American Red Cross

# Pathogen Reduction-Benefits and Challenges

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Medical Director

Carolinas Region

# Re/-Emerging Infections Are On The Rise


American Red Cross

# Other Sources of Blood Product Contamination

- Tissue damage with injury to underlying blood vessel walls
- Insufficient performance/maintenance of skin disinfection to VP site
- Donor presenting with an asymptomatic infection (UTI, URI)
- Apheresis technology: Amicus vs Trima

**ARC study: Eder et.al. Transfusion. 2017;57:2969 – 2976.**
2007 – 2014, ~2 million collections
Apheresis platform: 69% Amicus, 31% Trima

Implicated donations with septic reactions
Amicus: 25 donations rate: 17.6/ 100,000 donations
Trima: 3 donations rate: 1.8/ 100,000 donations

# Contamination is ranked #3 for Transfusion Reaction Fatalities

2016 FDA reported 14 transfusion related fatalities

#1: TACO – transfusion associated circulatory overload

#2: TRALI – transfusion related acute lung injury

#3: Contamination (bacteria, parasites, viruses)

# Most Common Type of Infectious Disease Contaminant in Blood Units: Bacteria

Most common blood product to be contaminated: PLATELETS

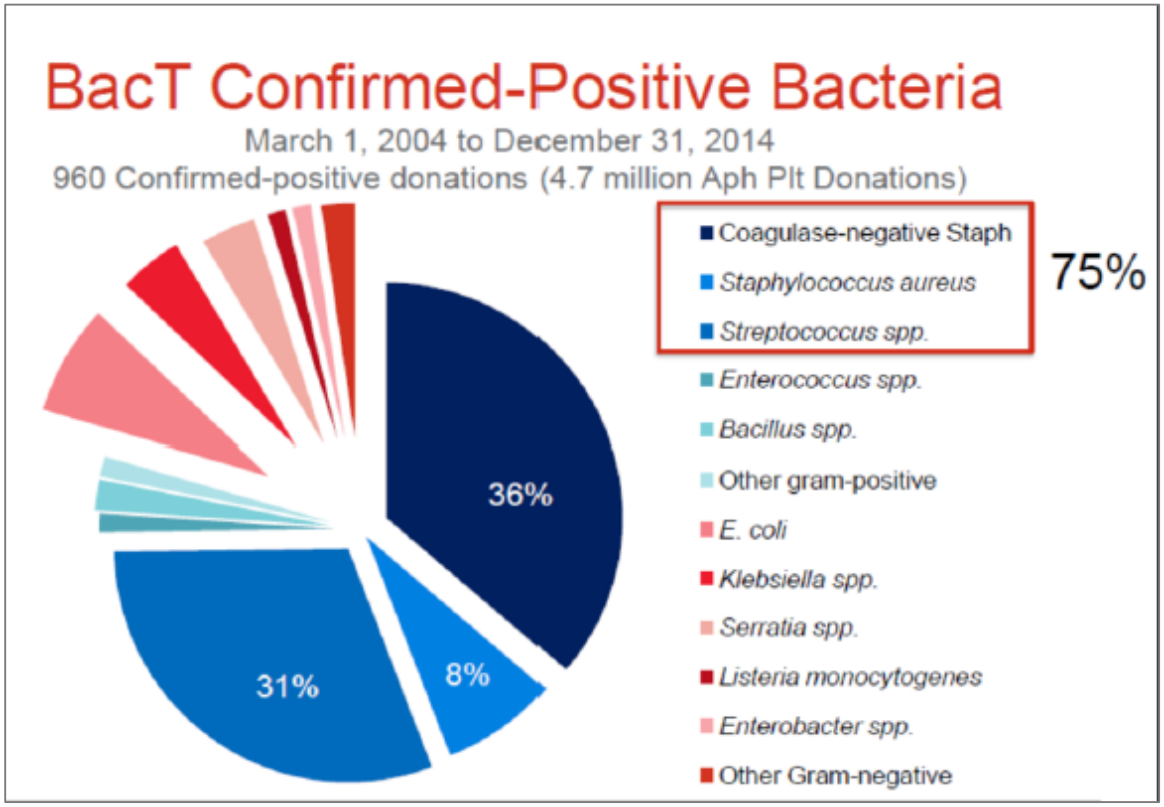
| Platelets | Incidence Rate |
|---|---|
| Contaminated | 1:1,000 |
| Experience Sepsis | 1:100,000 |
| Fatal Sepsis | 1:500,000 |

Due to overlying disease or delay in symptoms by >24 hours,
the actual number of septic transfusion reactions may be as 10x higher



Hong H et.al. Transfusion Medicine. 2016;127:496-502. Ramirez-Arcos S, et.al. Transfusion. 2017;57:2174 -2181.

# BacT Confirmed-Positive Bacteremia




75%

**Septic Reactions**

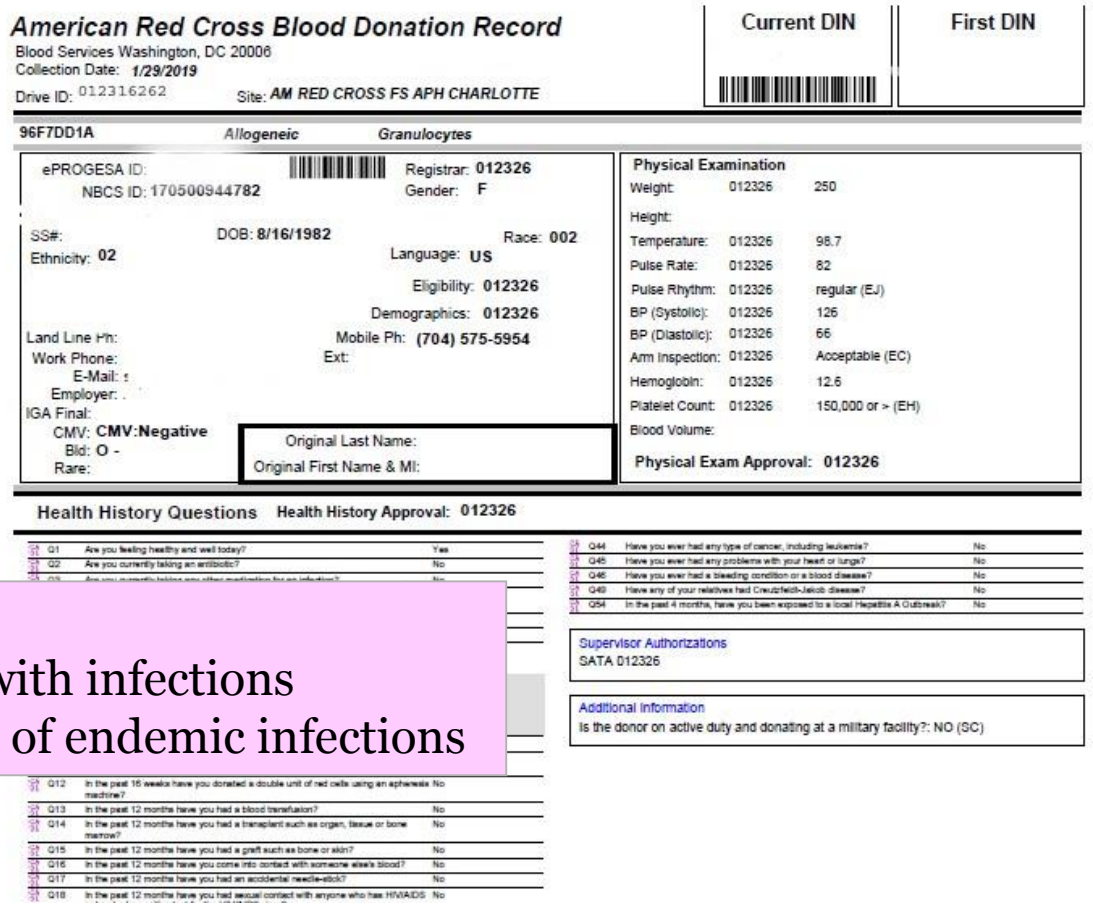
71% cases - same top three microorganisms identified

Data presented by Dr. Ross Herron, Medical Advisory Council Meeting, 5/22/2018



Eder et.al. Transfusion. 2014;54:857 – 862.

# First Line of Defense: the eBDR



**American Red Cross Blood Donation Record**

Blood Services Washington, DC 20006
Collection Date: *1/29/2019*
Drive ID: 012316262 Site: *AM RED CROSS FS APH CHARLOTTE*

Current DIN | First DIN

96F7DD1A *Allogeneic* *Granulocytes*

ePROGESA ID:
NBCS ID: 170500944782
Registrar: 012326
Gender: F

SS#:
Ethnicity: 02
DOB: 8/16/1982
Race: 002
Language: US
Eligibility: 012326
Demographics: 012326
Land Line Ph:
Work Phone:
E-Mail:
Employer:
Mobile Ph: (704) 575-5954
Ext:
IGA Final:
CMV: CMV:Negative
Bld: O -
Rare:

Original Last Name:
Original First Name & MI:

**Physical Examination**

| | | |
|---|---|---|
| Weight: | 012326 | 250 |
| Height: | | |
| Temperature: | 012326 | 98.7 |
| Pulse Rate: | 012326 | 82 |
| Pulse Rhythm: | 012326 | regular (EJ) |
| BP (Systolic): | 012326 | 126 |
| BP (Diastolic): | 012326 | 66 |
| Arm Inspection: | 012326 | Acceptable (EC) |
| Hemoglobin: | 012326 | 12.6 |
| Platelet Count: | 012326 | 150,000 or > (EH) |
| Blood Volume: | | |

**Physical Exam Approval: 012326**

**Health History Questions** **Health History Approval: 012326**

| | | |
|---|---|---|
| Q1 | Are you feeling healthy and well today? | Yes |
| Q2 | Are you currently taking an antibiotic? | No |
| Q12 | In the past 16 weeks have you donated a double unit of red cells using an apheresis machine? | No |
| Q13 | In the past 12 months have you had a blood transfusion? | No |
| Q14 | In the past 12 months have you had a transplant such as organ, tissue or bone marrow? | No |
| Q15 | In the past 12 months have you had a graft such as bone or skin? | No |
| Q16 | In the past 12 months have you come into contact with someone else's blood? | No |
| Q17 | In the past 12 months have you had an accidental needle-stick? | No |
| Q18 | In the past 12 months have you had sexual contact with anyone who has HIV/AIDS | No |
| Q44 | Have you ever had any type of cancer, including leukemia? | No |
| Q45 | Have you ever had any problems with your heart or lungs? | No |
| Q46 | Have you ever had a bleeding condition or a blood disease? | No |
| Q49 | Have any of your relatives had Creutzfeldt-Jakob disease? | No |
| Q54 | In the past 4 months, have you been exposed to a local Hepatitis A Outbreak? | No |

