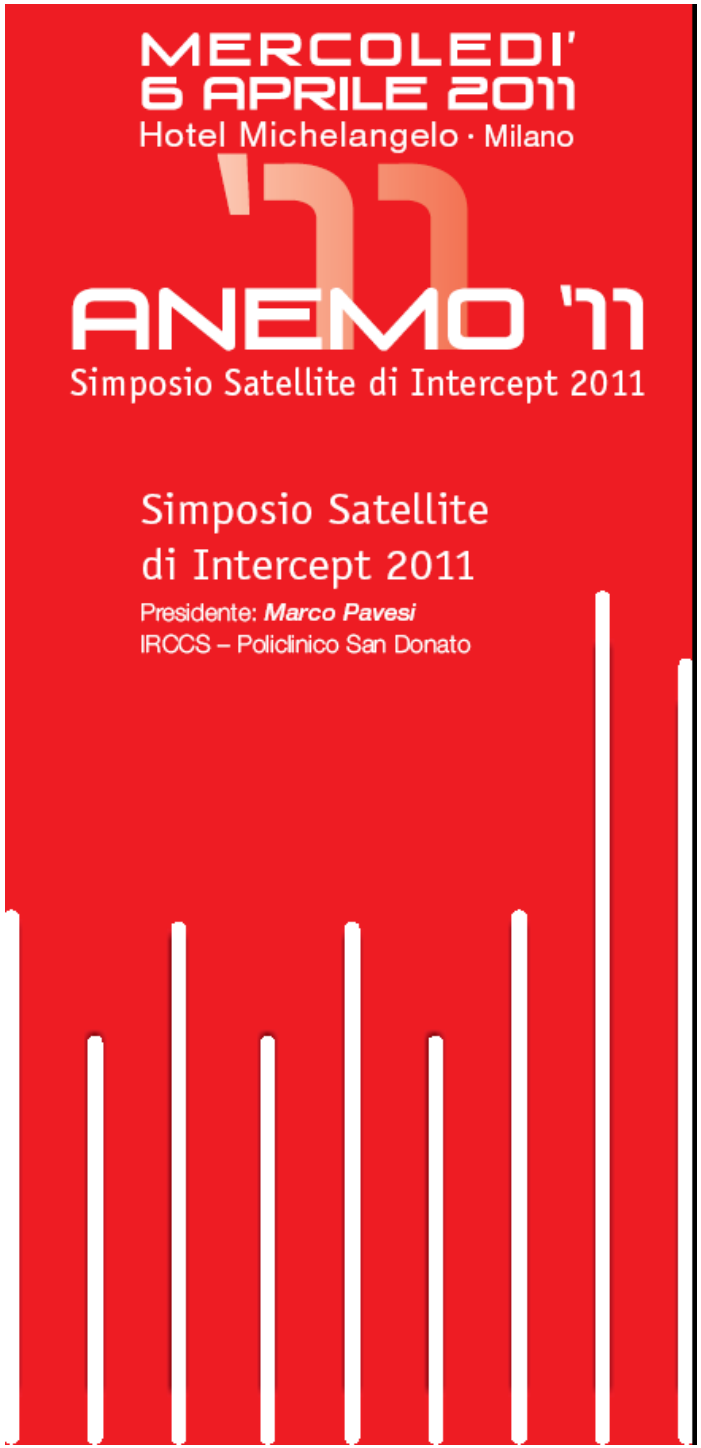


Fabbisogno trasfusionale: qual'è il programma più adeguato?

Giovanni Inghilleri,

Responsabile SIMT

A.O. Fatebenefratelli e Oftalmico

Milano, Italy

Predicting Blood Transfusion Requirements in Surgical Patients: Clinical Role

- To optimize blood inventory management;
- To make the best use of alternative strategies to allogeneic blood;

Strategies for allogeneic blood conservation

- Preoperative correction of anaemia
- Preoperative autologous blood donation
- rHuEPO stimulation of erythropoiesis
- Ultrasonic scalpel, argon beam coagulation
- Use procoagulant drugs
- Use of topical glues
- Acute normovolemic haemodilution
- Hypervolemic haemodilution
- Intra and post-operative blood salvage
- Use of blood substitutes

Maximum Surgical Blood Order Schedule (MSBOS)

- In the **1970s**, Friedman et al. proposed the use of **MSBOS** as a way to limit outdating risk.
- The MSBOS guidelines are widely accepted and **have been repeatedly shown to decrease unnecessary cross-matching and wastage**.
- MSBOS recommends that
  - *RBCs units should be cross-matched **only** for patients **undergoing surgery with a high likelihood** of blood transfusion*
  - *the n° of units x-matched should be **twice the median** requirement for that surgical procedure (cross-match-to-transfusion [C:T] ratio of 2:1).*

