French Heart Allocation Policy Handbook

Agence de la biomédecine

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I. INTRODUCTION

Agence de la biomédecine

The *Agence de la Biomédecine* [the *Agency*] is a state agency responsible for the public health issues related to organ, tissue, and cell transplantation, medically assisted reproduction (MAR), and embryology and human genetics in France. It manages the national organs transplant waiting lists, the registration of patients on these lists, the allocation of all organs retrieved in France, and the evaluation of these activities.

CRISTAL Database

The *Agency* developed and maintains the CRISTAL database to record information concerning the registration on transplant waiting lists, transplantation and pre- and post-transplantation follow-up of patients, as well as information pertaining to the coordination of organ procurement and allocation. This primary role of supporting the allocation of a scarce resource to patients directly contributes to health care. CRISTAL is also the main source of the accurate, quality-controlled data used for the evaluation of organ retrieval and transplant activities and published both in the *Agency's* annual reports and in specific studies.

Allocation System

Concerns about the equity and efficiency of the previous regional center-based allocation system led the *Agency* to develop a nationwide patient-based allocation policy. It set the terms and conditions of the organ allocation system, in collaboration with its Heart Transplant advisory and patients' associations.

An organ allocation system must respond to recipients' medical needs suitably, efficiently, and equitably. In most cases, it is impossible to do so by prioritizing different medical indications. The allocation system must therefore be designed to find a compromise between equity, efficiency, and feasibility. A score is, to date, the most efficient solution for supporting a multivariate patient-based allocation system offering fair access to transplant to all patients.

II. THE NATIONAL HEART TRANSPLANT ALLOCATION SCORE

A. BACKGROUND

Despite the steady increase in organ retrievals, hearts available for transplantation remain a scarce life-saving resource. The heart transplant allocation policy is designed to be:

- fair, regarding the patient's profile and the regional disparities in needs
- efficient, providing the community with the maximum benefit expected from this treatment
- transparent and objective
- realistic, considering the logistical constraints of organ procurement.

Before January 2018, heart transplant allocation required distinguishing candidates whose status was considered immediately life-threatening through three sequential national high-urgency (HU) priorities, defined by the patient's treatment modality. The highest HU1 priority was assigned to patients on either inotrope infusion or a short-term mechanical circulatory support system (MCS). HU2 priority was assigned to patients on long-term MCS with device-related complications, and HU3 priority to patients on a uncomplicated biventricular assist device (BiVAD) or a total artificial heart (TAH). Transplant teams requested these priorities for a given patient; these requests had to be validated by a heart transplant expert.

Analysis of data from the CRISTAL national registry showed that the 2004 allocation system did not adequately distinguish candidates' mortality risks and ended up by overprioritizing HU candidates.[1]

- Waitlist mortality was significantly lower for candidates with HU status than for those without it.

- HU candidates had a much higher transplant access rate than those without it.

- Grafts allocated through HU status were offered to specific recipients without considering donor-recipient matching and grafts allocated according to geography were offered to centers rather than candidates. The limited number of nonurgent listed patients in most centers on any given day prevented donor-recipient matching on criteria other than ABO blood type.

[1] Dorent, R., Jasseron, C., Audry, B., Bayer, F., Legeai, C., Cantrelle, C., ... & Bastien, O. (2020). New French heart allocation system: comparison with Eurotransplant and US allocation systems. American Journal of Transplantation, 20(5), 1236-1243.