Supervisor Authorizations
SATA 012326

Additional Information
Is the donor on active duty and donating at a military facility?: NO (SC)

- Current donor health
- Exposure to persons with infections
- Travel to at-risk areas of endemic infections

# Blood Center: Preventive Measures

- **Disinfectant of VP Site:**

  -- 2% Chlorhexidine gluconate

  -- Isopropyl alcohol

- **Diversion Steps:** ex; initial 20-50 ml of collection to pouch

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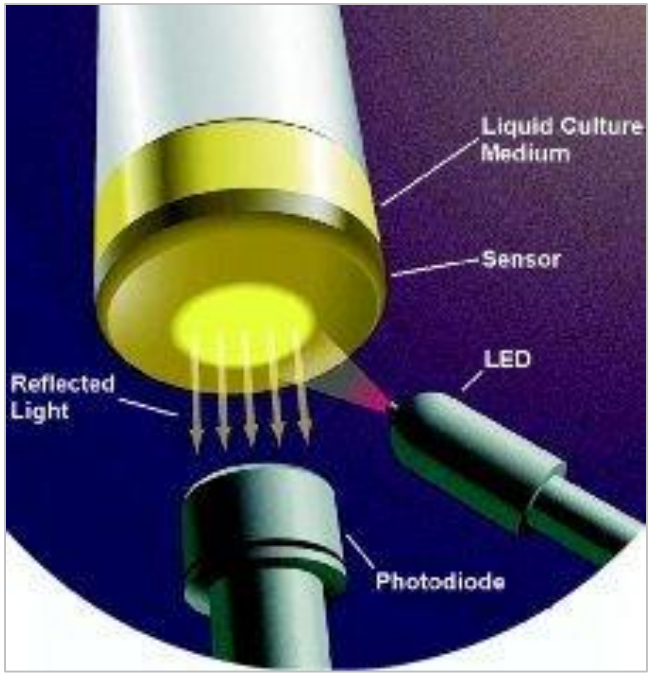
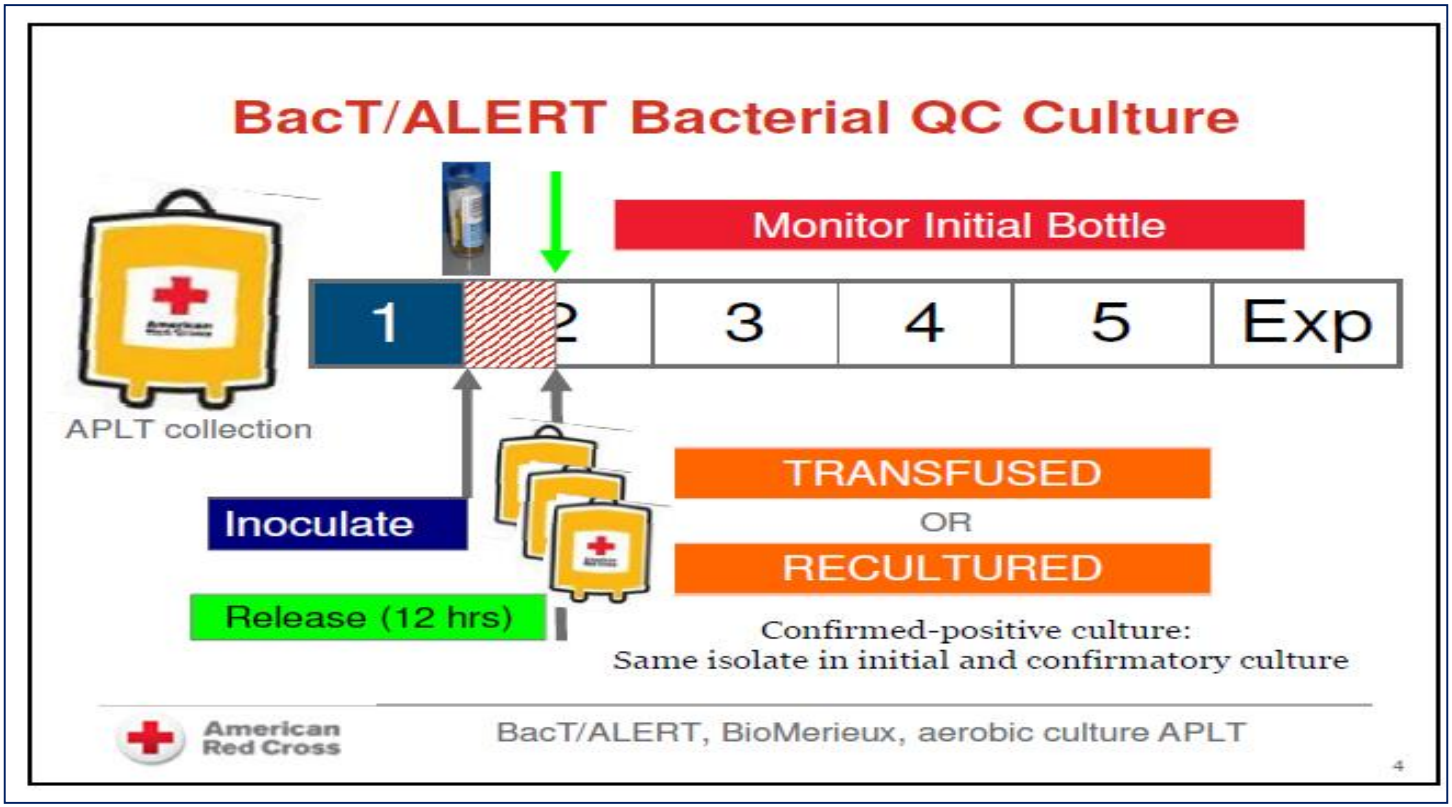
# Bacterial Testing

## BacT/ALERT (Biomerieux)

Sensor changes color in presence of $CO_2$




# Blood Center: Preventive Measure






Presentation: Herron R. Initiatives for Decreasing Septic Transfusion Reactions (STRs) from Platelets. Medical Advisory Council Meeting. 2018

# Summary of Bacterial Risks

- Reliance on donor memory recall
- Collection preventive measures are not effective
- Apheresis technology (Amicus)
- Product culture testing does not have sufficient sensitivity

<u>With current preventive measures</u>

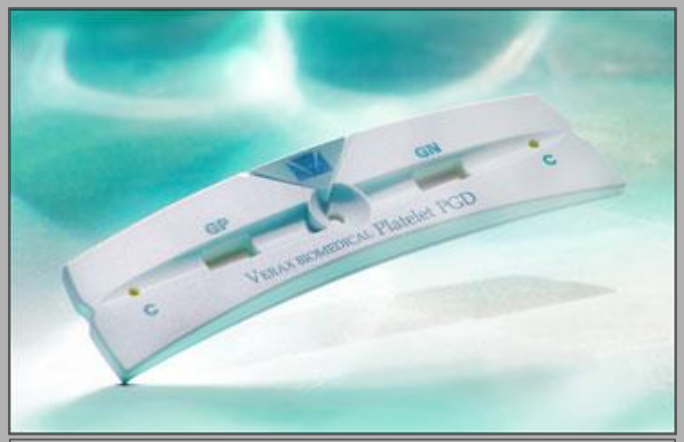
Contamination rate for apheresis platelets is 1:1,000 – 1:5,000

70% reduction of distributed contaminated apheresis platelet products

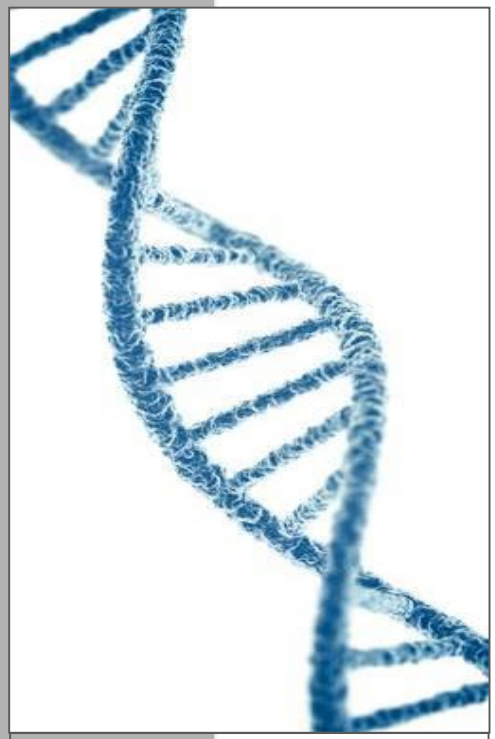

Under 21 Code of Federal Regulation 606.145(a)
Blood establishments and transfusion services must assure that the risk of bacterial contamination of platelets is adequately controlled using FDA approved or cleared devices, or other adequate and appropriate methods found acceptable for this purpose by FDA

# Strategies Include…


Culture




Rapid Testing (Verax)



Pathogen Reduction Technology

# FDA DRAFT GUIDANCE FOR INDUSTRY
# Bacterial Risk Control Strategies for Blood Collection Establishments and Transfusion Services to Enhance the Safety and Availability of Platelets for Transfusion

- December 2014:
  - Initial draft guidance for 5 day platelet storage
  - Include culture and rapid testing prior to transfusion
- March 2016:
  - Introduction of Pathogen Reduction technology
  - Enhancement of secondary testing to include culture as well as rapid testing
  - Testing options provided to extend platelet shelf-life to 7 days
- December 2018:
  - Refined timing for primary and secondary testing
  - Enhanced options to extend shelf-life to 7 days

# 2018 FDA DRAFT GUIDANCE FOR INDUSTRY
# Apheresis Platelets Bacterial Risk Control Strategies

| Strategy | Performed by ARC |
|---|---|
| **Primary culture:** | |
| ❑ Perform ≥ 24 hrs post collection | ✓ |
| ❑ Incubate for minimum of 12 hours | ✓ |
| ❑ Aerobic and anaerobic testing | ✓ |
| OR | |
| ❑ Pathogen Reduction | ✓ |
| **During 5 day platelet storage:** | |
| ❑ Secondary culture on Day 3 or 4 | No |
| OR | |
| ❑ Secondary testing with a rapid [Verax] test | No |
| OR | |
| ❑ Pathogen Reduction | Yes |

