NLR was less than 0.10, IE would be considered ruled out with the use of TTE without TEE.
  - 3—If the risk of IE was between 2–5% and the NLR was less than 0.20, it would be considered uncertain if IE may possibly be ruled out with a negative TTE without performing TEE.
  - 4—If the risk of IE was greater than 5% or the NLR was greater than 0.20, TEE would be considered necessary to rule out IE.
- Additionally, we considered that if the prevalence of endocarditis in low-risk patients with negative TTE was higher than 1.0%, these patients would benefit from TEE, in accordance with other authors [8].

Caldreon-Parra J (J clin med 2022) n=404 pts

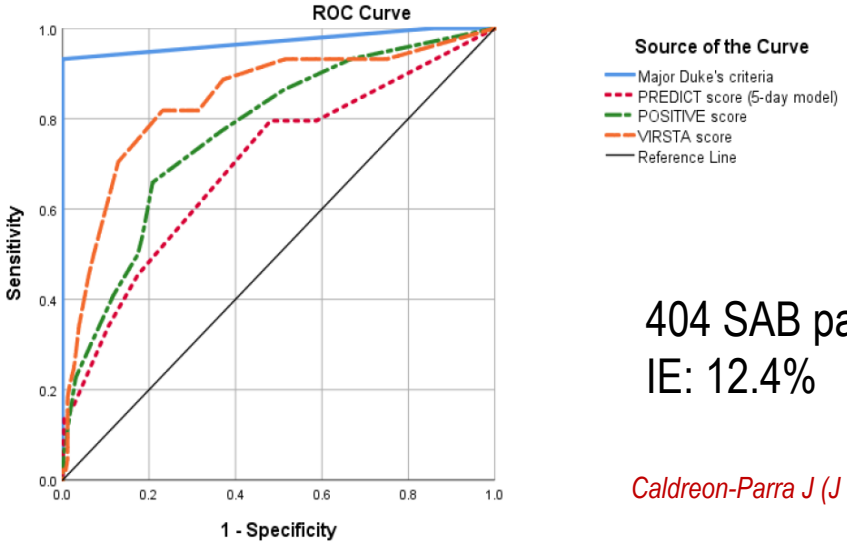
Echocardiography performed at most in 2/3 of pts with Staphylococcus aureus bacteremia

Référence	Source de données	Mode d'acquisition de la bactériémie	Nb patients	% échocardiographie	Suivi jusqu'à 12 semaines	Critère de jugement	Construction du score /identification des critères	Validation	Facteurs prédictifs d'EI inclus dans le score/critères
(Kaasch *et al*, 2011)	Analyse post-hoc de 2 études de cohortes prospectives (INSTINCT et SABG)	Nosocomial	304+432	ETT/ETO dans les 14 jours - 39,8% (INSTINCT) - 57,4% (SABG)	Non	EI certaine selon critères modifiés de Durack	Analyse univariée (Tests exacts de Fisher)	Pseudo-validation externe identification des facteurs dans les 2 cohortes (INSTINCT et SABG)	Bactériémie prolongée> 4 jours Dispositif intracardiaque Hémodialyse Ostéomyélite non vertébrale
(Khatib & Sharma, 2013)	Analyse post-hoc de 3 études de cohortes prospectives	Communautaire ou associé aux soins	805	ETT dans les 28 jours 36,6%	Non (revue des dossiers médicaux à 100 jours)	EI certaine selon critères modifiés de Durack	Analyse univariée	Pas de validation	Bactériémie prolongée > 3 jours Dispositif intracardiaque Foyer secondaire Rechute à 100 jours
(Showler *et al*, 2015)	Etude de cohorte rétrospective	Communautaire ou associé aux soins	833	64,7 % ETT *Analyses statistiques réalisées uniquement dans cette sous population*	Non	EI certaine selon critères modifiés de Durack	Prédicteurs identifiés à partir d'un modèle de régression logistique	Validation interne (méthode de split sample)	ETT non concluante Usager de drogue intraveineuse Matériel prothétique intracardiaque/antécédent d'EI/valvulopathie Bactériémie communautaire
(Palraj *et al*, 2015)	Etude de cohorte rétrospective monocentrique	Communautaire ou associé aux soins (Hors usagers de drogues par voie intraveineuse)	678	ETO dans les 14 jours 68%	Non (revue des dossiers médicaux)	EI certaine selon critères modifiés de Durack	Prédicteurs identifiés à partir de 2 modèles de régression logistique (modèle 1 : J1 ; modèle 2 :J5 après le diagnostic de bactériémie)	Validation interne (méthode de bootstrap classique)	Bactériémie communautaire Bactériémie prolongée> 3 jours Dispositif intracardiaque
(Heriot *et al*, 2015)	Etude de cohorte rétrospective monocentrique	Communautaire ou associé aux soins	532	ETT/ETO dans les 30 jours 64%	Non (revue des dossiers médicaux)	EI sur arguments échographiques (certains ou possibles)	Pas de construction de score – Analyse descriptive	Pas de validation	Bactériémie communautaire Bactériémie prolongée> 3 jours Dispositif intracardiaque