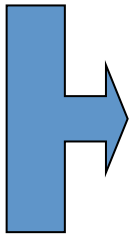
Maximum Surgical Blood Order Schedule (MSBOS)

- The MSBOS methods introduced the concept that prediction should based on specific hospital experience.
- It takes into account only “surgical variables” and specifically the type of surgery. Patient-correlated variable are not considered.
- **Main limit is the inability to accurately predict, for a given surgery, which patients are likely to receive a blood transfusion.**

How Well Can Transfusion Requirements Be Predicted?

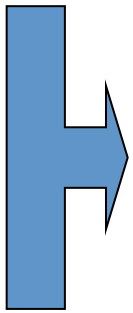
Parameters affecting transfusion requirements in surgical patients

1. **Surgical related parameters**
   1) Type of surgery
   2) Surgical technique
   3) ……



Amount of blood / RBCs lost in the perioperative period

2. **Patients related parameters**
   1. Hct, Hb concentration
   2. Body mass
   3. Clinical condition
   4. ……



Amount of blood / RBCs that the patient can loss before requiring Tx support.

How Well Can Transfusion Requirements Be Predicted?

Approaces to identify Pts at risk of requiring blood Tx / to define Pt's Tx requirements

1. Type of surgery (MSBOS) + some Pts related parameters
2. Score systems
3. Mathematical approaches

Type of surgery (MSBOS) + some Pts related parameters

- Much of the **variability in transfusion need** for a given surgery **lies with patient variables** and not with surgical variables.
- When performed by an experienced surgeon, a given type of surgery will result in similar blood loss for most patients, despite significant differences in patient blood volume or starting hematocrit.

Palmer T, Anesth Analg 2003;96:369 –75

Transfusion Medicine, 2007, **17**, 37–43

Blood transfusion requirement prediction in patients undergoing primary total hip and knee arthroplasty

S. Guerin,* C. Collins,* H. Kapoor,*† I. McClean† & D. Collins* **Department of Orthopaedic Surgery, St Mary's Orthopaedic Hospital, Cork, Ireland, and †Department of Orthopaedic Surgery, Dumfries and Galloway Royal Infirmary, Scotland, UK*

- Aim of the study:
  to analyse the **clinical factors** that would be **useful in predicting** patients who would **require blood transfusion.**
- Evaluated parameters were:
  age, **gender**, **body weight**, **operation**, **pre-op Hb**, **actual blood loss**, **postop Hb level**, whether a patient developed symptoms of anaemia (e.g. shortness of breath, dizziness or weakness), whether transfusion was administered and, if so, the number of units transfused.
- There were no autologous donations.

Transfusion Medicine, 2007, **17**, 37–43

Blood transfusion requirement prediction in patients undergoing primary total hip and knee arthroplasty

S. Guerin,* C. Collins,* H. Kapoor,*† I. McClean† & D. Collins* **Department of Orthopaedic Surgery, St Mary's Orthopaedic Hospital, Cork, Ireland, and †Department of Orthopaedic Surgery, Dumfries and Galloway Royal Infirmary, Scotland, UK*

- The **univariate analysis** revealed a significant relationship between postoperative blood Tx and **pre-op Hb levels** (P=0.001), **weight** (P= 0.019) and **age** (P=0.018) and not gender (P=0.47).
- However, **multivariate analysis** identified a significant relationship **only** between the need for transfusion and the **pre-op Hb (P=0.0001)** with weight (P=0.169) and age (P=0.058) being discounted as significant factors.

Preoperative Hemoglobin Levels and the Need for Transfusion After Prosthetic Hip and Knee Surgery

Analysis of Predictive Factors

By Jose A. Salido, MD, Luis A. Marín, MD, Luis A. Gómez, MD, Pedro Zorrilla, MD, and Cristóbal Martínez, MD

The Journal of Bone & Joint Surgery · jbjs.org
Volume 84-A · Number 2 · February 2002