# Enhanced BacT/ALERT Testing

| BacT/ALERT BPA (aerobic) | BacT/ALERT BPN (anaerobic) |
|---|---|
| ▪ Aerobe: requires O2 for growth<br>▪ Facultative anaerobe: can use O2<br>▪ Product sample 8 – 10 ml | ▪ Facultative anaerobe: can use O2<br>  ▪ Escherichia coli, Klebsiella<br>  ▪ Staphylococcus, Streptococcus<br>▪ Product sample 8 – 10 ml |

## ADDING ANAEROBIC CULTURE

PROS

- Increased detection of strict anaerobic microbes , such as Propionibacterum acnes
- Faster growth rate of facultative anaerobes, such as Staphylococcus genus
- Increase sample volume (double)…increase detection by 30 - 35%

CON

- Product wastage due to increased positives of non-clinically significant microbes
- Loss of product potency due to expanded sample volume; impact split rates

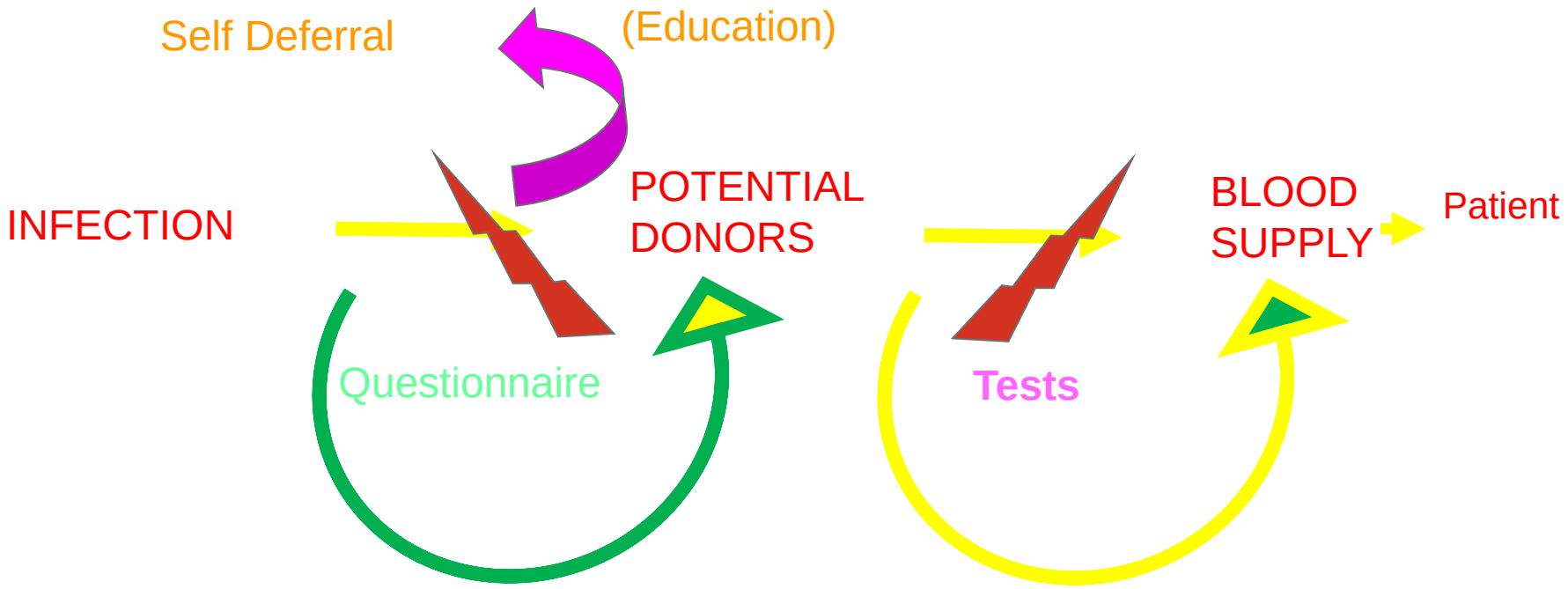
# Donor Eligibility Impact with Positive BacT/ALERT

INDEFINITE DEFERRAL

- Enteric (E coli, Klebsiella, Strep bovis)
- Oropharyngeal (Strep Beta hemolytic, Strep viridans)
- Staph aureus organisms
- Donor implicated in highly probable septic transfusion reaction

- Skin (non-Staph aureus)/ environmental contaminant –after second incident

# Protection of the Blood Supply




Ineffective Risk Identification
Test Seeking Behavior
Peer Pressure
Misunderstanding of Questions

Undetectable Strains
Infectious Disease Testing Lab Error
Test Failure
Window Period
New microbes

# Tests Performed on Blood Donations

| Year Implemented | Disease | Test |
|---|---|---|
| 1948 | Syphilis | Antibodies |
| 1971 | Hepatitis B | Hep B Surface Ag |
| 1985 | HIV | HIV 1 antibodies |
| 1986 | Non A-Non B Hepatitis | ALT |
| 1986 | Hepatitis B | Antibodies to core antigen |
| 1988 | HTLV | HTLV 1 antibodies |
| 1990 | Hepatitis C | Antibodies to Hep C Virus |
| 1992 | HIV | HIV 2 antibodies |
| 1995 | HTLV | HTLV 2 antibodies |
| 1996 | HIV 1 | HIV 1 p24 antigen |
| 1998 | HIV 1 and Hepatitis C | Nucleic Acid Testing |
| 2003 | West Nile Virus | Nucleic Acid Testing |
| 2007 | Trypanosoma cruzi | Antibodies |
| 2008 | Hepatitis B | Nucleic Acid Testing |

# Residual Risks for Current Infections from Blood Transfusions

| Virus | Risk |
|---|---|
| HCV | 1: 1,600,000 |
| HIV | 1: 1,900,000 |

Current and Emerging Infectious Risks of Blood Transfusions

Michael P. **Busch**, MD, PhD; Steven H. Kleinman, MD; George J. Nemo, PhD*JAMA.* 2003; 289(8):959-962. doi: 10.1001/jama.289.8.95

(modified)

# Pathogen Reduction

# Pathogen Reduction

**Table 1**
Degree of reduction of pathogens in log (adapted from [24] with Permission).

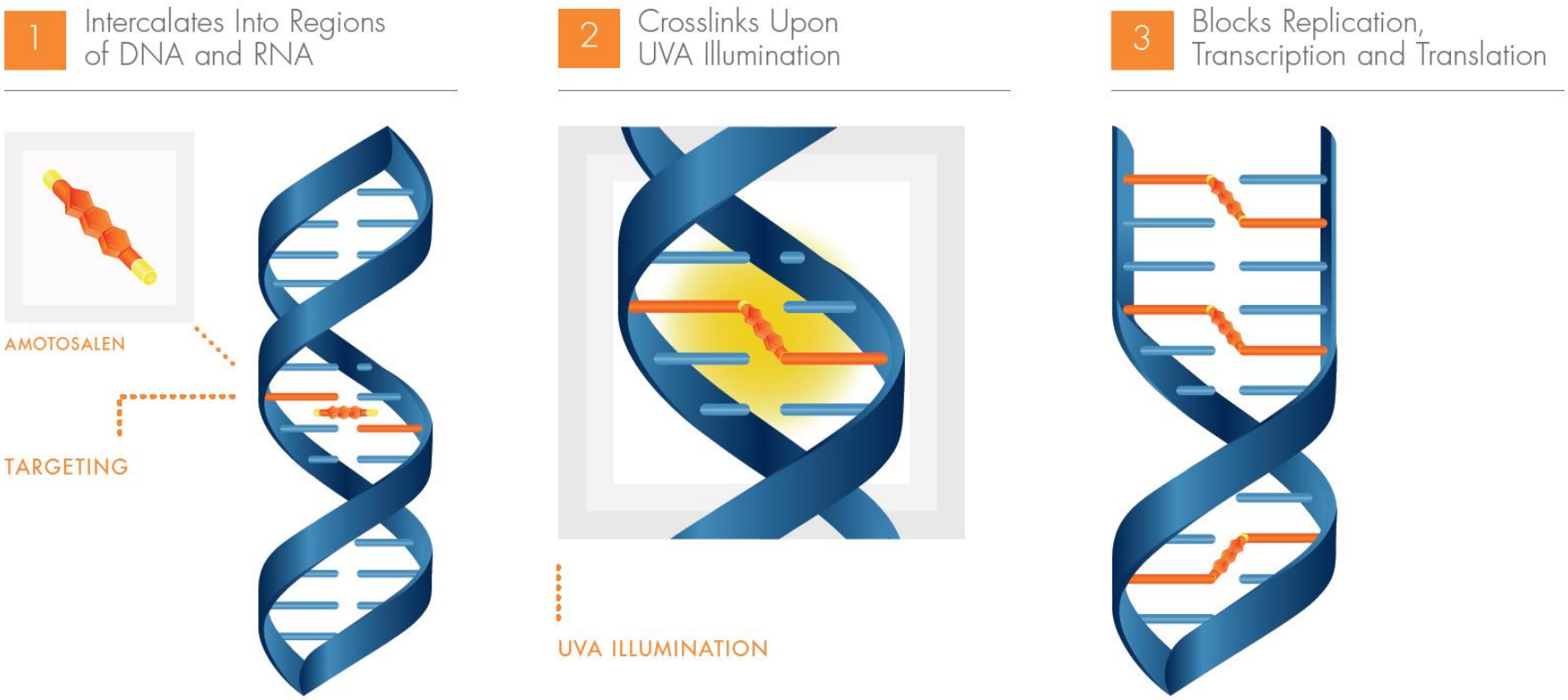
| | Amotosalen/UVA | Riboflavin/UV | UVC |
|---|---|---|---|
| ***Enveloped virus*** | | | |
| HBV | >5.5 | 2.3 | na* |
| HCV | >4.5 | 3.2 | na |
| HIV (cell free) | >6.2 | >5.9 | 1.4 |
| HIV (cell-associated) | >6.1 | >4.5 | na |
| HTLV-I | 4.7 | na | na |
| CMV (cell-associated) | >5.9 | na | na |
| West Nile virus | >6.0 | >5.1 | 5.4 |
| Chikungunya | >6.4 | 2.1 | na |
| Influenza A virus | >5.9 | >5 | na |
| ***Nonenveloped virus*** | | | |
| HAV | 0 | 1.8 | na |
| Parvovirus B19 | 3.5 to 5.0 | >5 | 5.46 |
| ***Bacteria*** | | | |
| *S. aureus* | ≥6.6 | ≥4 | >4.8 |
| *S. epidermidis* | ≥6.6 | 4.2 | 4.8 |
| *P. aeruginosa* | 4.5 | 4.6 | 4.9 |
| *E. coli* | ≥6.4 | 4.4 | >4 |
| ***Spirochaete bacteria*** | | | |
| *T. pallidum* | >6.8 | na | na |
| *B. burgdorferi* | >6.8 | na | na |
| ***Parasite*** | | | |
| *T. cruzi* | >5.3 | 6 | na |
| *P. falciparum* | >6 | >3.2 | na |

* Information not available.