Table 3. Validation of different clinical prediction rules to identify IE among SAB patients.

	Cut-Off	Sens.	Spec.	PPV	NPV	PLR	NLR	AUC
PREDICT (5-day model)	>1 point	90%	37.1%	16.7%	96.4%	1.43	0.27	0.70
POSITIVE	>4 points	76%	65.5%	23.6%	95.1%	2.17	0.37	0.78
VIRSTA	>2 points	92.0%	50.8%	20.8%	97.8%	1.84	0.16	0.85

IE: infective endocarditis. SAB: *Staphylococcus aureus* bacteriemia. Sens: sensitivity. Spec: Specificity. PPV: Positive predictive value. NPV: Negative predictive value. PLR: Positive likelihood ratio. NLR: Negative likelihood ratio. AUC: Area under the curve.



Journal of *Clinical Medicine*
MDPI

Article

Unreliability of Clinical Prediction Rules to Exclude without Echocardiography Infective Endocarditis in *Staphylococcus aureus* Bacteremia

Jorge Calderón-Parra [1,2,*], Itziar Diego-Yagüe [1], Beatriz Santamarina-Alcantud [3], Susana Mingo-Santos [4], Alberto Mora-Vargas [1], José Manuel Vázquez-Comendador [1], Ana Fernández-Cruz [1,2], Elena Muñez-Rubio [1,2], Andrea Gutiérrez-Villanueva [1], Isabel Sánchez-Romero [3] and Antonio Ramos-Martínez [1,2]

404 SAB patients
IE: 12.4%

Caldreon-Parra J (J clin med 2022) n=404 pts

J Antimicrob Chemother
https://doi.org/10.1093/jac/dkac129

Journal of Antimicrobial Chemotherapy

Clinical prediction scores and the utility of time to blood culture positivity in stratifying the risk of infective endocarditis in *Staphylococcus aureus* bacteraemia

Peter A. Simos [1,2]*, David J. Holland [3,4,5], Adam Stewart[6,7,8], Burcu Isler[1,6], Ian Hughes[9], Nathan Price[1], Andrew Henderson[1] and Kylie Alcorn[2]

106 SAB patients, 17% IE

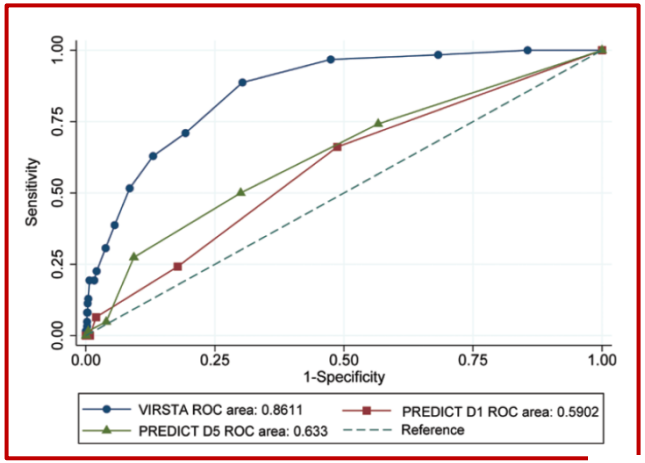
Table 2. Performance of clinical prediction scores in SAB