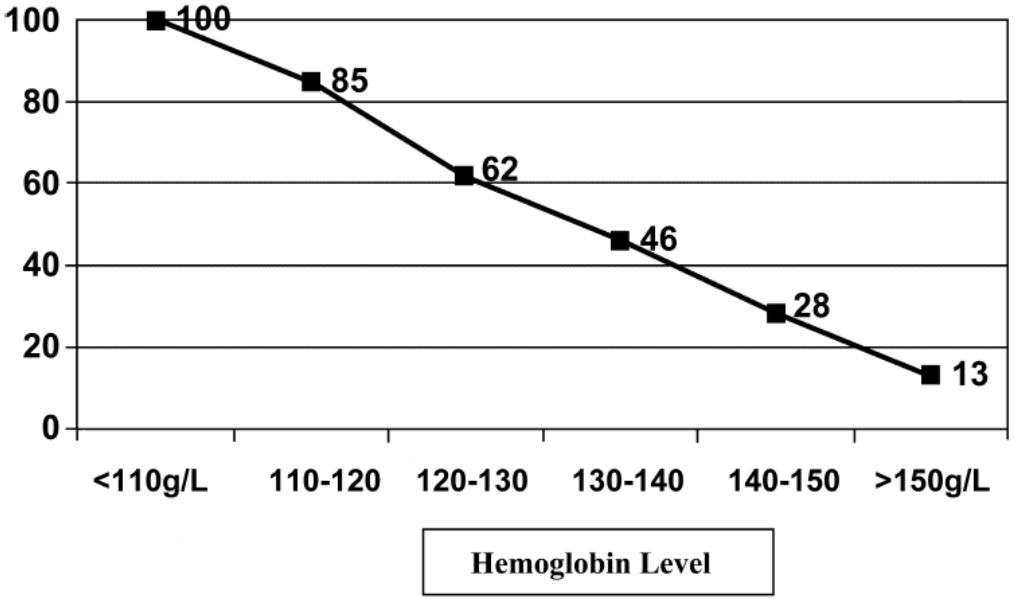


Fig. 2

Univariate analysis

relationship between Tx and

- **Preop Hb** (p = 0.0001)
- **Duration of surgery** (p= 0.0001)
- **Weight** (p= 0.002),
- **Height** (p = 0.019),
- **Gender** (p=0.0056).

Multivariate analysis

relationship only between TX and

- **Preop Hb** (p = 0.0001)
- **Weight** (p = 0.011);

% Pts transfused

- **Hb < 13 g = 69%**
- **Hb 13-15g = 36%**
- **Hb > 15 g = 13%**

Type of surgery (MSBOS) + some Pts related parameters Cardiac Surgery

Besides preop Hb a number of clinical and surgical parameters significantly correlate withTR (Shehata N *et al Vox Sang* 2007).

Magovern *et al. (Ann Thorac Surg* 1996) in 2000 CABG:
emergency operation, cardiogenic shock, **urgent operation**, catheterization-induced coronary occlusion, low left ventricular function, **low RBC mass**, **low body mass index**, age > 74 years, female sex, peripheral vascular disease, renal dysfunction, redo operation, diabetes and low serum albumin.

Parr *et al.*, *J Cardiothorac Vasc Anesth* 2003 in CABG pts:
increased age, **preop. creatinine**, **low body surface and preop Hct**, **operative emergency**, the lowest T°on CPB and the duration of CPB.
No association for gender and prolongation of coagulation tests.

Moskowitz *et al.*, *Ann Thorac Surg* 2004 in 307 CABG pts
Preop creatinine, type and the complexity of the operation (n° of vessels) and the **urgency of surgery**. Moreover, the authors identified a **diminished RBC mass** as one of the strongest predictors of transfusion

A Restrictive Use of Both Autologous Donation and Recombinant Human Erythropoietin Is an Efficient Policy for Primary Total Hip or Knee Arthroplasty

ANESTH ANALG
2004;99:262–71

Claude Couvret, MD*, Marc Laffon, MD*, Annick Baud, MD*, Valérie Payen, MD*,
Philippe Burdin, MD†, and Jacques Fusciardi*

Prospective observational study in consecutive patients undergoing primary THA or TKA.

Transfusion Policy:

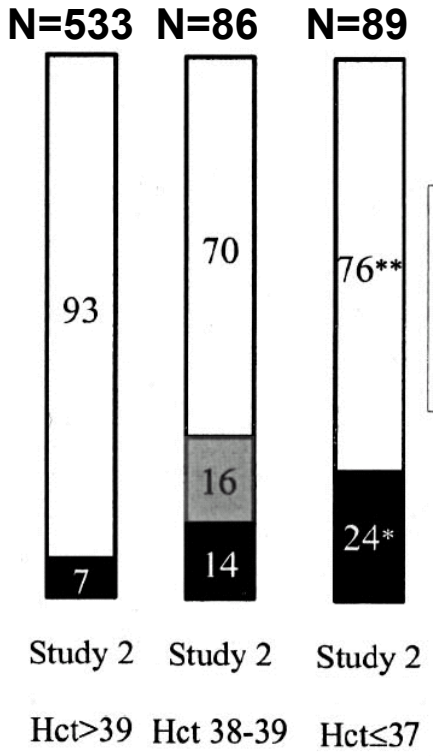
Pts with Hct > 39%: No PABD or EPO

Pts with Hct 37 – 39%: PABD 2 units

Pts with Hct < 37%: EPO

Results

In the group with Hct > 39% (**533 out 708 pts**) **only 7% received** allogeneic transfusion