Blood Reviews 2014: Vol. 28 pages 235-241.

# Mechanism of Action

**Targeting DNA and RNA to prevent pathogen proliferation**




The INTERCEPT® Blood System inactivates a broad spectrum of viruses, gram-positive and gram-negative bacteria, spirochetes, parasites and leukocytes


1. INTERCEPT Blood System for Plasma Package Insert, December 16, 2014.
2. INTERCEPT Blood System for Platelets Package Insert, December 18, 2014.

# Intercept® System for Platelets

# Intercept® System for Plasma

# The Cerus Intercept® Pathogen Reduction System

# Mechanism of Action

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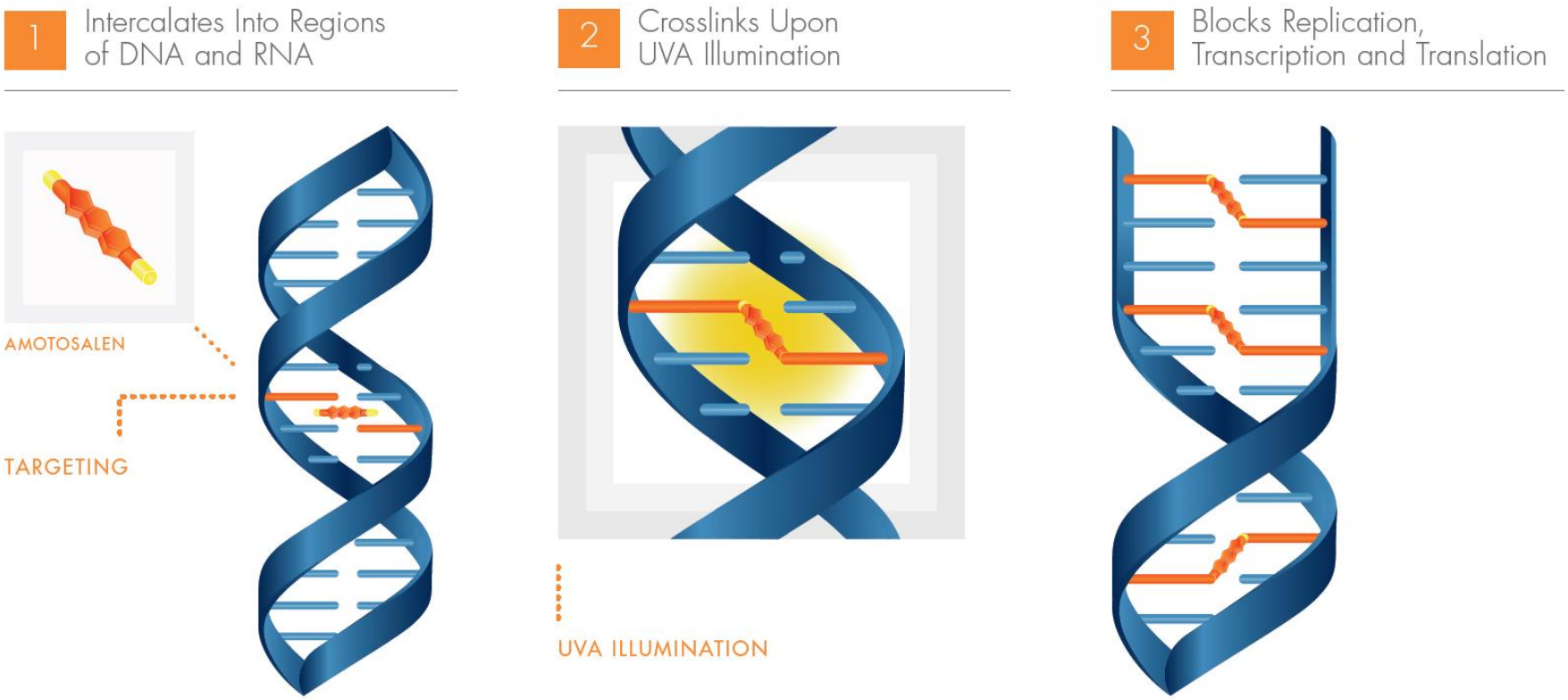


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2. INTERCEPT Blood System for Platelets Package Insert, December 18, 2014.

# Intercept® System for Platelets

# The Intercept® Illumimator

# How It Works

1 Transfer Apheresis platelet to the INTERCEPT® illumination bags and processing kit

2 

Add the amotosalen

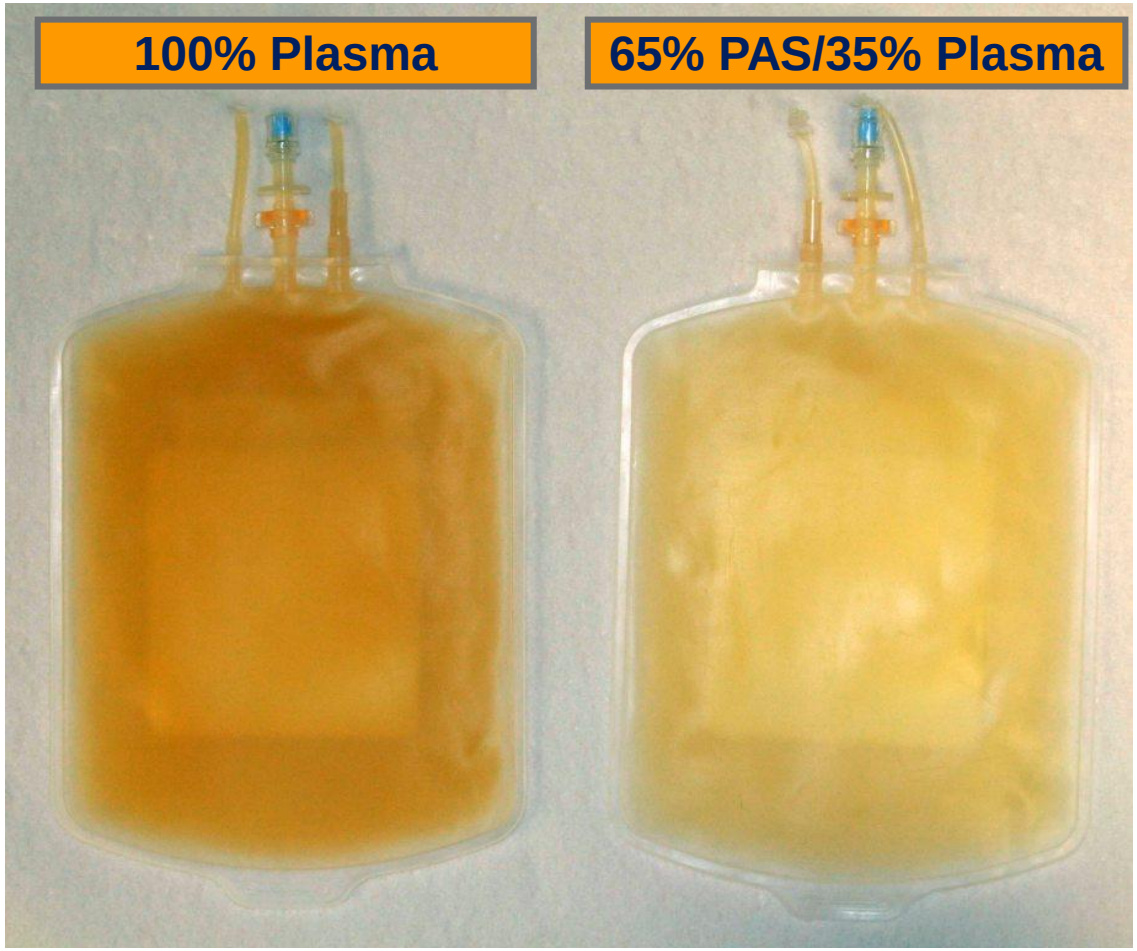
3 Illuminate

4 CAD & Store

5 


Labeled platelet units ready for distribution

# The Cerus Intercept ® Platelets are stored in a platelet additive solution (PAS)



# PAS Composition

| | |
|---|---|
| **ACETATE** | Energy source, buffer |
| **Citrate** | Anti-coagulant, energy source, buffer |
| **Phosphate** | Buffer, maintain ADP/ATP synthesis |
| **NaCl** | Isotonic osmolarity |

| | |
|---|---|
| **Donor Plasma (35%)** | Energy source – glucose, fatty acids, dextrose (ACD-A) |

# PAS Benefit #1
# Expansion of Donor Plasma Inventory

- Transfusable plasma
- Plasma utilized for further manufacturing for the production of other pharmacologic treatments (albumin, IVIG, clotting factors…)

# PAS Benefit #2
# Improves Platelet Storage Conditions

<u>An objective of PAS:</u> Improve platelet storage conditions

- Keep platelets healthy, fed, and alive during storage period of 5+ days
- Decrease production of bio-waste (i.e. lactate) that maybe harmful to platelets

# PAS Benefit #3
## Decrease Immune-mediated Transfusion Reactions

PAS Dilution → 36% protein loss

- Decrease anti-A and anti-B antibodies
- Decrease anti-HLA antibodies
- Decrease other proteins, biochemicals



Surowiecka M et.al. *Transfusion*. 2012;53 suppl. 81A

Weisberg SP et.al. *Transfusion* 2018;58:891-895.