B. A NEW HEART ALLOCATION SYSTEM

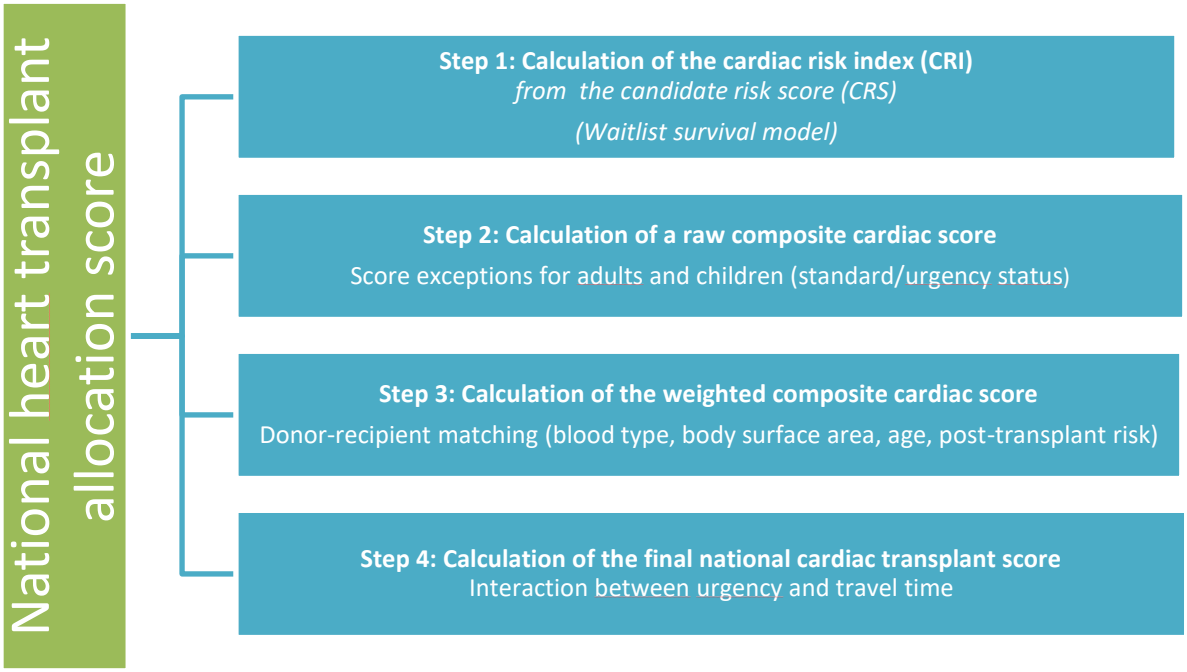
In view of these limitations, a new heart allocation system was designed, evaluated through computer simulations, and finally implemented in France in January 2018. The new allocation system is based on:

- A national score ranking all candidates on the waiting list
- The patient's objective risk of death on the waiting list
- Donor-recipient matching, based on criteria other than blood type, including a post-transplant survival risk function used to avoid futile heart transplants
- National graft sharing, taking travel time between procurement and transplant hospitals into account.

The national heart transplant allocation score comprises four steps:

- Step 1: calculation of the cardiac risk index (CRI)
- Step 2: calculation of a raw composite cardiac score (RCC score)
- Step 3: calculation of the weighted composite cardiac score (WCC score)
- Step 4: calculation of the final national cardiac transplant score (FNCT score)

Figure 1: The four steps of the new French heart allocation system



1. Step 1: Calculation of the cardiac risk index (CRI)

The cardiac risk index (CRI) is calculated from a candidate risk score (CRS) that predicts 1-year waitlist mortality. It was developed by the *Agency* from the cohort of patients registered on the CRISTAL national waiting list from 2010 through 2013.[2]

The CRS includes four components:

- Short-term mechanical circulatory support system (MCS)
- Plasma concentration of natriuretic peptides (NP)[3]
- Estimated glomerular filtration rate (eGFR)[4]
- Total serum bilirubin level.

For patients supported with extracorporeal circulation (ECMO, ECLS) or treated with intravenous inotropic drugs, the CRS is calculated from the laboratory values before extracorporeal circulation implantation or inotrope infusion. If the values from before initiation of these treatments are not available, the CRS is calculated from the most recent values.

Patients whose situation is worsening despite the ECMO or ECLS or the inotropic drug treatment will benefit by receiving the maximum value of the CRI. However, the CRI for patients without any of these treatments will be calculated with the most recent laboratory values (daily value) (Appendix 1.1).