Predictors of Transfusion Requirements for Cardiac Surgical Procedures at a Blood Conservation Center

David M. Moskowitz, MD, James J. Klein, MD, Aryeh Shander, MD, Katherine M. Cousineau, CCP, Richard S. Goldweit, MD, Carol Bodian, DrPH, Seth I. Perelman, MD, Hyun Kang, MD, Daniel A. Fink, MD, Howard C. Rothman, MD, and M. Arisan Ergin, MD, PhD

Ann Thorac Surg 2004;77:626 –34

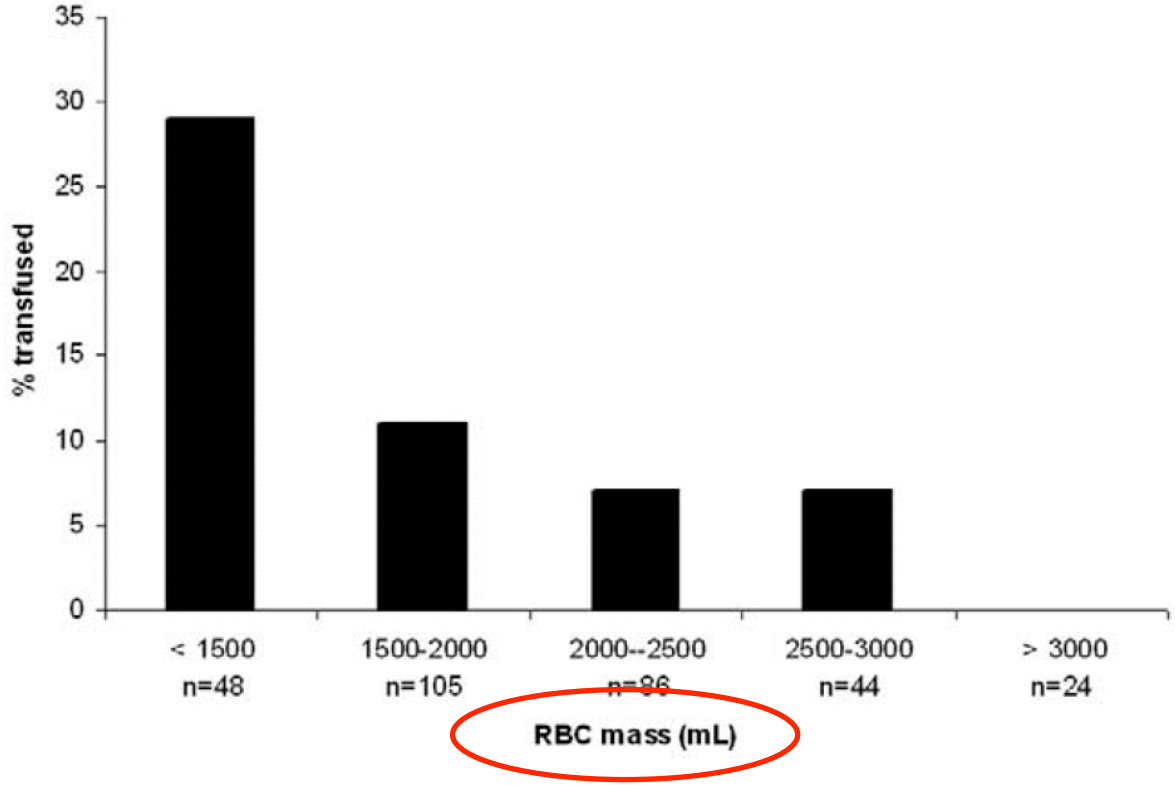


Fig 3. Red blood cell (RBC) mass versus transfusion rate.

How Well Can Transfusion Requirements Be Predicted?