# PAS Benefit #3
# Decrease Immune-mediated Transfusion Reactions

- Hemolytic transfusion reactions
  - Donor Anti-A,-B antibodies passively transfused can target patient's red cells for destruction (hemolysis) – potentially causing anemia
  - Patients : transfusion of ABO incompatible platelets or transplant patients whose ABO status is mixed due to receiving a donor graft with an incompatible blood type (donor A, patient B)

- TRALI – potential benefit is currently being investigated



Weisberg SP et.al. *Transfusion* 2018;58:891-895.

Surowiecka M et.al. *Transfusion*. 2012;53 suppl. 81A

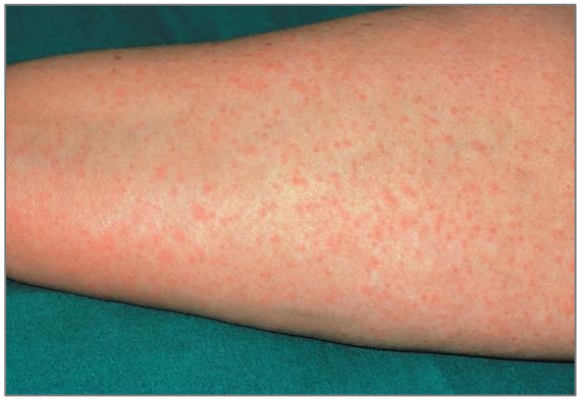
# PAS Benefit #4
# Reduce Allergic Type Transfusion Reactions

Allergic reactions: the most common transfusion reaction (4%)

**TABLE 1. ATR incidence by type of AP transfused**

| APs transfused | ATRs | Transfusions | Incidence | RR (95% CI) | p value |
|---|---|---|---|---|---|
| Non-PAS | 72 | 3884 | 1.85% | Referent | Referent |
| PAS | 12 | 1194 | 1.01% | 0.54 (0.30-0.99) | 0.04 |

PAS reduces allergic reactions associated with platelet transfusions by ~ 2x



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Arm image: The Pharmaceutical Journal: https://www.pharmaceutical-journal.com

Tobian AAR et.al. *Transfusion*. 2014;54;1523 – 1529.

# PAS Benefit #5
# Medical Cost Containment

- Pre-medication or Wash product charges
- Pre-medication side-effects, clinical management

- Reissue of blood product post-transfusion reaction
- Clinical transfusion work-ups
- Transfusion reaction may complicate patient's primary disease process
- May extend inpatient stay or if transfused in outpatient, may lead to hospitalization
- Emotional burden to patient and family

# PAS Benefit #6
# Improves PR-technology Efficiency

**Table 9 Platelet Collection and Processing Specifications for INTERCEPT Large Volume Processing Set**

| | Platelets in PAS-3 | Platelets in 100% Plasma |
|---|---|---|
| **Collection Specifications** | | |
| Platelet Source | Amicus Apheresis (PAS-3) | Trima Apheresis |
| Suspension Medium | PAS-3 and plasma (32-47%) | 100% Plasma |
| Platelet Input Volume | 300 – 390 mL | 300 – 390 mL |
| Platelet Dose | $3.0 - 6.0 \times 10^{11}$ | $3.0 - 5.2 \times 10^{11}$ |
| Platelet Count | $0.8 - 2.0 \times 10^{9}$/mL | $0.9 - 1.7 \times 10^{9}$/mL |
| RBC Content | $< 4 \times 10^{6}$ RBC/mL | $< 4 \times 10^{6}$ RBC/mL |
| **Processing Specifications** | | |
| Number of Storage Bags | 1 | 1 |
| CAD Time | 6-16 Hrs | 12-24 Hrs |
| Maximum Storage | 5 Days | 5 Days |

CAD: Compound Adsorption Device = residual removal of psoralen



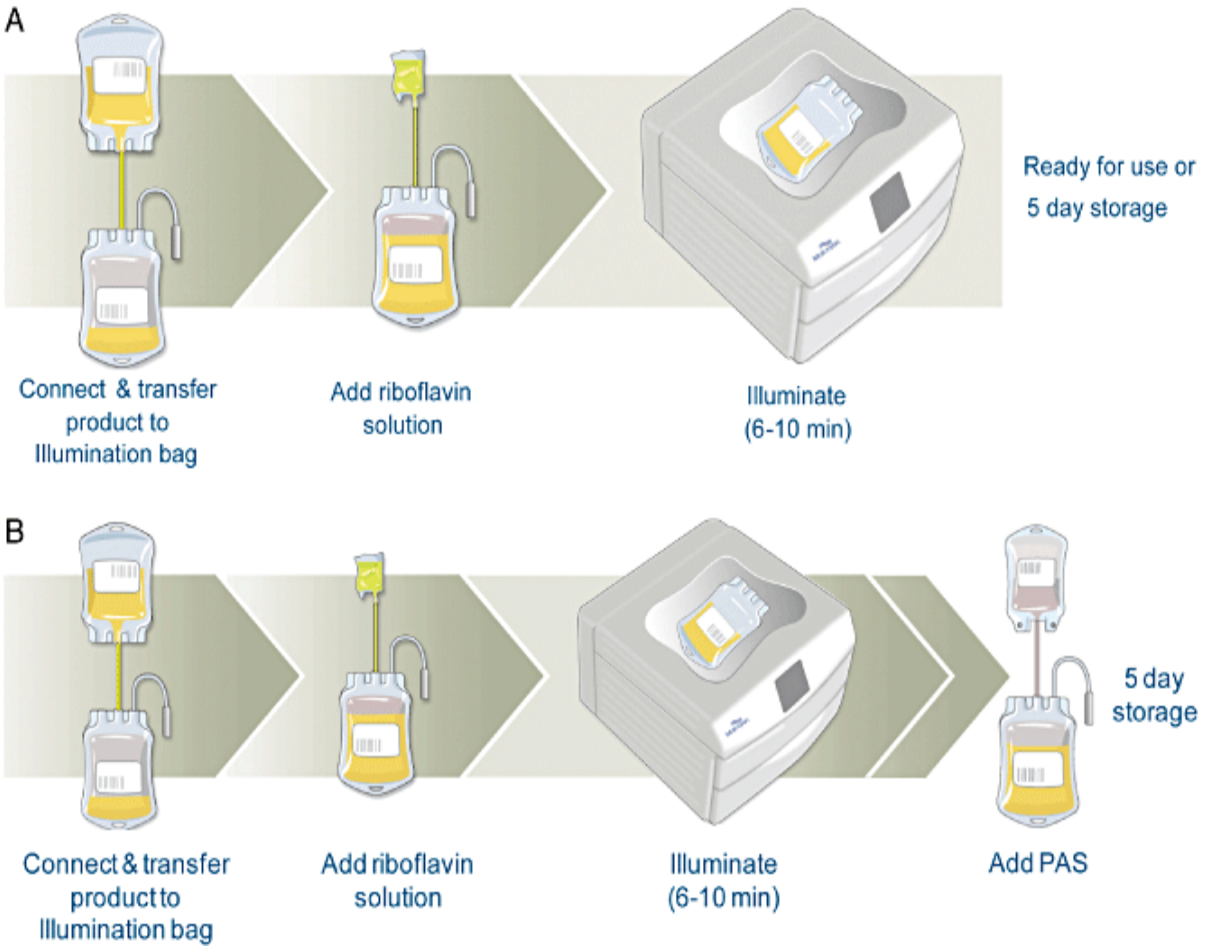
INTERCEPT. Cerus Corporation, Concord, CA, USA. 2016

# PAS/PR – Platelets: Overview of Benefits

| | PAS | Pathogen Reduction |
|---|---|---|
| **Sepsis** | | √ |
| TA-GvHD | | √ |
| Allergic | √ | |
| TRALI - theoretical | √ | |
| Hemolytic [ABO incompatibility] | √ | |
| | | |
| Increased Plasma Inventory | √ | |
| Maintain/ Expand Donor Base | | √ |

# The Terumo BCT Mirasol® Pathogen Reduction System

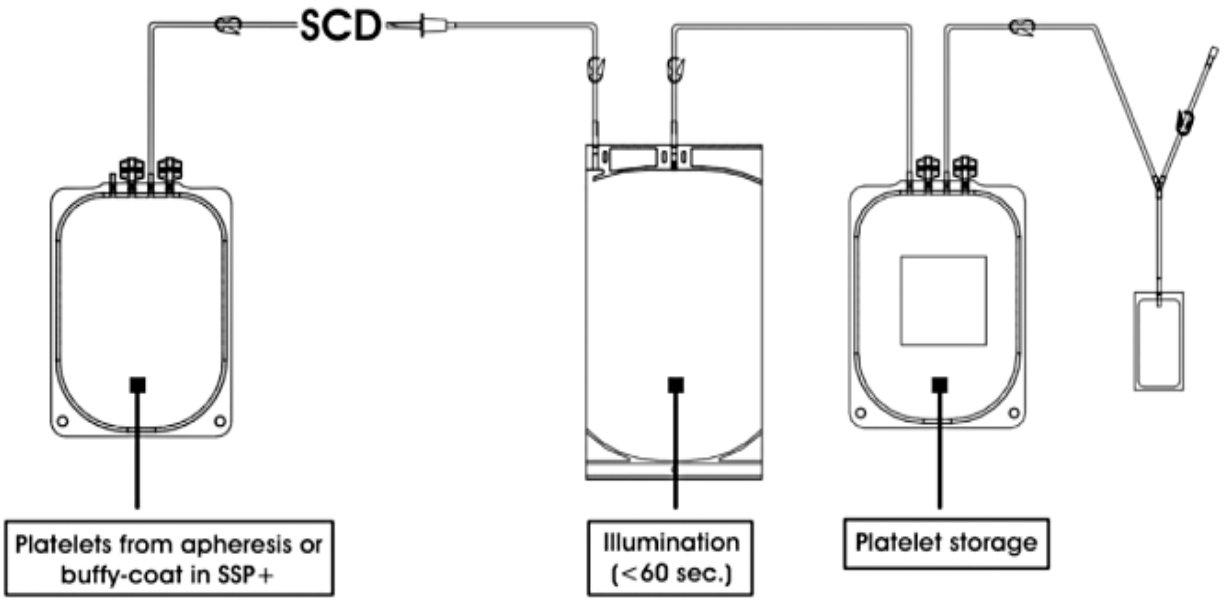
# The Terumo BCT Mirasol ® System




**Transfusion**
pages 1S-29S, 30 JUL 2009 DOI: 10.1111/j.1537-2995.2009.02279.x
http://onlinelibrary.wiley.com/doi/10.1111/j.1537-2995.2009.02279.x/full#f3