To obtain an easy-to-use positive integer ranging from 0 to 40, the CRS is then converted to a cardiac risk index (CRI) with the following formula:

$$\mathbf{CRI = \min(40, (CRS + 1.41) \times 10)}$$

[2] Jasseron, C., Legeai, C., Jacquelinet, C., Leprince, P., Cantrelle, C., Audry, B., ... & Dorent, R. (2017). Prediction of waitlist mortality in adult heart transplant candidates: the candidate risk score. Transplantation, 101(9), 2175-2182.
[3] Brain natriuretic peptide (BNP) or N-terminal pro-brain natriuretic peptide (proBNP)
[4] Modification of Diet in Renal Disease (MDRD) formula

2. Step 2: Calculation of a raw composite cardiac score

Exceptions to the CRS-based allocation system are allowed for the subcategories of candidates for whom the CRS seems to be an inappropriate measure of urgency; these include pediatric candidates, patients on long-term MCS with device-related complications, and patients with contraindications to VAD implantation. This situation was addressed by assigning score exceptions to these candidates by calculating a raw composite cardiac score (RCC score).

The RCC score has four mutually exclusive components (Appendix 1.2):

- Standard adult component
- Expert adult component (XPCA)
- Standard pediatric component
- Expert pediatric component (XPCP)

Figure 2: Raw composite cardiac score components

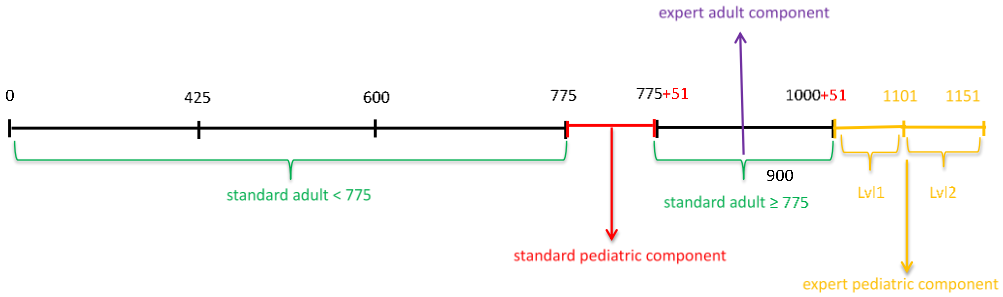


Table 1: Raw composite cardiac score components - Points

Components	Points	Priority request
Standard adult*	0 – 775 826 – 1051	Ø
Standard pediatric	776 – 825	Ø
Expert adult component (XPCA)	900	Needed
Expert pediatric component (XPCP) ➔ **level1 (XPCP1)** ➔ **level2 (XPCP2)**	1102 - 1151 1051 - 1101	Needed

a. Standard adult component

The standard adult component concerns adult patients (≥ 18 years) whose prognosis is predicted by the cardiac risk index (CRI). For adult patients supported with ECMO, these points are to be reduced by 10% a day starting at the 12th day of implantation and canceled from the 16th day (Score = 0) (Appendix 1.2.2).
This new measure was implemented on April 9, 2019, to prevent excessive ECMO utilization.

b. Standard pediatric component

The standard pediatric component is for non-emergency patients aged younger than 18 years. For this component, 776 points are assigned, and this number increases with the time spent on the waiting list, to reach a maximum of 825 points (Appendix 1.2.4).

c. Expert adult component (XPCA)

The expert adult component may be granted in clinical situations when there is an increased waitlist mortality or delisting for worsening medical condition, because the CRI calculation does not take these factors into account. An expert reviews the component request. Up to 900 points can be allocated immediately or over a 3-month period. In the latter case, the patient received 300 points one month after the priority request, another 300 points after two months, and reaches the total of 900 points at the end of the three-month period.

The score characteristics are designed to give patients with an expert adult component (XPCA) a higher score than they would have obtained with a standard adult component (Appendix 1.2.3).

Table 2: Time period for awarding the maximum points for the expert adult component (XPCA)

Criteria	Points	Period
Long-term MCS thrombosis	900	immediately
Long-term MCS dysfunction excluding thrombosis	900	immediately
Life-threatening ventricular arrhythmias	900	immediately
Bleeding on long-term MCS	900	progressively over 3 months
Long-term MCS-related infection	900	progressively over 3 months
Contraindications to long-term MCS	900	progressively over 3 months
Biventricular mechanical circulatory support or total artificial heart	900	progressively over 3 months

d. Expert pediatric component (XPCP)

Heart candidates aged younger than 18 years at the time of registration may be assigned to either of the following levels: XPCP1 and XPCP2.
The ranking in these two levels depends directly on the clinical situation and the seniority date of the priority request.
The Expert Pediatric Component 1 (XPCP1) assigns from 1102 to 1151 points, and the Expert Pediatric Component 2 (XPCP2) from 1051 to 1101 points (Appendix 1.2.5).

