

Re-introducing whole blood in routine  
practice: Experiences  
from air ambulance usage and  
implementation in the hospital  
transfusion package

Tor Hervig  
Haukeland UniversityHospital  
Bergen, Norway

# The return of whole blood?

- .....it is time for the blood banking community to consider that the currently products and our civilian-based hospital procedures do not suit the needs of all patients and join the quest”

Richard B. Weisskopf and Paul Ness, Editorial,  
Transfusion 2013

# Agenda

- Transfusion policies
- Whole blood?
- Whole blood experiences by Bergen Air Ambulance
- Concluding remarks

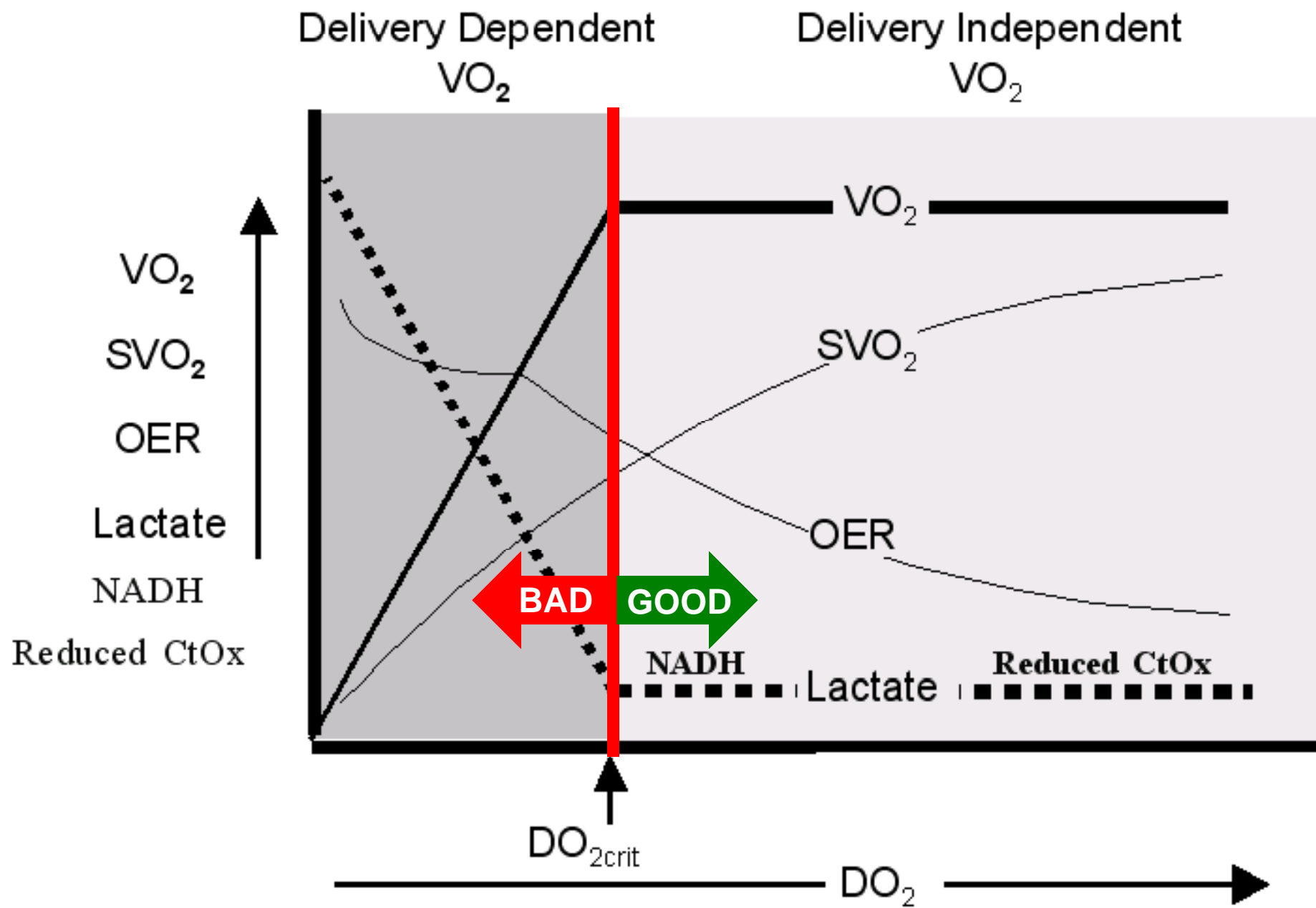


# Haukeland University Hospital

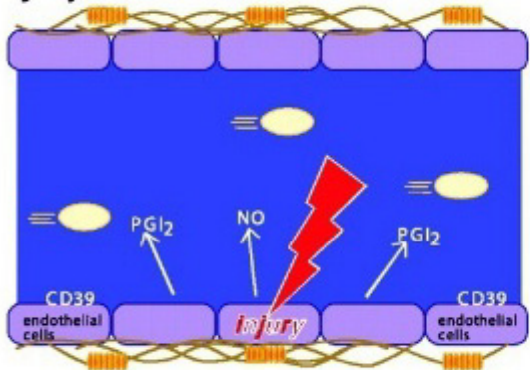


## «Guidelines» – transfusion in bleeding patients

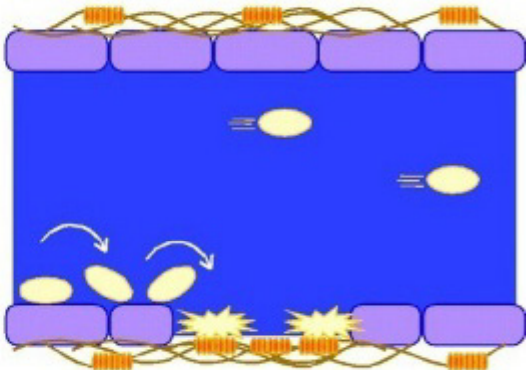
- Blood loss in % of EBV:
- < 40% crystalloids + colloids (albumin?)
- 40% - 90% + RBC
- >100% + plasma
- 1 plasma unit per 2-4 RBCs
- Platelet count <  $50 \times 10^9/l$ : + PC (if surgical bleeding control)