Estimation of Tx requirement based on type of surgery and single patient correlated variable

- Simple;
- Criteria defined in each centre;
- Most relevant parameters Hb and RBCs mass;
- Effective in identifying Pts not requiring Tx support;
- Not effective to define Tx requirements (n° of units transfused).

Original article

A risk score for predicting perioperative blood transfusion in liver surgery

C. Pulitanò[1], M. Arru[1], L. Bellio[2], S. Rossini[2], G. Ferla[1] and L. Aldrighetti[1]

[1]Department of Surgery – Liver Unit and [2]Transfusion Medicine Service, Scientific Institute San Raffaele, Vita-Salute San Raffaele University, Milan, Italy

Methods: Data from 480 Pts who underwent hepatic resection were analysed. The data set was split randomly into a derivation set of two-thirds and a validation set of one-third. Univariable analysis was carried out to determine the association between clinico- pathological factors and blood transfusion. Significant variables were entered into a multiple logistic regression model, and a transfusion risk score (TRS) was developed. The accuracy of the system was validated by calculating the area under the receiver–operator characteristic (ROC) curve.

Table 3 Multivariable analysis of predictive factors for perioperative blood transfusion

	Odds ratio	*P**
Haemoglobin ≤ 12·5 g/dl	3·50 (2·21, 6·72)	0·001
Exposure of vena cava	3·10 (1·32, 7·13)	0·004
Cirrhosis	3·20 (1·62, 7·00)	0·010
Associated surgical procedures	3·10 (2·95, 7·01)	0·020
Largest tumour > 4 cm	3·39 (1·67, 7·23)	0·012

Univariable predictors of blood transfusion	
Parameter	P value
Male sex	0,189
Age >65 years	0,351
Associated co-morbidities	0,183
Cardiopulmonary disease	0,784
Diabetes	0,891
Cirrhosis	**0,085**
Weight >70 kg	0,586
Pathology	0,035
Neoadjuvant chemotherapy	0,309
Largest tumour >4 cm	**<0.001**
Previous liver resection	0,353
Exposure of vena cava	**<0,001**
Non-anatomical resection	0,936
Bilobar distribution of tumours	0,355
Multiple resections	0,332
Extent of liver resection	0,001
Associated procedures	**<0,001**
ASA score >2	0,414
Haemoglobin <12 • 5 g/dl	**<0,001**
Platelet count <250 × 109/l	0,390
PT-INR >1	0,008
Albumin <40 g/dl 39 (	0,001
ALT >60 units/l 30	0,339
Total bilirubin >1,2 mg/dl	0,389
GGT >70 units/l	0,008

Original article

A risk score for predicting perioperative blood transfusion in liver surgery

C. Pulitanò[1], M. Arru[1], L. Bellio[2], S. Rossini[2], G. Ferla[1] and L. Aldrighetti[1]

[1]Department of Surgery – Liver Unit and [2]Transfusion Medicine Service, Scientific Institute San Raffaele, Vita-Salute San Raffaele University, Milan, Italy

Table 4 Frequency of blood transfusion by transfusion risk score

	Derivation set ($n = 320$)			Internal validation set ($n = 160$)		
TRS	No. of patients*	No. of patients transfused*	Blood transfused per patient (units)†	No. of patients*	No. of patients transfused*	Blood transfused per patient (units)†
0	61 (19·1)	2 (3)	0 (0–2)	32 (20·0)	1 (3)	0 (0–2)
1	88 (27·5)	4 (5)	0 (0–2)	48 (30·0)	2 (4)	0 (0–2)
2	108 (33·8)	45 (41·6)	1 (0–4)	54 (33·8)	28 (52)	1 (0–6)
3	35 (10·9)	30 (86)	2 (0–8)	17 (10·6)	12 (75)	2 (0–10)
4	19 (5·9)	18 (95)	3 (0–12)	6 (3·8)	5 (83)	3 (0–16)
5	9 (2·8)	9 (100)	4 (4–32)	3 (1·9)	3 (100)	4 (4–10)

Table 5 Amount of blood transfused in 150 patients with a transfusion risk score of 2 or more

TRS	No. of patients transfused	Blood transfused per patient (units)*
2	73	2 (1–6)
3	42	2 (2–10)
4	23	3 (2–16)
5	12	4 (4–32)

*Values are median (range); no. of units transfused applies to only those patients who had a transfusion TRS, transfusion risk score.

Calculated area under the curve was 0,89 indicating good discrimination.

N° of units of blood transfused correlated significantly with the TRS.