# The Macopharma Theraplex ® Pathogen Reduction System

# The Macopharma Theraplex ® System




**Transfusion**
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http://onlinelibrary.wiley.com/doi/10.1111/j.1537-2995.2009.02279.x/full#f4

# How Effective is PR -Technology?

| | INTERCEPT |
|---|---|
| BACTERIA | |
| Ecoli | >6.2[1] |
| Serratia marsescens | >6.6[1] |
| Klebsiella pneumonia | 5.8[1] |
| Enterobacter cloacae | 5.5[1] |
| Staph epidermidis | >6.0[1] |
| Staph aureus | >5.3[1] |
| Bacillus cereus (spore) | 3.7[1] |
| Priprionobacterium acnes | >6.4[1] |
| Yersenia enterocolitica | .5.9 |
| PRION | - |

**Targeted reduction rate of ≥4 log10**

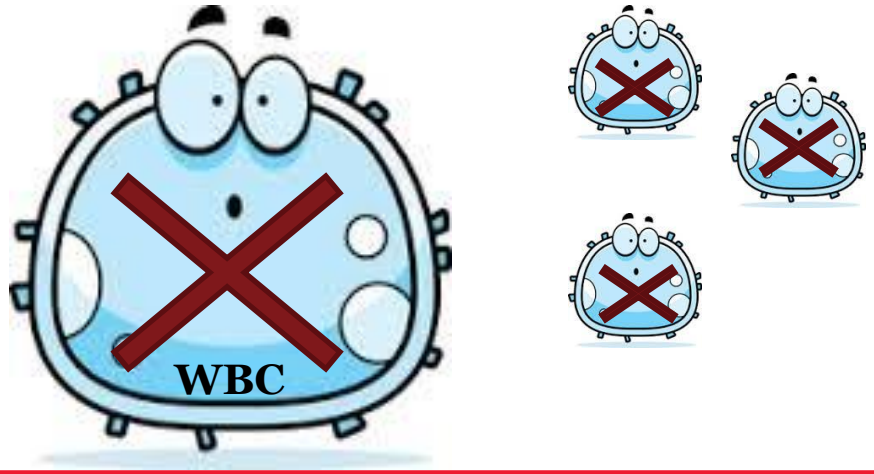
| | INTERCEPT |
|---|---|
| **VIRUSES** | |
| **Chikungunya** | >5.7[1] |
| **CMV (cell associated)** | >4.9[1] |
| **HAV** | 0 |
| **HBV** | >5.5 |
| **HCV** | >4.5 |
| **HIV-1** | >5.4[1] |
| **WNV** | >5.7[1] |
| **Parvovirus B19** | >3.5 |
| **PARASITES** | |
| Babesia microti | >4.8[1] |
| **Plasmodium falciparium** | >5.5[1] |
| **Trypasonosoma cruzi** | >5.2[1] |

# Additional Benefits of Pathogen Reduction

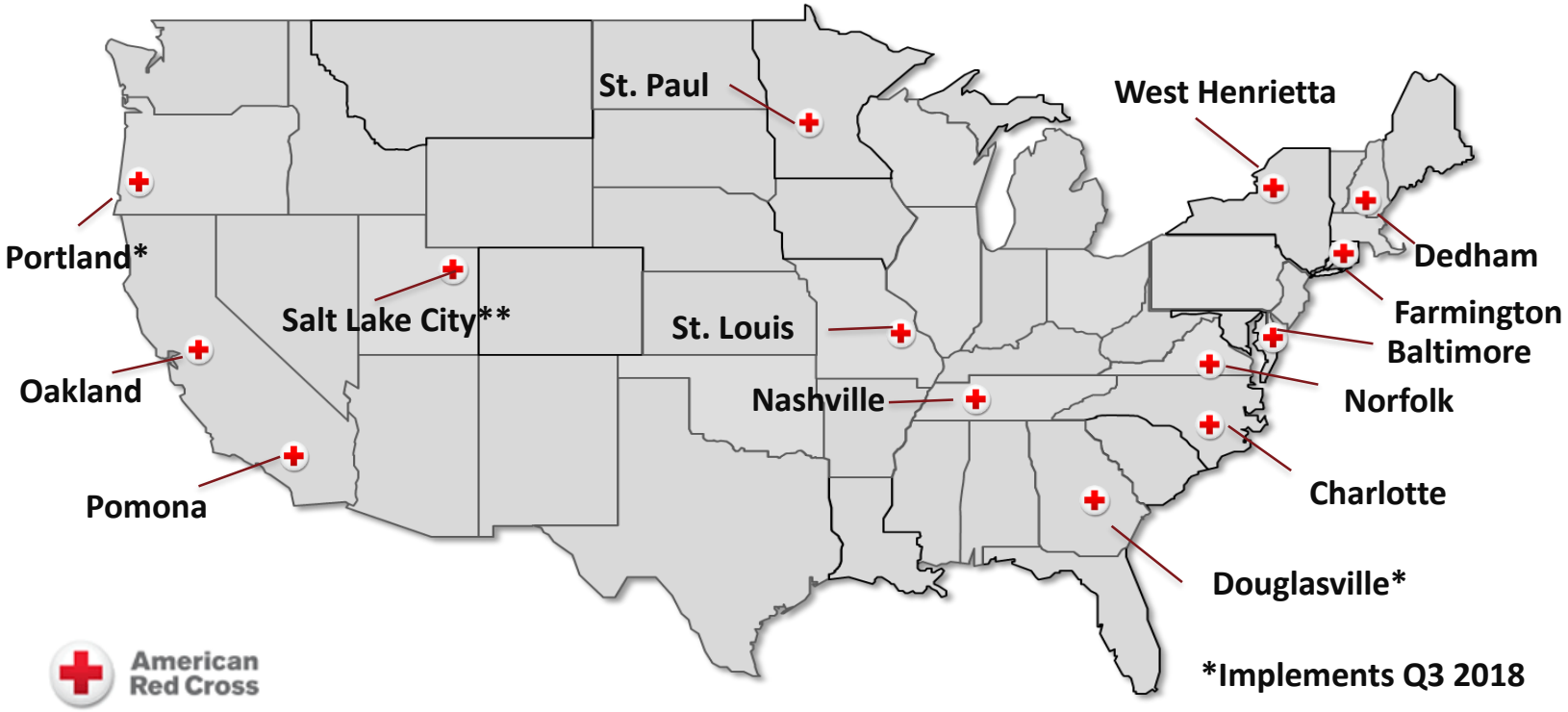
Transfusion Associated Graft vs Host Disease – rare but lethal (90%)

- Condition where the donor white cells see the recipient's body as foreign
- Mismatch of donor/ recipient HLA antigens
- Patients at risk:  immunodeficient/ -suppressed; receiving blood from family
- Preventive measures:  irradiation or Pathogen Reduction

Pathogen Reduction – disrupts white cell's DNA, preventing cellular replication



# Pathogen Reduction Technology
# ARC Manufacturing Sites



# Pathogen Reduction
# What's Next for Cerus?

- Cryoprecipitate
  - 10/2018:  FDA approves 'Breakthrough Devise' designation
  - Expedited review and approval determination - pending
- Red Blood Cells
  - 5/2018:  Cerus announces partnership with the US Dept of Health for phase 3 study in adult patients undergoing cardiac surgeries
  - 12/2018:  submission of European CE Mark for approval review
- Plasma – FDA approved in 2014
- Platelets – FDA approved in 2014

# The Safety of the Blood Supply — Time to Raise the Bar

Edward L. Snyder, M.D., Susan L. Stramer, Ph.D., and Richard J. Benjamin, M.D., Ph.D.

NEJM 2015; 372:1882-1885

May 14, 2015

DOI: 10.1056/NEJMp1500154

**Pathogen-Reduction Technologies Approved and in Development in the United States and Europe.***

| Component and Source | Manufacturer and Technology | Treatment Process | Manner of Inhibiting Replication | Regulatory Status |
|---|---|---|---|---|
| **Platelets** | | | | |
| Individual volunteer donors | Cerus Intercept Blood System | Psoralen (amotosalen) and UVA light exposure | Formation of DNA and RNA monoadducts and cross-linkage | FDA approved; CE marked |
| | Terumo BCT Mirasol Pathogen Reduction Technology (PRT) System | Riboflavin and ultraviolet light exposure | Direct DNA and RNA damage and guanine modification | Phase 3 study planned in the United States; CE marked |
| | Macopharma Theraflex ultraviolet platelets | UVC light exposure | Direct DNA and RNA damage and thymine dimer formation | CE marked |
| **Plasma** | | | | |
| Pools of volunteer and paid donors | Octapharma Octaplas | Plasma pools treated with solvent, tri-*n*-butyl phosphate and detergent (octoxynol) | Lipid membrane disruption of enveloped viruses | FDA approved; CE marked |
| Individual and minipools of volunteer donors | Cerus Intercept Blood System | Psoralen (amotosalen) and UVA light exposure | Formation of DNA and RNA monoadducts and cross-linkage | FDA approved; CE marked |
| Individual volunteer donors | Macopharma Theraflex MB Plasma System | Filtration, methylene blue treatment and visible light exposure | DNA and RNA damage by type I and type II redox reactions | CE marked |
| | Terumo BCT Mirasol PRT System | Riboflavin and ultraviolet light exposure | Direct DNA and RNA damage and guanine modification | CE marked |
| **Whole blood** | | | | |
| Individual volunteer donors | Terumo BCT Mirasol PRT System | Riboflavin and ultraviolet light exposure | Direct DNA and RNA damage and guanine modification | Phase 3 studies planned in the United States, completed in Africa |
| **Red cells** | | | | |
| Individual volunteer donors | Cerus Intercept Blood System | Frangible Anchor-Linker Effector (S303) and glutathione | Formation of DNA and RNA monoadducts and cross-linkage | U.S. phase 2 and European phase 3 studies complete |