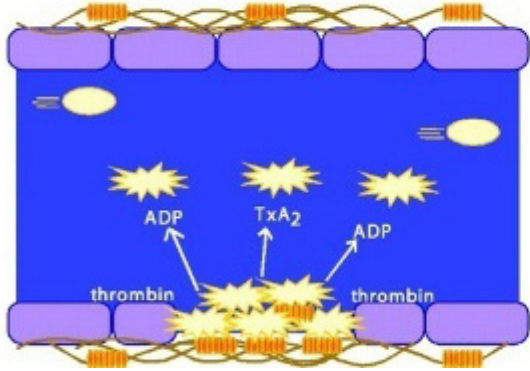
A. Injury



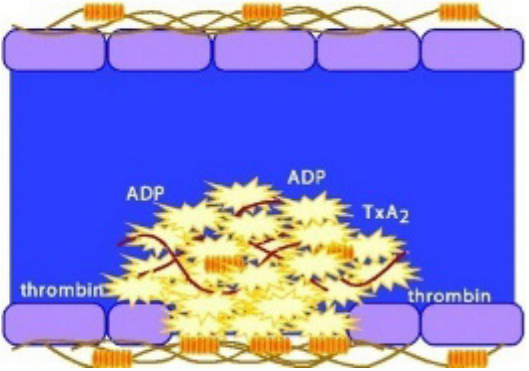
B. Initiation



C. Extension



D. Stabilization



Tissue Factor-Bearing Cell



VIIIa

IX

### 3. Propagation

IXa

X



IXa

VIIIa

Xa

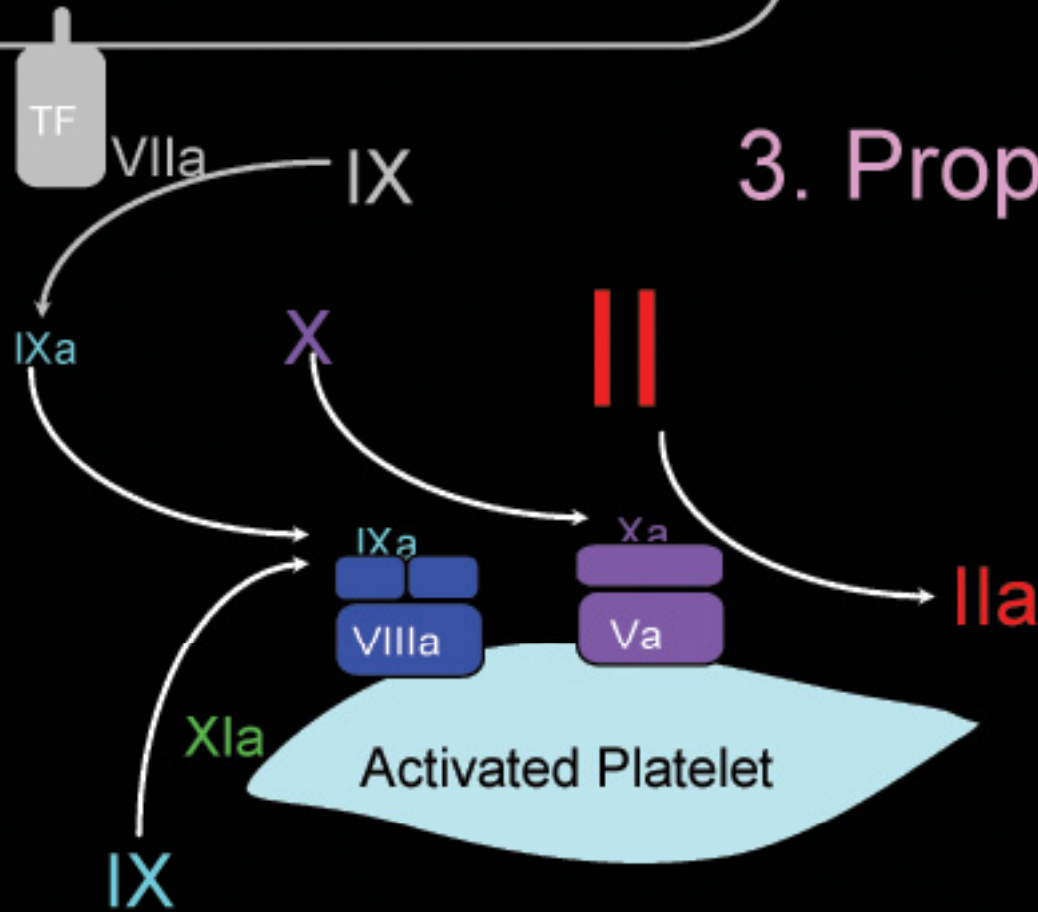
Va

IIa

XIa

Activated Platelet

IX

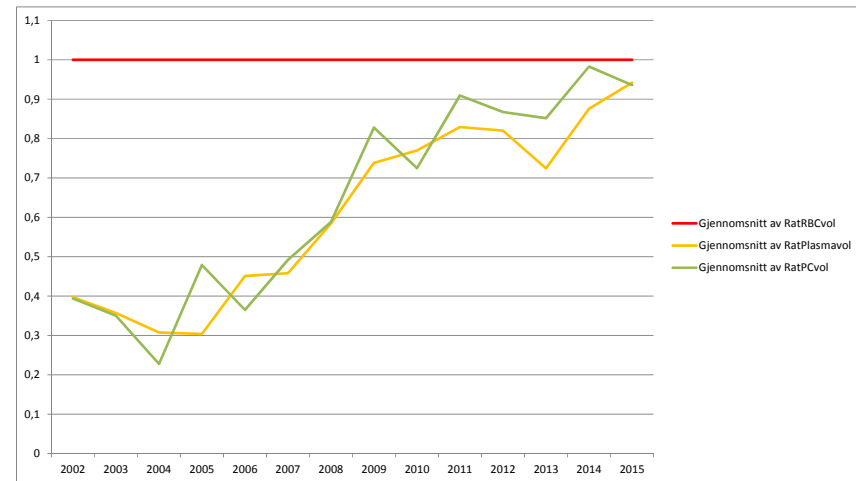
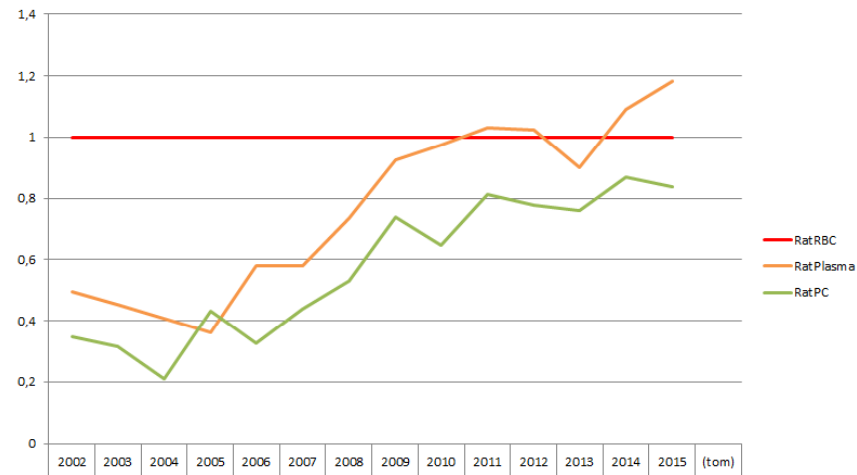