Predicting Allogeneic Blood Transfusion Use in Total Joint Arthroplasty

Anesth Analg 2004; 99: 1239-44

Saifudin Rashiq, MB, MSc, FRCPC, Meera Shah, Ava K. Chow, MSc,
Paul J. O'Connor, MB, FFARCSI, and Barry A. Finegan, MB, FRCPC
Department of Anesthesiology and Pain Medicine, University of Alberta, Edmonton, Alberta, Canada

Methods

- **Univariate analysis** performed to look for associations between allogeneic Tx and each of the predictor variables.
- Predictor variables (known before surgery) showing a significant relationship (P 0.05) were considered for inclusion in the **regression modelling process**.
- The **odds ratio for Tx for each predictor variable** was multiplied to yield an arithmetically convenient integer, and these new covariates were used to create a scoring system.
- The scores were categorized into 4 groups (transfusion risk of 10% or less, 10%– 30%, 30% –50%, and 50%).

Predicting Allogeneic Blood Transfusion Use in Total Joint Arthroplasty

Anesth Analg 2004; 99: 1239-44

Table 4. Clinical Prediction Rule for Allogeneic Transfusion in Total Joint Arthroplasty

Variable	Value	Score
Age (yr)	<65	0
	65–79	20
	80+	30
Sex	Male	0
	Female	20
Weight (kg)	≤60	65
	61–70	40
	71–80	25
	81–90	20
	>90	0
Hemoglobin (g/dL)	≤120	140
	121–130	95
	131–140	40
	141–150	35
	>150	0
ASA Classification	I or II	0
	III or greater	15
Revision surgery?	No	0
	Yes	25

Scores for each variable are added together.

The predicted risk of allogenic Tx based on total scores is as follows:

- **score of 0–100, 10% or less;**
- **score of 100 –150, 10% – 30%;**
- **score of 150 – 200, 30%–50%;**
- **score more than 200, 50%.**

Validation Set (**934 patients**)		
Score	% Pts in this group	% of Pts transfused
0-100	46	13
100-150	31	33
150-200	14	44
> 200	9	64

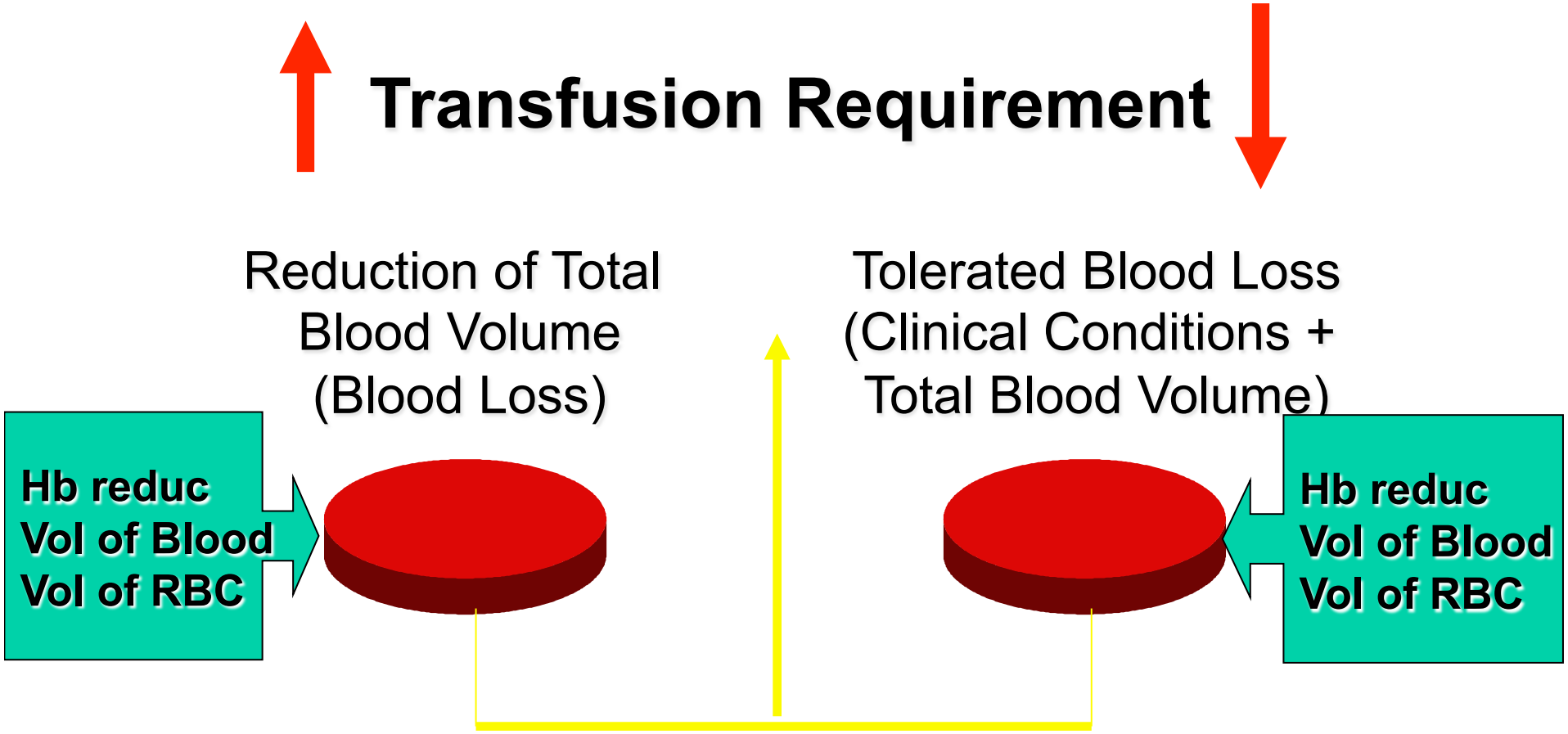
How Well Can Transfusion Requirements Be Predicted?