Note: Children reaching adult age maintain the points from any previously assigned pediatric expert component.

Table 3: Expert pediatric component (XPCP)

Clinical situations justifying a request for XPCP1 points	Clinical situations justifying a request for XPCP2 points
Complicated long-term circulatory support device	Uncomplicated long-term circulatory support device
Complicated ECMO	Uncomplicated ECMO
Contraindication to the implementation of a Berlin Heart Excor®	Inotropic infusion

3. Step 3: Calculation of the weighted composite cardiac score (WCC score)

The new allocation system has changed the donor-recipient blood type and size matching criteria and now includes donor-recipient age and post-transplant risk matching. This WCC score takes the following components into account (Appendix 1.3):

- Raw composite cardiac score (RCC score)
- Donor-recipient matching :
    - Age donor-recipient matching
    - Blood type donor-recipient matching
    - Morphology (body surface area) donor-recipient matching
    - Donor-recipient risk matching

These filters apply for each heart transplant offer.

a. Donor-recipient age matching

The score is weighted by the age difference between the donor and the candidate, assigning the full score to candidates within 15 years of the donor's age and assigning a score of zero to candidates more than 40 years older than the donor.
For candidates 15-40 years older than the donor, the score decreases linearly from 100% to 0%.
The number of points allocated by the standard adult component thus depends on the recipient-donor age difference (Appendix 1.3.1).

Donor younger than recipient:

- ✓ Age difference ≤ 15 years : ➔ 100% of the points
- ✓ 15 ≤ Age difference ≤ 40 years : ➔ decreasing percentage of points from 100% to 0%
- ✓ Age difference > 40 years : ➔ 0% of the points

Donor older than recipient:

- ✓ Age difference ≤ 40 years : ➔ 100% of the points
- ✓ 40 ≤ Age difference ≥ 65 years : ➔ decreasing percentage of points from 100% to 0%
- ✓ Age difference > 65 years : ➔ 0% of the points

b. Donor-recipient blood type matching

The new allocation system generalizes ABO-compatible transplantation in adult recipients with blood types B and AB.
Blood type A donor hearts are therefore offered to type A and AB candidates, blood type O grafts only to type O and B candidates, and blood type B grafts to type B and AB candidates.
ABO-compatible transplantation remains the general rule for pediatric candidates (Appendix 1.3.2).

Table 4: Blood type matching prioritization

Recipient age	Donor ABO	Recipient ABO
≥ 18 Years old	A	→ A, AB
	AB	→ AB
	B	→ B, AB(1)
	O	→ O, B
< 18 Years old	A	→ Blood type matching
	AB	
	B	
	O	

(1) Blood type B recipients have priority over blood type AB recipients

c. Donor-recipient morphology (body surface area: BSA) matching

Body weight was used to match donor and recipient size in the previous allocation system, but body surface area (BSA) is used in the new system. Grafts are currently offered to adult candidates when donor BSA is not more than 20% lower than the candidate's BSA and to pediatric candidates when donor BSA is not more than 20% lower and not more than 300% greater than the candidate's BSA.
In accordance with the International Society for Heart and Lung Transplantation guidelines, grafts from male donors weighing more than 70 kg are offered to all candidates. (Appendix 1.3.3)

Table 5: Donor-recipient body surface area matching

Recipient	Donor
Adult	DBSA* > 80% RBSA** or man ≥ 70 kg
Pediatric	DBSA ∈ [80%; 300%] RBSA or man ≥ 70 kg

DBSA*: Donor body surface area RBSA**: Recipient body surface area

d. Donor-recipient related post-transplant risk score

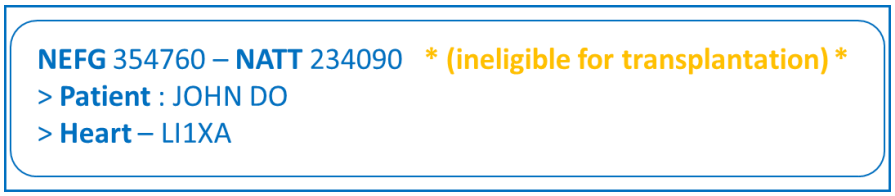
The new allocation system uses a transplant risk score (TRS) that predicts the risk of graft loss at 1 year, based on recipient and donor characteristics. The TRS includes four recipient factors (1-4) and two donor factors (5, 6):