# 2007 – introducing transfusion package

- 6 red cell concentrates
- 6 Octaplas(ma)
- 2 platelet concentrates ( Pool from 4 buffy coats)

(Per Johansson, Copenhagen experience)

# Changing ratios



# Goal of transfusion therapy in massive bleedings

- Hemoglobin concentration 8-10g/dl
- Platelet concentration  $> 100 \times 10^9/L$
- Fibrinogen  $> 2 \text{ g/dl}$

# Volume and Concentrations Between Component Therapy vs Warm Whole Blood



## Component Therapy:

**1U PRBC + 1U PLT + 1U FFP + 1 U cryo**

**680 COLD mL**

- **Hct 29%**
- **Plt 80K**
- **Coag factors 65% of initial concentration**
- **1000 mg Fibrinogen**

## FWB:

**500 mL**

**Hct: 38-50%**

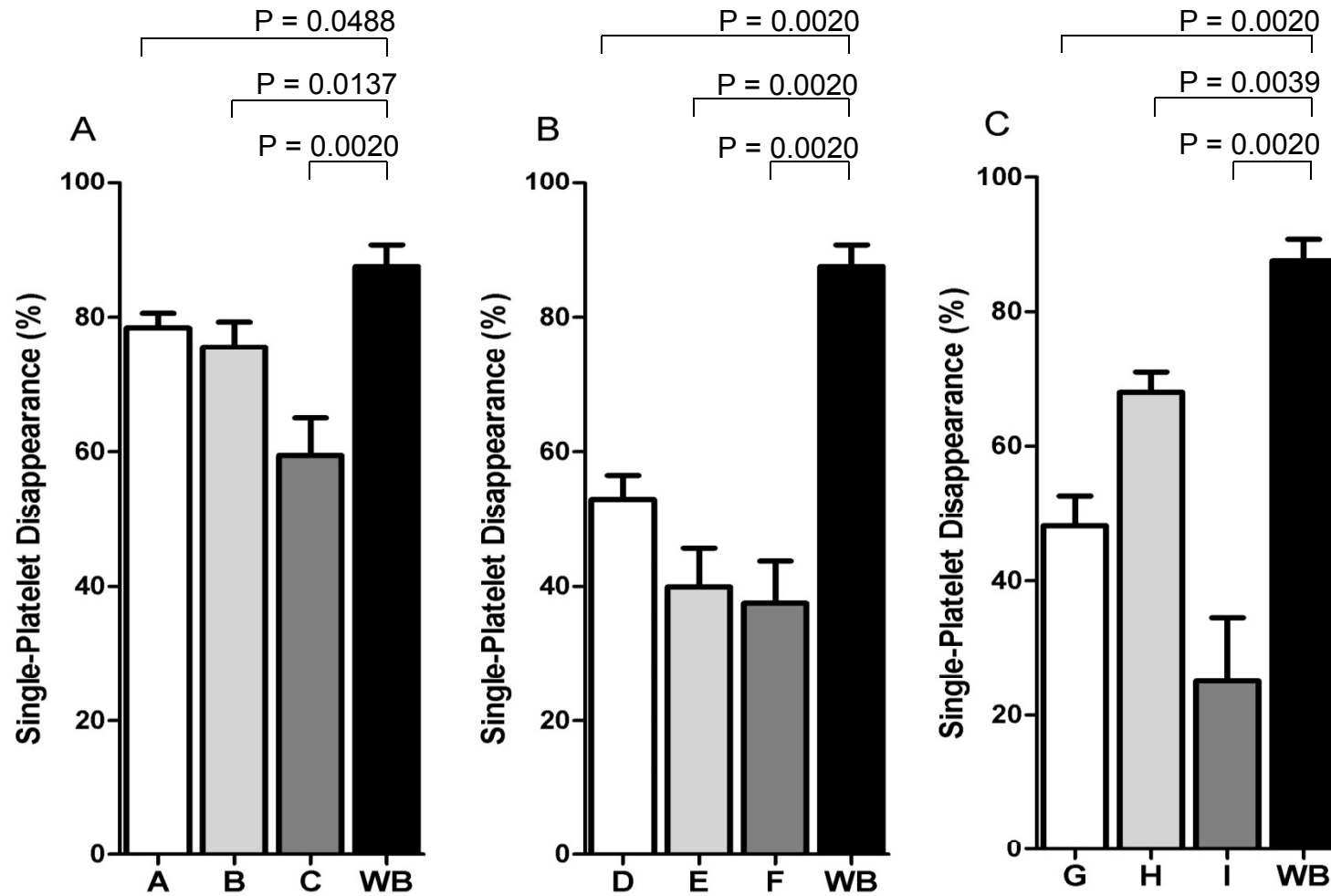
**Plt: 150-400K**

**Coag concentration 100%**

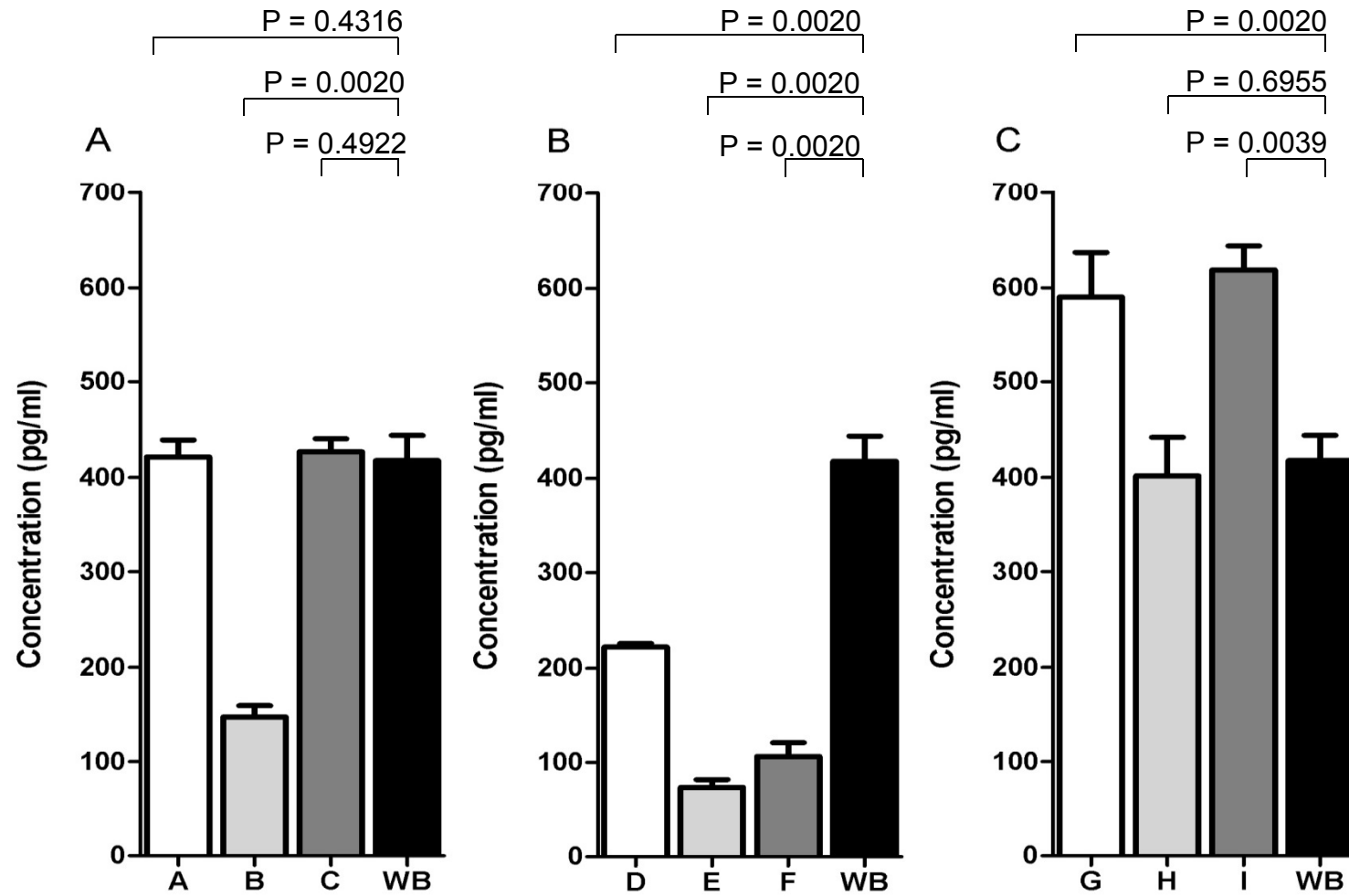