Estimation of Tx requirement based on Scoring Systems

- Simple but require knowledge in statistics;
- Parameters and their weight must be defined in each centre;
- Effective in defining the probability for a Pts to requiring Tx support;
- Not effective to define Tx requirements (n° of units transfused).

Mathematical approaches to Tx requirement prediction

Define transfusion requirements taking into account measured value of the parameters that determine TR



A prospettive randomized trial of the **surgical blood order equation** for ordering red cells for total arthroplasty patients.

Nuttall GA, Santrach WC Ereth MH et al. Transfusion 1998; 38: 828-33

- SBOE used to calculate the n° of RBCs units to order, as follows:

  Hb lost – (pre Hb – Min Hb) = Units to order

- Hb lost for THR previously measured: **3.7±1.7**
- The SBOE system
  - **Exactly matched** n° of units ordered with transfused in **58%;**
  - **Ordered more** RBCs units than transfused in **19%**
  - **Underordered** RBCs units in **23%**

Surgical blood order equation in femoral fracture surgery.

Kajja I, et al Transfusion Medicine 2011; 21: 7-12

- SBOE vs current order method in a case-control study in homgeneous group of pts (n=62 each)
- SBOE used to calculate the n° of RBCs units to order, as follows:

  Hb lost – (pre Hb – Min Hb) = Units to order
- Hb lost for FF previously measured: **3.3±1.56**

Table 2. Correct prediction of blood use

	Correctly predicted blood use		
	Yes	No	
Cases (SBOE)	TP = 46	FN = 16	62
Controls (unaided orders)	FP = 27	TN = 35	62
Total	73	51	124

- Overall accuracy:
  SBOE= 65,3%; Unaided ordering= 34,7%

Mercuriali F, Inghilleri G. Proposal of an algorithm to help the choice of the best transfusion strategy.
Curr Med Res Opin 1996;13:465-78

Transfusion need =
predicted RBC loss - tolerated RBC loss

RBCs loss = **Circulating RBC mass reduction** (from presurgery to postoperative day 5) **plus the volume of RBC transfused**

$= PBV \times (Hct_{preop} - Hct_{day\ 5\ postop}) + mL\ RBC_{transfused}$

Tolerated RBC loss =**Volume of RBC loss to reach an accepted minimal Hct value** (according to clinical condition)

$= PBV \times (Hct_{baseline} - Hct_{min\ acceptable})$

Mercuriali F, Inghilleri G. Proposal of an algorithm to help the choice of the best transfusion strategy.
Curr Med Res Opin 1996;13:465-78

Total Estimated RBC Loss

$cRBCsV_{presurgery} - cRBCsV_{day\ 5\ postop} + mL\ RBC_{transfused}$

Where

cRBCsV = PBV x Hct

PBV (predicted blood volume) =

Female = 0.3561 x height $(m)^3$ + 0.03308 x weight (kg) + 0.1833

Male= 0.3669 x height $(m)^3$ + 0.03219 x weight (kg) + 0.6041

mL RBC transfused = mL PAD RBC Tx + No of allogeneic units Tx x 200 mL + mL of salvaged RBC

Mercuriali F, Inghilleri G. Proposal of an algorithm to help the choice of the best transfusion strategy.
Curr Med Res Opin 1996;13:465-78