1. Age
2. Primary diagnosis
3. Estimated glomerular filtration rate (eGFR)
4. Total bilirubin level
5. Donor age
6. Donor gender

Post-transplant graft loss risk operates in an on-off mode (i.e., it is used to filter candidates but does not change their score). In practice, candidates with a predicted 1-year graft loss risk of 50% or higher cannot receive a graft proposal, regardless of their score (Appendix 1.3.4).

The *Agency* notifies the transplant team with an "Ineligible for transplantation" message when their patient is ineligible for transplantation because of a predicted 1-year graft loss risk of 50% or above. The notification is displayed on the patient's medical record screen as below:

Figure 3: Record screen from the CRISTAL database



4. Step 4: Calculation of the final national cardiac transplant score (FNCT score)

The final step in the calculation of the national cardiac transplant score results from an interaction between the weighted composite cardiac score (WCC score) and the travel time between the retrieval and transplant sites, calculated with a geographical model (GM) (Appendix 1.4).

Geographical model

The national geographical sharing model is a gravity model combining priority level, defined by the score, and travel time between procurement and transplant centers, calculated by road and airplane. It balances the candidate's medical urgency and the travel time between procurement and transplant centers, with a higher weight for medical urgency than distance. This alternative to local, regional, and national graft sharing models offers a compromise between distance and medical need.

Figure 4: Final national cardiac transplant score

FNCT_Score = WCC_Score x GM

References

Dorent, R., Jasseron, C., Audry, B., Bayer, F., Legeai, C., Cantrelle, C., ... & Bastien, O. (2020). New French heart allocation system: comparison with Eurotransplant and US allocation systems. American Journal of Transplantation, 20(5), 1236-1243.

Jasseron, C., Legeai, C., Jacquelinet, C., Nubret-Le Coniat, K., Flécher, E., Cantrelle, C., ... & Dorent, R. (2019). Optimization of heart allocation: the transplant risk score. American Journal of Transplantation, 19(5), 1507-1517.

Jasseron, C., Legeai, C., Jacquelinet, C., Leprince, P., Cantrelle, C., Audry, B., ... & Dorent, R. (2017). Prediction of waitlist mortality in adult heart transplant candidates: the candidate risk score. Transplantation, 101(9), 2175-2182.

Appendix

The transplant team's proposal filters on donors

The transplant team can select donor weight, height, and age characteristics. These criteria are then used for the heart transplant allocation.

Note: These data may be modified throughout the waiting period. If no information is entered during this period, all grafts meeting the morphological matching criteria defined above will be offered.

Table 6: Donor-recipient matching: weight, height, and age

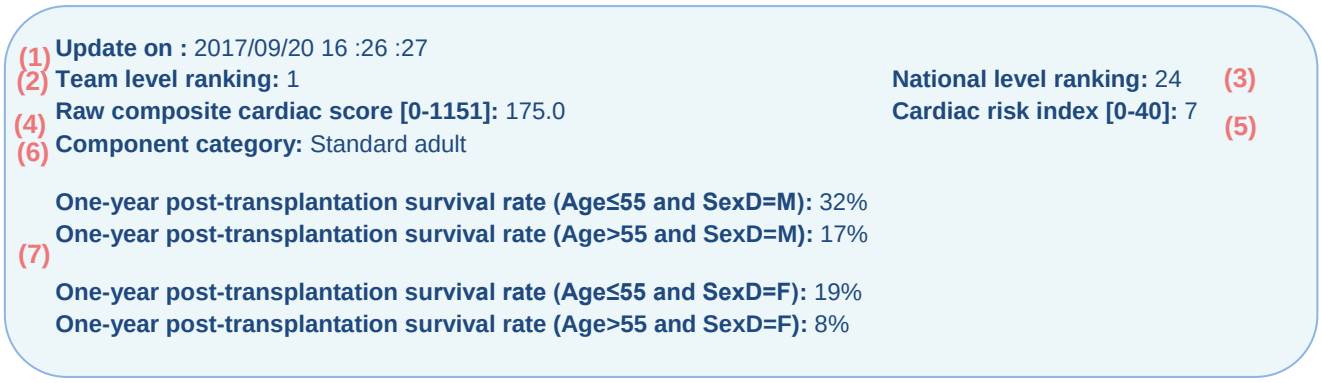
Donor minimum weight:	**50 kg**	**Donor maximum weight:**	**90 kg**
Donor minimum height:	**150 cm**	**Donor maximum height:**	**190 cm**
Donor minimum age:	**18 years**	**Donor maximum age:**	**50 years**