**1000 mg Fibrinogen**

- Armand & Hess, Transfusion Med. Rev., 2003

# Single platelet disappearance



# Thrombin-Antithrombin complex



# What happened?

Universal WB  
4°C stored



RBC



FFP



aPLT



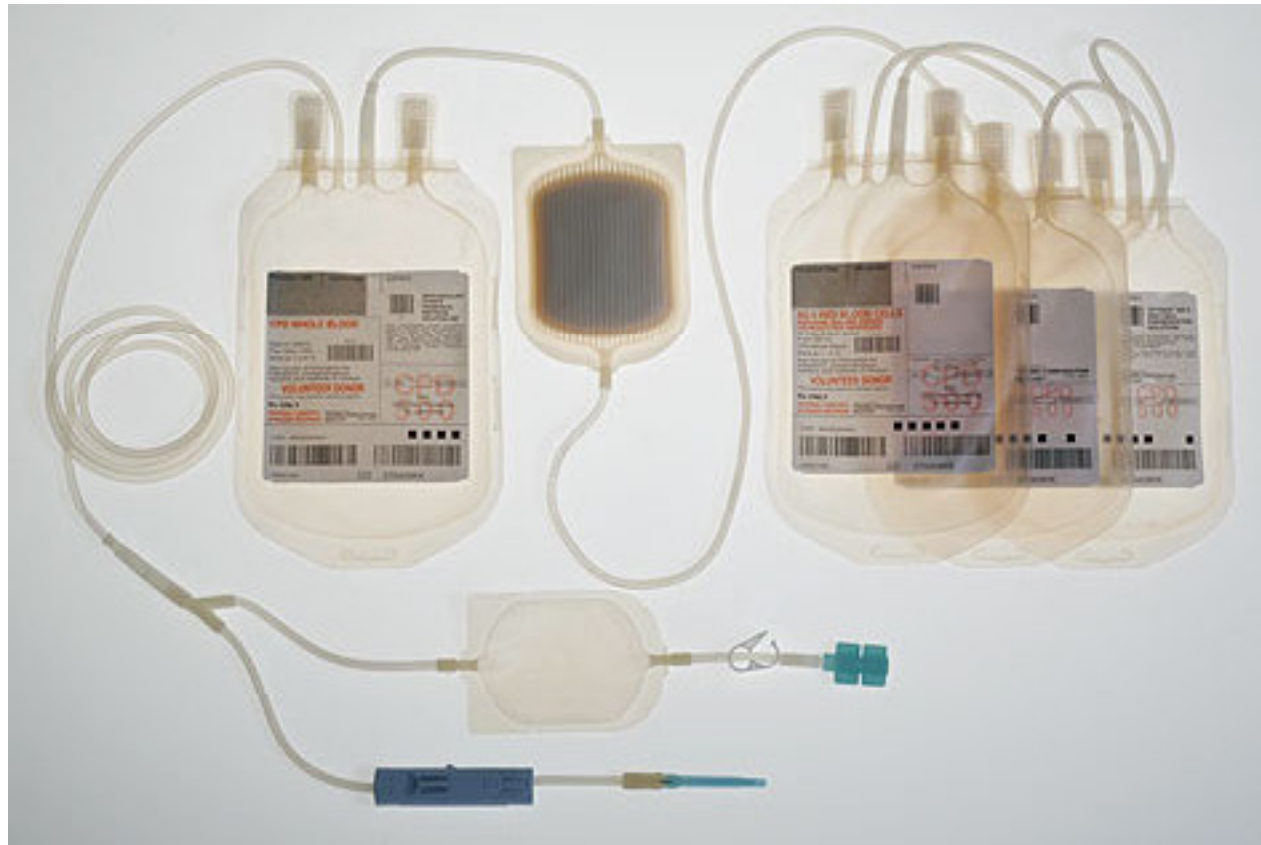
## Issues concerning whole blood

- What is whole blood?
- Leukocyte reduction
- Pathogen reduction
- If whole blood should be used, we then must be able to produce red cell concentrates from “not-used” whole blood
- Cold stored platelets for the bleeding patients needing platelet transfusion?
- Risk of hemolysis

# What is whole blood?

- Cold Fresh Whole Blood (storage time 48h)
- Cold Stored Whole Blood (storage time 35 days)
- Warm Fresh Whole Blood (storage time warm 8h, then cold 16h)
- Appropriate storage time?