	Sensitivity	Specificity	PPV	NPV	LR+	LR−
PREDICT Day 1 ≥ 4	5.6 (0.1–27.3)	97.7 (92.0–99.7)	33.3 (4.6–83.9)	83.5 (81.8–85.0)	2.4 (0.2–25.5)	1.0 (0.9–1.1)
PREDICT Day 5 ≥ 2	94.4 (72.7–99.9)	26.1 (17.3–36.6)	20.7 (18.1–23.6)	95.8 (76.8–99.4)	1.3 (1.1–1.5)	0.2 (0.0–1.5)
POSITIVE > 4	77.8 (52.4–93.6)	73.9 (63.4–82.7)	37.8 (28.4–48.3)	94.2 (87.2–97.5)	3.0 (1.9–4.6)	0.3 (0.1–0.7)
VIRSTA ≥ 3	94.4 (72.7–99.9)	37.5 (27.4–48.5)	23.6 (20.3–27.3)	97.1 (82.8–99.6)	1.5 (1.2–1.8)	0.2 (0.0–1.0)
TTP ≤ 11.5 h	88.9 (65.3–98.6)	71.6 (61.0–80.7)	39.0 (30.7–48.1)	96.9 (89.4–99.2)	3.1 (2.2–4.5)	0.2 (0.0–0.6)
VIRSTA+	100.0 (81.5–100.0)	33.0 (23.3–43.8)	23.4 (20.9–26.1)	100	1.5 (1.3–1.7)	0

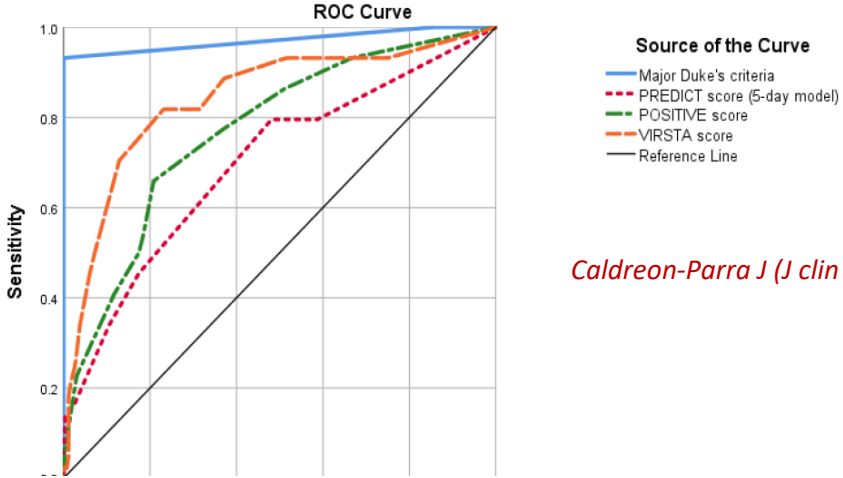
Data are % (95% CI). VIRTSA+ is the standard VIRSTA score plus TTP ≤ 11.5 h. TTP ≤ 11.5 h was determined as the optimal cut-off for predicting IE according to the Youden index.

Conclusions: The VIRSTA and POSITIVE scores were the strongest predictors for IE complicating SAB. The addition of TTP to VIRSTA (VIRSTA+) significantly improved discriminatory value and may be safely used to rationalize echocardiography strategies.

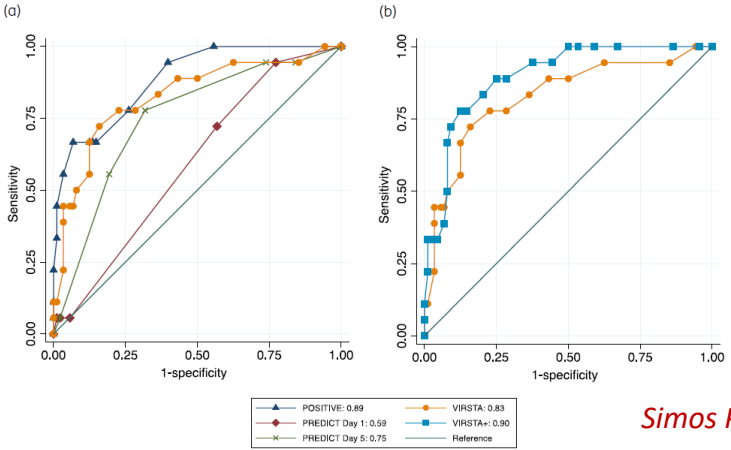
Simos PA J Antimicrobial Chemother 2022



JS Peinado-Acevedo (CID 2021) n=922 pts



Caldreon-Parra J (J clin med 2022) n=404 pts



Simos PA J Antimicrobial Chemother 2022

Figure 3. ROC curves of existing prediction scores (a). VIRSTA+ significantly improves discriminatory power of the traditional VIRSTA score by the addition of TTP ≤ 11.5 h ($P = 0.015$) (b). This figure appears in colour in the online version of *JAC* and in black and white in the print version of *JAC*.