CE: European union approval

NEJM 372; 20 May 14, 2015

**Pathogen-Reduction Technologies Approved and in Development in the United States and Europe.***

| Component and Source | Manufacturer and Technology | Treatment Process | Manner of Inhibiting Replication | Regulatory Status |
|---|---|---|---|---|
| **Platelets** | | | | |
| Individual volunteer donors | Cerus Intercept Blood System | Psoralen (amotosalen) and UVA light exposure | Formation of DNA and RNA monoadducts and cross-linkage | FDA approved; CE marked |
| | Terumo BCT Mirasol Pathogen Reduction Technology (PRT) System | Riboflavin and ultraviolet light exposure | Direct DNA and RNA damage and guanine modification | Phase 3 study planned in the United States; CE marked |
| | Macopharma Theraflex ultraviolet platelets | UVC light exposure | Direct DNA and RNA damage and thymine dimer formation | CE marked |
| **Plasma** | | | | |
| Pools of volunteer and paid donors | Octapharma Octaplas | Plasma pools treated with solvent, tri-*n*-butyl phosphate and detergent (octoxynol) | Lipid membrane disruption of enveloped viruses | FDA approved; CE marked |
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NEJM 372; 20 May 14, 2015

# Additional challenges

- PR reduction varies by technology
- Relative loss of component yield
- Reduced functionality
- Unknown residual infectivity of agents with pathogen loads that exceed validated inactivation efficacy
- Resistance by certain pathogens (e.g., non-enveloped viruses for certain technologies and spore forming bacteria)
- Short-term and long-term clinical adverse events have not been reproducibly documented

American Red Cross

# SPRINT Study

# Therapeutic efficacy and safety of platelets treated with a photochemical process for pathogen inactivation: the SPRINT Trial

Jeffrey McCullough, David H. Vesole, Richard J. Benjamin, Sherrill J. Slichter, Alvaro Pineda, Edward Snyder, Edward A. Stadtmauer, Ileana Lopez-Plaza, Steven Coutre, Ronald G. Strauss, Lawrence T. Goodnough, Joy L. Fridey, Thomas Raife, Ritchard Cable, Scott Murphy, Frank Howard IV, Kathryn Davis, Jin-Sying Lin, Peyton Metzel, Laurence Corash, Antonis Koutsoukos, Lily Lin, Donald H. Buchholz, and Maureen G. Conlan

**We report a transfusion trial of platelets photochemically treated for pathogen inactivation using the synthetic psoralen amotosalen HCl. Patients with thrombocytopenia were randomly assigned to receive either photochemically treated (PCT) or conventional (control) platelets for up to 28 days. The primary end point was the proportion of patients with World Health Organization (WHO) grade 2 bleeding during the period of platelet support. A total of 645 patients (318 PCT and 327 control) were evaluated. The primary end point, the incidence of grade 2 bleeding (58.5% PCT versus 57.5% control), and the secondary end point, the incidence of grade 3 or 4 bleeding (4.1% PCT versus 6.1% control), were equivalent between the 2 groups ($P = .001$ by noninferiority). The mean 1-hour posttransfusion platelet corrected count increment (CCI) ($11.1 \times 10^3$ PCT versus $16.0 \times 10^3$ control), average number of days to next platelet transfusion (1.9 PCT versus 2.4 control), and number of platelet transfusions (8.4 PCT versus 6.2 control) were different ($P < .001$). Transfusion reactions were fewer following PCT platelets (3.0% PCT versus 4.4% control; $P = .02$). The incidence of grade 2 bleeding was equivalent for PCT and conventional platelets, although posttransfusion platelet count increments and days to next transfusion were decreased for PCT compared with conventional platelets. (Blood. 2004;104: 1534-1541)**



## Introduction

Blood. 2004; 104:1534-1541.

# Table 5. Proportion of patients with grade 2 or higher bleeding

| | PCT, n (%) n = 318 | Control, n (%) n = 327 | *P*[*] |
|---|---|---|---|
| Any grade 2 bleeding | 186 (58.5) | 188 (57.5) | <.01[‡] |
| Grade 2 bleeding by bleeding site | | | |
| Genitourinary | 104 (32.7) | 103 (31.5) | 0.80 |
| Mucocutaneous | 82 (25.8) | 65 (19.9) | 0.08 |
| Invasive sites | 69 (21.7) | 65 (19.9) | 0.63 |
| Gastrointestinal | 60 (18.9) | 63 (19.3) | 0.92 |
| Respiratory | 35 (11.0) | 28 (8.6) | 0.35 |
| Musculoskeletal | 15 (4.7) | 18 (5.5) | 0.72 |
| Body cavity | 0 (0.0) | 1 (0.3) | 1.00 |
| Neurologic | 0 (0.0) | 0 (0.0) | — |
| Any grade 3 or 4 bleeding | 13 (4.1) | 20 (6.1) | <.01[‡] |

No difference between test and control

— indicates not applicable.

* Fisher exact test was used to calculate the *P* value for each of the 8 potential bleeding sites

† The *P* value for the overall proportion of patients with grade 2 bleeding was < .01, based on a noninferiority test with a noninferiority margin of 0.125 (one-sided 95% confidence interval of difference: —1, 0.07). By using this method, a *P* value of < .05 indicates that PCT was not inferior to control

‡ The *P* value for any grade 3 or 4 bleeding was < .01, based on a noninferiority test with a noninferiority margin of .07 (one-sided 95% confidence interval of difference: —1, 0.013). By using this method, a *P* value of < .05 indicates that PCT was not inferior to control

Blood. 2004; 104:1534-1541.

# Table 6. Platelet and RBC transfusions during the study

| | PCT, n = 318 | Control, n = 327 | *P* |
|---|---|---|---|
| Platelet transfusions | | | |
| Total number | 2678 | 2041 | — |
| Mean number per patient | 8.4 | 6.2 | < .001 |
| Mean number per day of platelet support* | 0.74 | 0.65 | < .001 |
| Interval between transfusions, d | 1.9 | 2.4 | < .001 |
| Platelet dose, $\times 10^{11}$ | | | |
| Mean average dose | 3.7 | 4.0 | < .001 |
| Percentage of platelet doses less than $3.0 \times 10^{11}$ | 20 | 12 | < .01 |
| Mean total dose over entire transfusion period | 29.4 | 24.1 | .01 |
| Duration of platelet storage, d | 3.4 | 3.6 | < .05 |
| RBC transfusions | | | |
| Mean number per patient | 4.8 | 4.3 | .13 |
| Mean number per day of platelet support* | 0.31 | 0.30 | .53 |

Difference between test and control

- — indicates not applicable.
- * Days of platelet support is defined as number of days from the first to the last study platelet transfusion

Blood. 2004; 104:1534-1541.

# Table 7. Mean platelet responses following platelet transfusions

| | PCT; n = 318 | Control; n = 327 |
|---|---|---|
| Before transfusion | | |
| Platelet count, × $10^9$/L | 15.1 | 15.2 |
| 1 h after transfusion | | |
| Platelet count, × $10^9$/L | 36.5* | 49.5 |
| Count increment, × $10^9$/L | 21.4* | 34.1 |
| Corrected count increment, × $10^3$ | 11.1* | 16.0 |
| 24 h after transfusion | | |
| Platelet count, × $10^9$/L | 27.9* | 36.1 |
| Count increment, × $10^9$/L | 13.2* | 21.5 |
| Corrected count increment, × $10^3$ | 6.7* | 10.1 |

* *P* < .001 compared with control



Blood. 2004; 104:1534-1541.

# Table 9. Adverse events during the study

| | PCT, %; n = 318 | Control, %; n = 327 | *P* |
|---|---|---|---|
| Any adverse event* | 99.7 | 98.2 | .12 |
| Grade III or IV adverse event | 78.9 | 78.6 | .92 |
| Serious adverse event† | 27.0 | 24.8 | .53 |
| Treatment-related adverse event‡ | 26.4 | 29.4 | .43 |
| Death§ | 3.5 | 5.2 | .34 |

* Adverse events were graded I to IV using the National Cancer Institute Common Toxicity Criteria (NCI-CTC)[38] and coded to Preferred Term by using Medical Directory for Regulatory Affairs (MedDRA)[39]
† Serious adverse events were defined by using Food and Drug Administration (FDA) criteria[40]
‡ Treatment-related adverse events were reported as possibly or probably related to the study platelet transfusions by the blinded investigator at each site
§ One patient in each group died of hemorrhage; both deaths involved pulmonary alveolar hemorrhage thought to result from toxicity of the myeloablative preparative regimen



Blood. 2004; 104:1534-1541.

# SPRINT Study

Conclusion:

The incidence of grade 2 bleeding was equivalent for PCT and conventional platelets, although post transfusion platelet count increments and days to next transfusion were decreased for PCT compared with conventional platelets.



Blood. 2004; 104:1534-1541.

Discussion of Pathogen Reduction at the

11/16/2009 to 11/17/2009 meeting of the

FDA Blood Product Advisory Committee

# Study Designs (Phases III and IV) for Product Development of Human Platelets Using the Cerus Intercept® Blood System for Pathogen Inactivation

A summary of FDA concerns presented for the BPAC discussion

- Issue Summary — The FDA has concerns about efficacy (bleeding events) and safety (imbalance of adverse events).
- Even though the previous study (SPRINT) met the primary endpoint, secondary endpoints did not support the study conclusion that the pathogen reduction platelets were non-inferior to untreated platelets.
  - More platelets and more frequent transfusions were needed.
  - Mean days of grade 2 bleeding were higher in the treatment arm ($p = 0.023$).
  - Additionally, hemostatic adverse events were more frequently observed in the test arm. The data did not establish whether the reduced hemostatic efficacy was attributable to lower platelet numbers or impaired platelet function.



http://www.aabb.org/advocacy/government/bpac/Pages/bpacmeeting111609.aspx

# Study Designs (Phases III and IV) for Product Development of Human Platelets Using the Cerus Intercept® Blood System for Pathogen Inactivation

A summary of FDA concerns presented for the BPAC discussion

FDA Perspective presented by Jaro Vostal, MD, PhD:

- S59 pathogen reduction process damages platelets.
- Damage results in reduced circulation of treated platelets, which leads to lower corrected count increments, or CCIs, and more frequent platelet transfusions.
- Hemostasis appears to be impaired after S59 treatment in comparison to conventional platelets, due to either low platelet counts or loss of platelet efficacy, or both.
- S59 damaged platelets appear to be associated with ARDS, hypocalcemia, syncope and pneumonitis not otherwise specified.
- An additional phase III clinical trial is needed to resolve the hemostasis efficacy and adverse event profile of S59 treated platelets.



http://www.aabb.org/advocacy/government/bpac/Pages/bpacmeeting111609.aspx

# FDA Approves the First Systems of Pathogen Reduction for Plasma and Platelets Stored in a PAS Solution

**U.S. Food and Drug Administration**
Protecting and Promoting *Your* Health

**FDA News Release**

# FDA approves pathogen reduction system to treat platelets

**For Immediate Release**

December 19, 2014

## Release

The U.S. Food and Drug Administration yesterday approved the Intercept Blood System for platelets, the first pathogen reduction system to treat single donor apheresis platelets. The system is for use by blood establishments that collect and manufacture blood and blood components to prepare pathogen reduced platelets for transfusion to reduce the risk of transfusion-transmitted infections.