Raw composite cardiac score (RCC score)

This screen summarizes information about the patient's cardiac score:

- (1) the update date and time of the RCC score
- (2) the team level ranking (based on the value of the RCC score)
- (3) the national level ranking (based on the value of the RCC score)
- (4) the value of the RCC score
- (5) the cardiac risk index (CRI)
- (6) the component category (pediatric, adult etc.)
- (7) the one-year post-transplantation survival rate (including donor age and gender)

Figure 5: Record screen from the CRISTAL database - Raw composite cardiac score (RCC score)



1.1. Cardiac risk index calculation (CRI)

CRI= If (CEC2 !='O' AND DRG2 !='O') Then

CRIj

Else

max(CRIj,CRIi)

End If

1.1.1. CRI Constant

C_CRI=1.301335 x 0 + 0.157691 x 1 - 0.510058 x ln(150) + 0.615711 x ln(5)

1.1.2. Cardiac risk index for the current day (CRIj)

CRIj=min(40, max(0, Round(F_RiskPreGRFj* - C_CRI**) x 10)))

** F_RiskPreGRFj = Candidate risk score function for the current day*

*** C_CRI = CRI constant*

1.1.2.1. Candidate risk score (CRS) function for the current day

F_RiskPreGRFj =*1.301335 x F_ECMO*
+ 0.157691 x F_Decile_NPj
- 0.510058 x F_Ln_GFR_WLj
+ 0.615711 x F_Ln_BILI_WLj

1.1.2.2. Short-term mechanical circulatory system (MCS) function

F_ECMO=If (CEC2='O') Then
1
Else
0
End If

1.1.2.3. Natriuretic peptide decile function (BNP or NT-ProBNP) for the current day

F_Decile_NPj= If (CEC2='O' OR CAT2='O' OR SIAV2='B') Then 10

Else If (BNP2 is NULL AND PROBNP2 is NULL) Then 1

Else If (PROBNP2 is NOT NULL AND (Current_Date-DPROBNB2)<= Delay_Var_Bio_WL) Then

PROBNP	Fct_Decile_NPj
< 928	1
< 1478	2
< 2044	3
< 2661	4
< 3416	5
< 4406	6
< 5645	7
< 8000	8
< 11332	9
>= 11332	10

Else If (BNP2 is NOT NULL AND (Current_Date -DBNB2)<= Delay_Var_Bio_WL) Then

BNP	Fct_Decile_NPj
< 189	1
< 314	2
< 481	3
< 622	4
< 818	5
< 1074	6
< 1317	7
< 1702	8
< 2696	9
>= 2696	10

Else 1
End If
End If
End If
End If

1.1.2.4. Glomerular filtration rate (MDRD equation) function for the current day

F_Ln_GFR_WLj=If (DIA2='O') Then ln(15)
Else If (CREAT2 is NULL OR (Current_date-DCREAT2)> Delay_Var_Bio_WL) Then ln(150)
Else ln(min(150,max(1, F_GFRj)))
End If
End If

F_GFRj=186.3
x ((CREAT2/88.4)$^{(-1.154)}$)
x ((AGER)(-0.203))
x (Si (SEXR='F') Then 0.742 Else 1)

1.1.2.5. Bilirubin function for the current day

F_Ln_BILI_WLj= If (BILI2 is NULL OR (Current_date -DBILI2)> Delay_Var_Bio_WL) Then ln(5)
Else ln(min(230, max(5, BILI2)))
End If

1.1.1. Cardiac risk index before inotropic infusion or ECMO implantation (CRIi)

CRIi=min(40,max(0,Round(F_RiskPreGRFi* - C_CRI**) x 10)))