# Leukocyte reduction sparing platelets



# Pathogen reduction: Primary Endpoint

*Platelet 24-hour Relative Recovery*

## Analysis

	Per Protocol Population		Modified BEST Population	
	Treated, Stored	Fresh, Control	Treated, Stored	Fresh, Control
N	14	14	13	13
mean (SD)	43.31 (9.32)	52.01 (11.76)	43.02 (9.64)	51.90 (12.23)
median	46.99	50.54	46.91	48.14
95% CI <sup>a</sup>	37.9, 48.7	45.2, 58.8	37.2, 48.9	44.5, 59.3
Lower one-sided 95% CI <sup>b,c</sup>	76.22		75.24	
Normality test P-value <sup>d</sup>	0.296		0.227	

Abbreviations: CI = confidence interval, N = count or number, SD = standard deviation.

<sup>a</sup> 95% CI of the mean based on the normality assumption for continuous variables.

<sup>b</sup> Relative Recovery = (Treatment recovery value (% recovery) divided by Control sample recovery) x 100.

<sup>c</sup> The lower one-sided 95% CI was generated from a 1-sample t test.

<sup>d</sup> Shapiro-Wilk test was used to test for normality.

# Primary Endpoint Analysis

## Platelet Survival Time



	Per Protocol Population		Modified BEST Population	
	Treated, Stored	Fresh, Control	Treated, Stored	Fresh, Control
N	14	14	13	13
mean (SD)	152.9 (28.6)	188.8 (23.5)	157.1 (24.8)	192.7 (19.0)
median	151.4	188.7	156.6	192.3
95% CI <sup>a</sup>	136.4, 169.4	175.2, 202.3	142.1, 172.1	181.2, 204.2
Lower one-sided 95% CI <sup>b,c</sup>	77.00		77.64	
Normality test P-value <sup>d</sup>	0.653		0.801	

Abbreviations: CI = confidence interval, N = count or number, SD = standard deviation.

<sup>a</sup> 95% CI of the mean based on the normality assumption for continuous variables.

<sup>b</sup> Relative Survival = Treatment survival time (hours) divided by Control sample survival time.

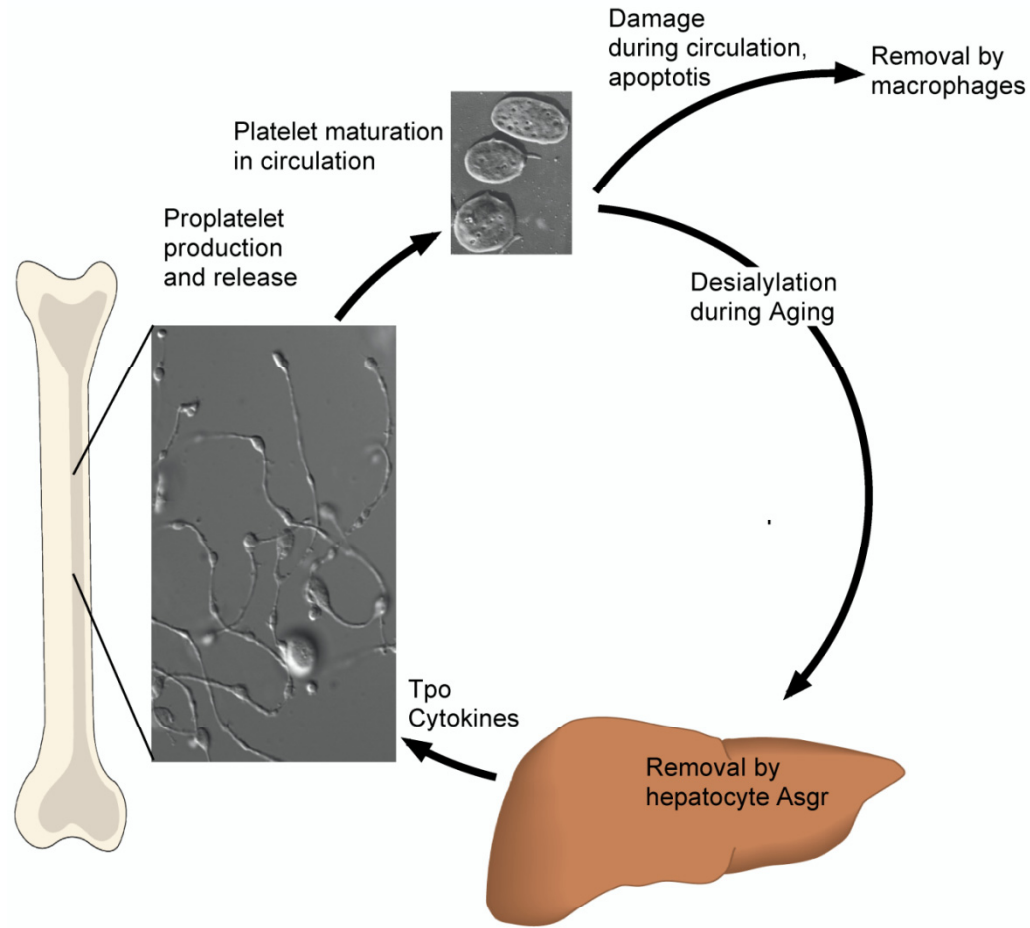
<sup>c</sup> The lower one-sided 95% CI was generated from a 1-sample t test.

<sup>d</sup> Shapiro-Wilk test was used to test for normality.