Transfusion requirement expressed in mL of RBCs

- Difference between predicted and tolerated RBC loss
- **When a negative figure is obtained:**
  PABD or EPO not indicated (type and screen + stand by intraoperative salvage)
- **When a positive figure is obtained:**
  The figure represents the transfusion need expressed in mL of RBCs

A Restrictive Use of Both Autologous Donation and Recombinant Human Erythropoietin Is an Efficient Policy for Primary Total Hip or Knee Arthroplasty

Claude Couvret, MD*, Marc Laffon, MD*, Annick Baud, MD*, Valérie Payen, MD*, Philippe Burdin, MD†, and Jacques Fusciardi*

Study 1

- At the preoperative anesthesia evaluation the Pt's estimated RBC reserve was calculated and compared with estimated loss (using Mercuriali & Inghilleri formulas)
- The median RBC loss was previously estimated to be **538 mL for THA** (range, 100–1212 mL) and **693 mL for TKA** (range, 272–1535 mL).
- **PABD was indicated if RBC reserve was < 800 mL (THA) or < 1000 mL (TKA).**

N° of Pts evaluated = 182	
Pts with no expected Tx requirement	91
Pts with no expected Tx req. but Tx	17 (19%)
Autologous units collected	172
Auto units Tx	93
Auto units wasted	79 (45%)

“Metodo per la definizione preoperatoria del fabbisogno trasfusionale nel paziente chirurgico. Valutazione per un suo utilizzo nella selezione dei pazienti in cui adottare strategie alternative alla trasfusione di sangue allogenico”
PROGETTI PIANO SANGUE 2008 REGIONE LOMBARDIA

Obbiettivi

verificare l’efficacia del metodo proposto nel prevedere il fabbisogno trasfusionale di pz sottoposti ad intervento di chirurgia ortopedica maggiore e la sua idoneità ad essere utilizzato per selezionare i pz in cui è appropriato il ricorso tecniche alternative alla trasfusione di sangue;

Pazienti

906 Pz: PTA, PTG ed EndoPTA - Ist. Ortop.G. Pini (nov 07 - ott 08)

1° fase: Def perdite = **484** pz**; 2° fase** Valid. Mod. = **422** Pz

Ipotesi valutata

valore di perdita attesa = valore mediano per intervento e sesso

PTA : M = 850mL; F = 630mL . PTG M = 800 mL F = 670 mL

Hb minima accet: 9 g/dL x età < 80; 9,5 g/dL x età > 80 anni

“Metodo per la definizione preoperatoria del fabbisogno trasfusionale nel paziente chirurgico. Valutazione per un suo utilizzo nella selezione dei pazienti in cui adottare strategie alternative alla trasfusione di sangue allogenico”
PROGETTI PIANO SANGUE 2008 REGIONE LOMBARDIA

valore di perdita attesa = valore mediano per tipo intervento e sesso

PTA : M = 850mL; F = 630mL . PTG M = 800 mL F = 670 mL

		Fabbisogno trasfusionale previsto		
		NO (Fab Neg)	Si (Fab Pos)	Totale
Supporto Tx	NO o	28	45	73
	SI	3	128	131
	Totale	31	173	204

	Valore	95% CI	
Prevalenza supporto Tx	**64,2%**	57,2%	70,8%
Sensibilità	**97,7%**	93,5%	99,5%
Specificità	**38,4%**	27,2%	50,5%
Valore Predittivo Positivo	**74,0%**	66,8%	80,4%
Valore Predittivo Negativo	**90,3%**	74,2%	98,0%
Accuratezza	**76,47**		

Mathematical approaches to Tx requirement prediction

Critical points

- ✓ **Which value utilize as "predicted blood loss".**
  Originally Mercuriali & Inghilleri approach utilized the 80° percentile of distribution of the volume of RBCs lost, but the median or mean value is probably more appropriate.
- ✓ **Large database for defining RBCs loss statistics.**
  The impact of some clinical parameters (i.e. hypertension) on blood loss should ideally be evaluated by measurement of blood loss in affected patients
- ✓ **To have adequate IT support to collect data.**
- ✓ **Continuous updating of database and statistics**

Predicting Blood Transfusion Requirements in Surgical Patients

Conclusions

- ✓ Different strategies to predict transfusion requirement in surgical patients are currently available;
- ✓ The choice of the strategy to be used depend on the required precision and the intended use;
- ✓ Reliable predictions must be based on accurate analysis of the specific centre experience
- ✓ Collaboration between different specialists involved in the transfusion process is mandatory