** F_RisKPreGRFi = Initial CRS Function*
*** C_CRI = CRI constant*

1.1.1.1.1. Initial CRS Function

F_RiskPreGRFi =*1.301335 x F_ECMO*
+ 0.157691 x F_Decile_NPi
- 0.510058 x F_Ln_GFR_WLi
+ 0.615711 x F_Ln_BILI_WLi

1.1.1.2. Short-term mechanical circulatory system (MCS) function

F_ECMO=If (CEC2='O') Then 1

Else 0

End If

1.1.1.3. Initial Natriuretic peptide decile function (BNP ou NT-ProBNP)

F_Decile_NPi= If (CEC2='O' OR CAT2='O' OR SIAV2='B') Then 10

Else If (BNP_AVI is NULL AND PBN_AVI is NULL) Then 1

Else IF (PBN_AVI is NOT NULL) Then

PROBNP	Fct_Decile_NPi
< 928	1
< 1478	2
< 2044	3
< 2661	4
< 3416	5
< 4406	6
< 5645	7
< 8000	8
< 11332	9
>= 11332	10

Else If (BNP_AVI is NOT NULL) Then

BNP	Fct_Decile_NPi
< 189	1
< 314	2
< 481	3
< 622	4
< 818	5
< 1074	6
< 1317	7
< 1702	8
< 2696	9
>= 2696	10

Else 1

End If

End If

End If

End If

1.1.1.4. Initial glomerular filtration rate (MDRD equation) function

F_Ln_GFR_WLi=If (DIA_AVI='O') Then ln(15)
Else If (CRE_AVI is NULL Then ln(150)
Else ln(min(150,max(1,F_DFGi)))
End If
End If

F_GFRi=186.3
x ((CRE_AVI/88.4)$^{(-1.154)}$)
x ((AGER)(-0.203))
x (Si (SEXR='F') Then 0.742 Else 1)

1.1.1.5. Initial bilirubin function

F_Ln_BILI_WLi= If (BILI_AVI is NULL) Then ln(5)
Else ln(min(230, max(5, BILI_AVI)))
End If

1.2. Raw composite cardiac score (RCC_Score)

RCC_Score =
Comp_Ad_Std
+ Comp_Ad_XPCA
+ Comp_Ped_Std
+ Comp_Pes_XPCP

- Comp_Ad_Std = *Standard adult component,*
- Comp_Ad_XPCA = *Expert adult component,*
- Comp_Ped_Std = *Standard pediatric component,*
- Comp_Ped_XPCP = *Expert pediatric component*

1.2.1. Standardized CRI function

F_CRI= If CRI<31 Then 1000*CRI/40
Else (1000*CRI/40)+ 51
End If

1.2.2. **Standard adult component**

```
F_Comp_ECMO(Delay_ECMO, S1, S2, Discount)= Si Delay_ECMO < S1 Then 1
        Else If (Delay_ECMO < S2) Then 1- Discount x (Delay_ECMO -(S1-1))
                Else 0
                End If
        End If

F_Choice_Arm_Deter(Ratio,Counter)=If(Floor((Counter-1)*Ratio)≠Floor(Counter*Ratio) Then 'ASSIST'
        Else 'AMBUL'
        Counter

Comp_Ad_Std=If (AGER>=18 AND URGENCE NOT IN ('XPCA', 'XPCP1','XPCP2')) Then
        If CEC2='O' Then F_CRI x F_Comp_ECMO(SYSTEM.DATE()-DCEC2, 12, 16, 0.1)
                Else If (SIAV2='G') Then
                        If (F_Choice_Arm_Deter (0.2,Counter)='ASSIST') Then
                                750+5*min(5, (Current_Date-DAV2)/365.25)
                        Else F_CRI
                        End If
                Else F_CRI
                End If
          End If
Else 0
End If
```

1.2.3. **Expert adult component (XPCA)**

```
 Comp_Ad_XPCA =If (AGER>=18 AND URGENCE='XPCA') Then
        If XPC=0 Then max(F_CRI, KXPC)
                Else max(F_CRI, KXPC x max(0, min(1, DAURG/XPC)))
                End If
        Else 0
        End If
```