# Logistics: Quality of red cell concentrates during storage (data from unfiltered whole blood)

	Day 7	Day 14	Day 21	Day 28	Day 35	Day 42
Hb (g/dL)	20.3	20.5	20.5	20.9	20.4	20.2
Hemolysis (%)	0.09	0.16	0.20	0.21	0.28	0.30
Potassium (mmol/L)	1.2	12.4	18.8	27.4	31.4	38.7
Glucose (mmol/L)	28.2	23.4	20.8	18.3	16.1	14.3
Ph	6.86	6.68	6.55	6.47	6.42	6.37
pCO <sub>2</sub> (kPa)	8.8	5.8	7.3	9.3	19.9	
Base (mmol/L)	-19.7	-24.0	-27.3	-29.5	-30.3	-31.2
pO <sub>2</sub> (kPa)	5.9	10.4	11.0	9.2	8.6	7.4

# The platelet cold storage lesion



# COLD STORED APHERESIS PLATELETS FOR TREATMENT OF POSTOPERATIVE BLEEDING IN CARDIOTHORACIC SURGERY

Strandenes G, Kristoffersen EK, Bjerkvig CK, Fosse TK,  
Hervig T, Cap AP, Aden JK, Haaverstad R, Kvalheim V,  
Lunde THF, Braathen H, Sivertsen J, Apelseth TO

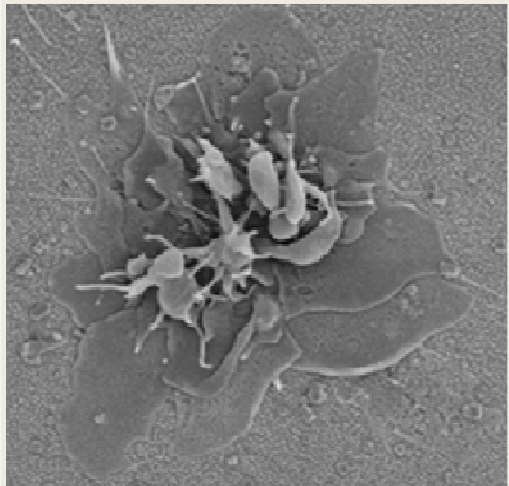
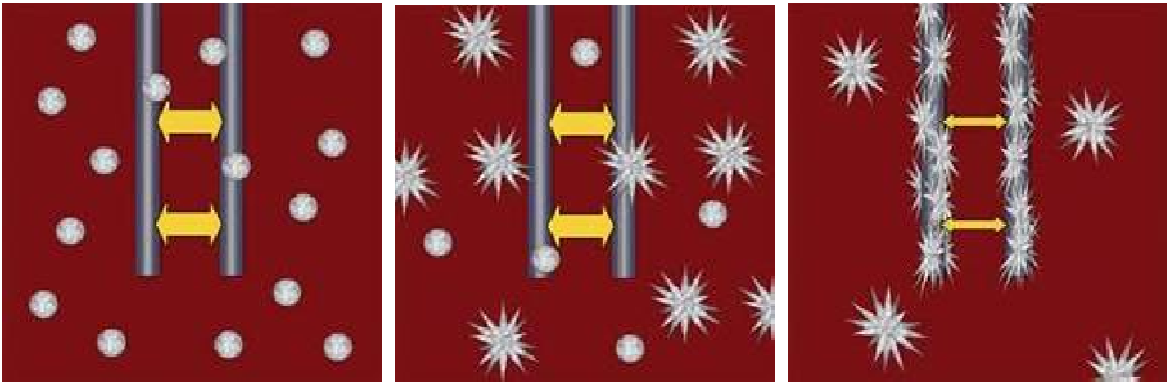
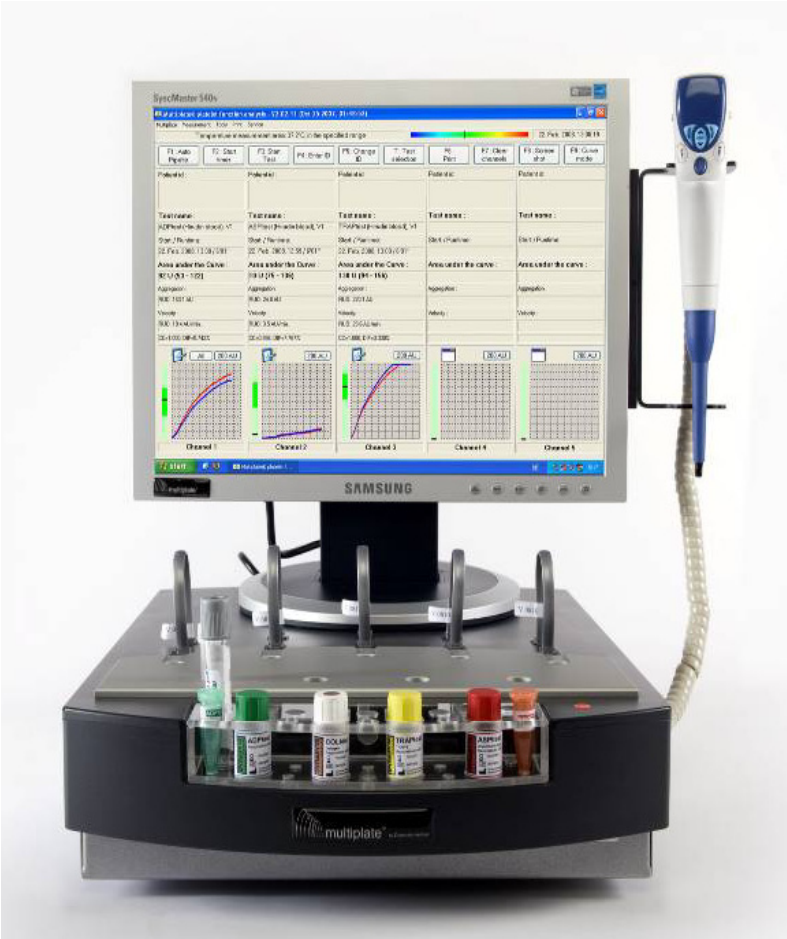
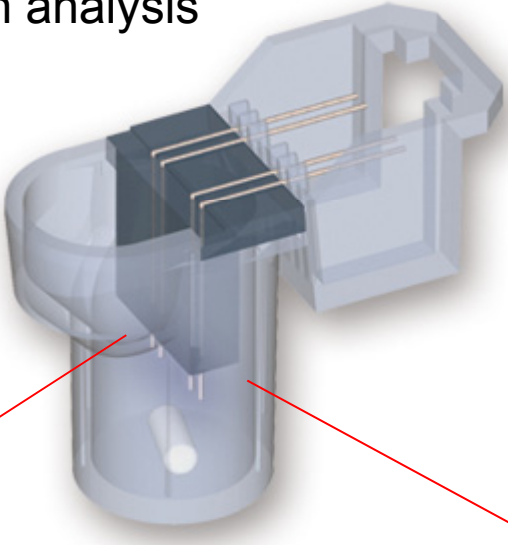
# Study population

- Study site: Haukeland University Hospital, Bergen, Norway
- Inclusion criteria:
  - i. Patients undergoing cardiothoracic surgery
  - ii. Expected extra corporal circulation (ECC) time > 120 minutes
  - iii. Dual platelet inhibition
- Patient enrollment:
  - Prior to surgery
- Sample size: 20+20 platelet transfused patients