On Dec. 16, the FDA also approved the Intercept Blood System for the preparation of plasma to reduce the risk of transfusion-transmitted infections.

The Intercept System for platelets has been shown to reduce the number of a broad range of viruses, bacteria and other pathogens that may contaminate platelets. Examples of some of the pathogens that may be reduced using the Intercept Blood System include HIV, hepatitis B and C viruses, West Nile virus and gram-negative and gram-positive bacteria. The Intercept process also reduces the number of T cells (a type of white blood cell) to a level that lowers the risk of transfusion-associated graft-versus-host disease (TA-GvHD). TA-GvHD is a rare, but often fatal, complication of blood transfusion in which the donor's T cells attack the recipient's tissues.

# FDA's Position on Intercept® -Treated Platelets after the Publication of the Sprint Study

# Studies that lead to the approval of Intercept ® - Treated Plasma and Platelets

# Package Insert for Intercept® - Treated Platelets

**Post-Marketing Studies**

Safety data were obtained from three hemovigilance (HV) programs in routine use without patient selection: the Cerus hemovigilance program and the regulatory surveillance programs in France and in Switzerland.(39-49 )

The populations monitored in the Cerus hemovigilance studies included 4,067 patients, where 59 patients were under the age of 1 year and 185 patients were 1-18 years of age. 51% of the patients enrolled in these studies were hematology-oncology patients, of which 12% were HSCT patients. Adverse events within 24 hours and serious adverse events within 7 days of platelet transfusion were reported. The frequencies of adverse events attributed to Intercept® processed platelet transfusions were not increased compared to conventional platelet transfusions reported in European regulatory hemovigilance programs.



http://www.fda.gov/downloads/BiologicsBloodVaccines/BloodBloodProducts/ApprovedProducts/PremarketApprovalsPMAs/UCM427522.pdf

# Package Insert for Intercept® - Treated Platelets

**ANSM and Swissmedic Active HV Programs (France and Switzerland)**

Since 2009, INTERCEPT ® processed platelets have been monitored in comparison to other types of platelet concentrates transfused in France and Switzerland through a national hemovigilance program.(44-49)

In Switzerland, INTERCEPT ® processed platelets were phased into routine use during 2011, accounting for approximately 80% of all platelet concentrates transfused that year, and 100% of platelets produced thereafter. No septic transfusion reactions due to bacterial contamination of platelets were observed after the introduction of Intercept® processed platelets in France or Switzerland.

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http://www.fda.gov/downloads/BiologicsBloodVaccines/BloodBloodProducts/ApprovedProducts/PremarketApprovalsPMAs/UCM427522.pdf

# Package Insert for Intercept® - Treated Platelets

**ANSM and Swissmedic Active HV Programs (France and Switzerland)**

The number of TRALI reported to the HV systems during the years 2009-2013 is small, and the TRALI rates were similar in both groups. There were 6/187,142 TRALI cases per Intercept® processed platelet transfusions, for a TRALI rate of 0.33 per 10,000 platelet transfusion, compared to 37/1,109,135 TRALI cases per conventional platelet transfusions, for a rate of 0.32 per 10,000 platelet transfusions. Limitations of the hemovigilance system include data collection that was limited to only transfusion associated AEs (TRALI, TACO, TAD, etc.) as assessed by the reporter.



http://www.fda.gov/downloads/BiologicsBloodVaccines/BloodBloodProducts/ApprovedProducts/PremarketApprovalsPMAs/UCM427522.pdf

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While the Intercept System for platelets has been shown to be effective in reducing pathogens, there is no pathogen inactivation process that has been shown to eliminate all pathogens. Certain viruses (e.g. non-enveloped viruses, such as human parvovirus B19) and spores formed by certain bacteria are known to be resistant to the Intercept process.

# Irradiation

Advancing Transfusion and Cellular Therapies Worldwide

Association Bulletin #16-05

**Date:** March 17, 2016

**To:** AABB Members

**From:** Donna Regan, MT(ASCP)SBB – President
Miriam A. Markowitz – Chief Executive Officer

**Re:** Changes to the 30th edition of *Standards for Blood Banks and Transfusion Services*

Association Bulletins, which are approved for distribution by the AABB Board of Directors, may include announcements of standards or requirements for accreditation, recommendations on emerging trends or best practices, and/or pertinent information. This bulletin describes three changes to the 30th edition of *Standards for Blood Banks and Transfusion Services (BBTS Standards)*. These changes are:

1) Revisions to Requirements for Prevention of Transfusion-Associated Graft-vs-Host Disease
2) Extended Expiration Date for Apheresis Platelets Leukocytes Reduced
3) Adjusted Effective Date for Standards Affected by FDA Final Rule (issued May 22, 2015)

**1) Revisions to Requirements for Prevention of Transfusion-Associated Graft-vs-Host Disease**

**Summary**

Standard 5.19.3 has been expanded and a new Standard 5.19.3.1 has been added. The newly renumbered Standard 5.19.3.2 (formerly 5.19.3.1) has been expanded. These changes are intended to allow for the use of certain pathogen reduction technologies to prevent transfusion-associated graft-vs-host disease.

The standards read as follows:

**5.19.3 ~~Irradiation~~ Prevention of Transfusion-Associated Graft-vs-Host Disease**

The BB/TS shall have a policy regarding the ~~transfusion of irradiated components~~ **prevention of transfusion-associated graft-vs-host disease**.

**5.19.3.1** **Methods known to prevent transfusion-associated graft-vs-host disease shall be used, and include either irradiation or the use of a pathogen reduction technology that is known to inactivate residual leukocytes and is cleared or approved by the FDA or Competent Authority.**

**5.19.3.2** At a minimum, cellular components shall be ~~irradiated when~~ **prepared by a method known to prevent transfusion-associated graft-vs-host disease when**:

# AABB Symposium on Implementation of Pathogen-Reduced Blood Components

April 27 – 28, 2015

American Red Cross | SUCCESS

# Background and Key Challenges

However, there are many barriers to adopting of Pathogen Reduction Technologies (PRT), including:

- The perception that the blood supply is already “safe enough;”
- No single PRT method can treat all blood components;
- The inability of current PRTs to inactivate all infectious agents;
- Concern over potential risks to transfusion recipients from residual chemical agents used to inactivate pathogens; and
- The high cost of PRT in the absence of favorable health economic analyses or an adequate reimbursement schema.

# Perspectives on US PRT Implementation

Ed Snyder, MD, discussed Yale-New Haven Hospital's approach to implementing PR. He suggested that widespread adoption of PR may require an FDA mandate and accrediting organizations, like AABB and the College of American Pathologists (CAP), requiring PR in their standards. Dr. Snyder added that the Centers for Medicare & Medicaid (CMS) must reimburse hospitals for the additional cost of PR. Maintaining a dual inventory of PR platelets and standard issue platelets would present logistical difficulties, suggesting that moving to a 100 percent PR-platelet inventory is preferable, according to Dr. Snyder.

# Bacterial Risk Control Strategies for Blood Collection Establishments and Transfusion Services to Enhance the Safety and Availability of Platelets for Transfusion

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## Draft Guidance for Industry

**This guidance document is for comment purposes only.**

# Implications of the FDA Draft Guidance

| Action | Day 4 (mandated) | Day 5 (mandated) | Day 6 (voluntary) | Day 7 (voluntary) |
|---|---|---|---|---|
| Need to use a secondary screening test for bacterial contamination | Yes (done the day of transfusion, valid for 24 hours) | Yes (done the day of transfusion, valid for 24 hours) | Yes (done the day of transfusion, valid for 24 hours) | Yes (done the day of transfusion, valid for 24 hours) |
| Need to change the label on the platelet bag (in terms of the expiration date) | No | No | **Yes** | **Yes** |
| Need to register with the FDA to use these platelets | No | No | **Yes** | **Yes** |
| Can Use Pathogen-reduced platelets as a substitute for a secondary screening test for bacterial contamination | Yes | Yes | *No* | *No* |

# Benefits of PR Platelets

- Multi-log reduction of most blood borne pathogens:
- --Bacteria ⇨gram (+) and gram (-)
- --Lipid-enveloped viruses (HIV, CMV, etc...)
- Effective inactivation of lymphocytes. Protects against TA-GVHD and eliminates need for either gamma or x-ray irradiation

# Benefits of PR Platelets-continued

- Decreased generation of cytokines by PR treated leukocytes contained in the SDP platelet unit
- Decreased risk of allergic reactions for SDP stored in PAS-C

American Red Cross

# PR Technology Constraints

- SDP collected on Amicus instrument-stored in PAS-C for 5 days at 20-24C
- SDP collected on Trima instrument- stored in autologous plasma for 5 days at 20-24C
- Storage duration, 5 days only, no 7 day approval
- Collection bags limited to single/double bags-no triple collection sets
- Guard band requirements
- Limited number of blood centers have been licensed to manufacture Pathogen Reduced platelets

American Red Cross

# Current PR Status in American Red Cross

- American Red Cross initiated routine pathogen reduced for SDPs in July 2016
- Collected in platelet additive solution (PAS) on Amicus instrument
- 17/23 manufacturing sites have implemented INTERCEPT and are producing pathogen-reduced SDPs stored in PAS
- Distributions to 100+ hospital customers
- Additional manufacturing sites are coming on-line as well as other sites in the planning phase

American Red Cross

# Moving forward…

- Await FDA final guidance for *Bacterial Risk Control Strategies to Enhance the Safety and Availability of Platelets…*
- Guidance will assist hospitals with plans for implementation of PR
- Guidance will assist blood centers in planning and strategy for PR platelet production
- Ongoing hospital education regarding PR

American Red Cross

# Acknowledgements


- Corrine Goldberg MD  American Red Cross
- Jorge Rios MD American Red Cross
- Ed Snyder MD Yale University Hospital


American Red Cross