1.2.4. **Standard pediatric component**

```
Comp_Ped_Std= If [AGER<18 AND URGENCE NOT IN ('XPCP1','XPCP2')] Then
775+50 x max(0, min(1, DA/24))
        Else 0
        End If
```

1.2.5. **Expert pediatric component (XPCP)**

Comp_Ped_XPCP= If (URGENCE IN (’XPCP1’,’XPC2’)) Then KXPC +50 x max(0, min(1,DAURG/24))
Else 0
End If

1.3. Weighted composite cardiac score (WCC_Score)

WCC_Score = RCC_Score
x F1_DifAge
x F2_ABO
x F3_SC
x F4_SurvPostGRF

1.3.1. **Donor-recipient age matching function**

ΔAgeRD = (AGER-AGED)

F0_DifAge = If ΔAgeRD <0 Then (ΔAgeRD +65)/25
Else 1-(ΔAgeRD -15)/25
End If

F1_DifAge = If (AGER>=18) Then min(1;max(0; F0_DifAge))
Else 1
End If

1.3.2. **Donor-recipient blood type matching function**

F2_ABO =If [ABOD = ABOR] Or
(ABOD = "A" AND ABOR="AB") Or (ABOD = "O" AND ABOR="B") Then 1
Else If (ABOD = "B" AND ABOR="AB") Then **0.1**
Else 0
End If
End If

1.3.3. **Morphology (body surface area: BSA) matching function**

$F\_BSA(Height,Weight) = 0{,}007184 \times Height^{.725} \times Weight^{.425}$

F3_BSA = If (AGER>=18) Then
If [0,8 x F_BSA(TAILLER,POIDSR) < F_BSA(TAILLED,POIDSD) OR (SEXD='H' AND POIDSD ≥ 70)]
Then 1
Else 0
End If
Else If [(0,8 x F_BSA(TAILLER,POIDSR) < F_BSA(TAILLED,POIDSD) AND
3 x F_BSA(TAILLER,POIDSR) > F_BSA(TAILLED,POIDSD)) OR
(SEXD='H' AND POIDSD ≥ 70)] Then 1
Else 0
End If
End If

1.3.4. **Donor-recipient related post-transplant risk function**

1.3.4.1. 1 year post-transplant survival

Survival is calculated from a Cox model, and the coefficient 0.6785748856 corresponds to S0 (t=1 year).

$F\_SurvPostGRF = 0.6785748856^{\exp(F\_RiskPostGRF)}$

1.3.4.2. Transplant risk score (TRS) function

F_RiskPostGRF=
0.50608 x F_AGER
+ 0.50754 x F_DISEASE
+ 0.40268 x F_Ln_BILI_GRF
- 0.54443 x F_Ln_GFR_GRF
+ 0.36262 x F_SEXRD
+ 0.41714 x F_AGED

1.3.4.3. Recipient age function

F_AGER=If (AGER > 50) Then 1
Else 0
End If

1.3.4.4. Recipient initial disease function

F_DISEASE=If [(**MAL** OR **MAL2** OR **MAL3)** IN ('Valvular cardiomyopathy', congenital heart disease')]
Then 1
Else 0
End If

1.3.4.5. Post-transplant bilirubin function

F_Ln_BILI_GRF= If (BILI is NULL OR (Current_Date-DBILI)> Delay_Var_Bio_GRF) Then ln(230)
Else ln(min(230, max(5, BILI)))
End If

1.3.4.6. Post-transplant glomerular filtration rate function

F_Ln_GFR_GRF= Si (DIALYSE='O') Then ln(15)
Else If (CREAT is NULL OR (Current_Date-DCREAT)> Delay_Var_Bio_GRF) Then ln(1)
Else ln(min(150,max(1, F_GFR)))
End If
End If

1.3.4.7. Donor-recipient sex matching function

F_SEXRD= If (SEXD='F' AND SEXR='M') Then 1
Else 0
End If

1.3.4.8. Donor age function

F_AGED=If (AGED > 55) Then 1
Else 0
End If

1.4. Final national cardiac transplant Score (FNCT_Score)

FNCT_Score = WCC_Score x GM

GM *=1/exp(0,0000002 x****TTRTS****$^{2.9}$) (Geographical model)*

TTRTS *= travel time between the retrieval and transplant sites*