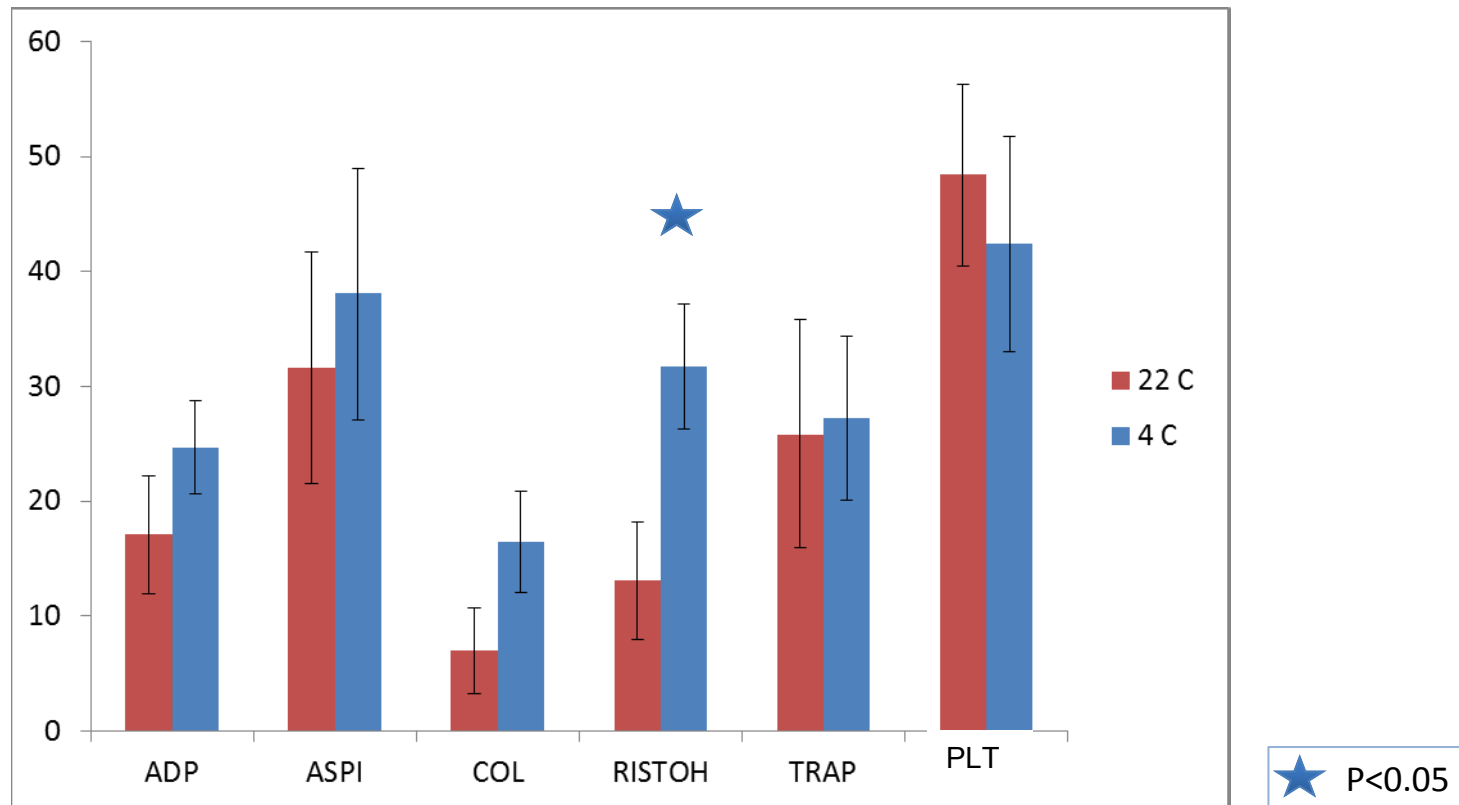


# ► Multiplate®

platelet function analysis  
in whole blood  
based on  
impedance  
aggregometry

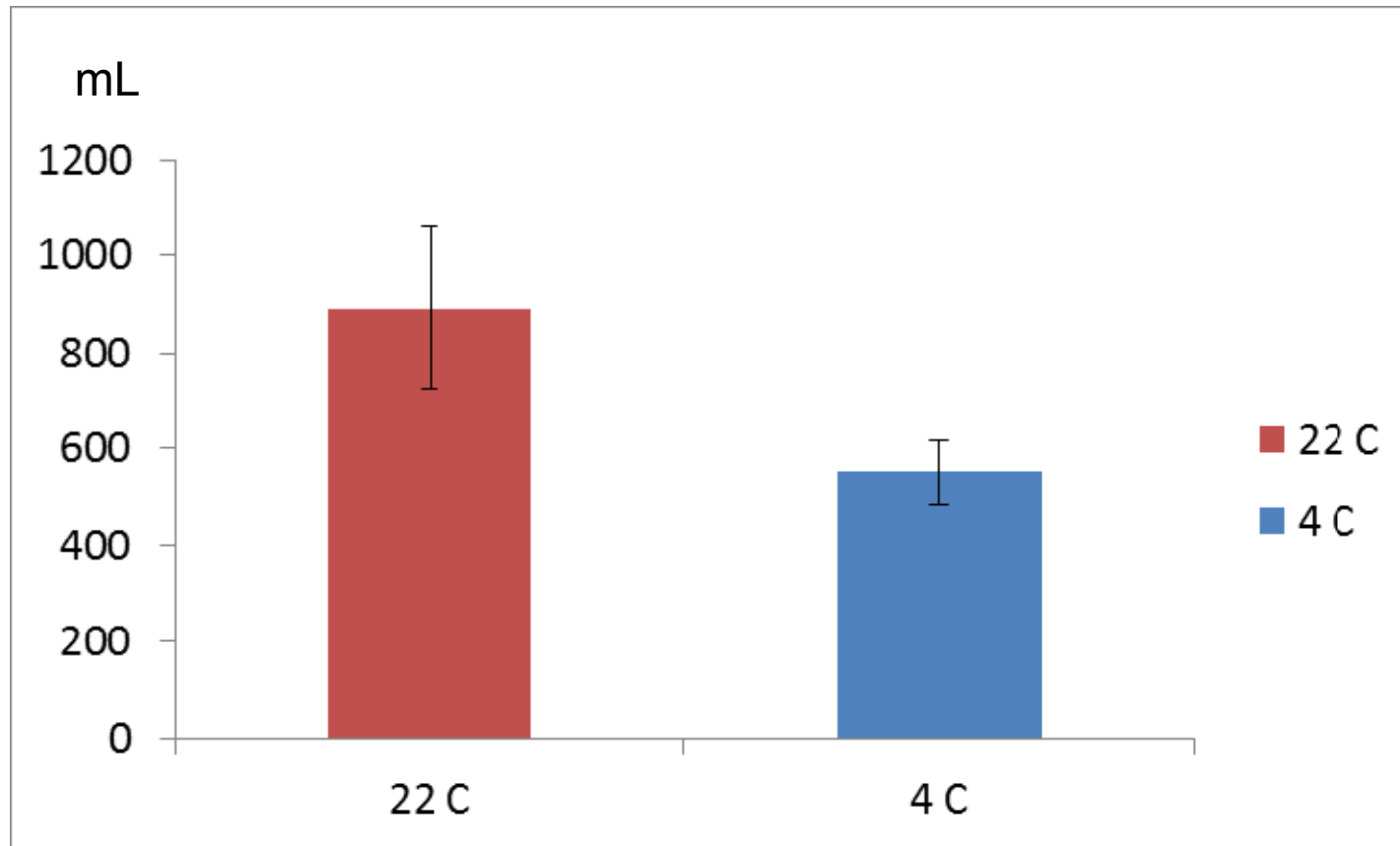


# increase in *In vitro* Platelet aggregation response and platelet count after platelet transfusion\*



\*Measured by impedance aggregometry (Multiplate™).  
Results include first transfusion episode.

# Blood loss measured by chest Tube output \*



\*Observation time: from chest closure until 8 am day 1 after surgery.

# Risk of hemolysis

- Korea
  - 400,000 low titer Group O whole blood transfusions with no severe hemolytic reactions when low titer defined as  $< 250$
- Vietnam
  - 230,300 whole blood transfusions, 1967-1969
    - 1 severe hemolytic transfusion reaction
    - High titer ( $> 256$ ) Group O whole blood used accidentally

# Bergen titer guidelines

Anti-A and anti-B

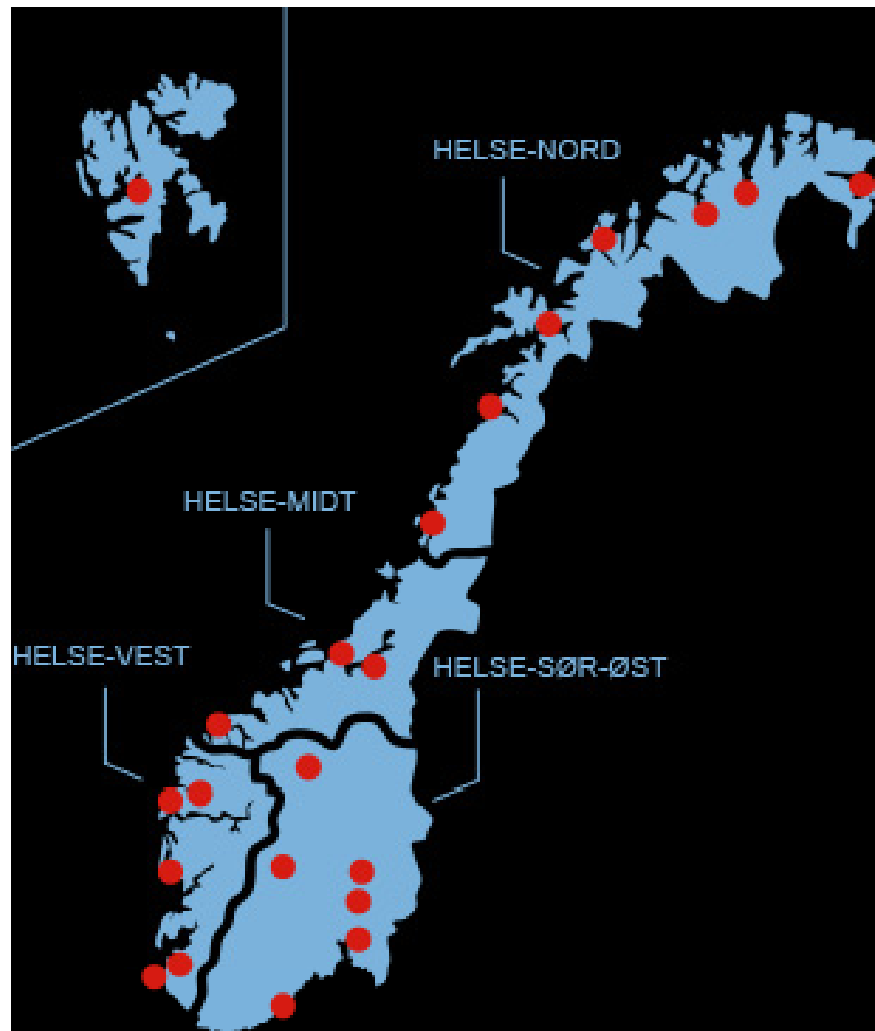
IgM < 100

IgG < 400

# Whole blood as of today, Bergen

- Occasional usage in hospital -> transfusion in acute package 2-6 months ahead
- 2 units delivered to military operations/14 days
- 2 units to Bergen Air Ambulance weekly

# Norwegian Air Ambulance



# Bergen Air Ambulance



# Blood components in Norwegian Air Ambulance

- Until 2012: In some emergencies
- 2012: SAG-red cells and LyoPlas introduced in Bergen
- 2015: Whole blood introduced in Bergen
- 2016: All air ambulances use red cell concentrates and Lyoplas
- 2017: Whole blood introduced in at least two more air ambulances

# Whole blood in the air ambulance

- 2 whole blood units in the helicopter
- Start 10.12.15

# Patient characteristics

- 11 “clean patients”
- 1 patient continued WB treatment in hospital
- 1 patient was treated with red cell concentrate + Lyoplas as WB was not available

# Age

- Mean 46 years
- Range 3-93 years

# Bleeding categories

- 4 penetrating traumas
- 6 blunt traumas
- 2 GI-bleedings
- 1 surgical bleeding

# Initial blood pressure

- Mean 93 mmHg
- Range: 0-200 mmHg

# Initial heart rate

- Mean: 82/min
- Range: 0-125/min

# Status at hospital admission

- 2 dead

Hemoglobin concentration

Mean: 13.1 g/dl

Range: 11.2-14.8 g/dl

# Mortality

3/11

# Final data

**Mortality**

3/11

**Whole blood consumption**

18 units in 12 patients

# Thanks to

- Geir Strandenes
- Geir Arne Sunde
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- Hanne Braathen
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