

Blood Banking & Transfusion Medicine 101

Requirements for Storage & Expiration

Presented by:
Kathleen E. Puca, MD, MT(ASCP)SBB
Senior Medical Director
Versiti, Blood Center of Wisconsin
Milwaukee, WI

www.aabb.org

1

Learning Objectives

After participating in this program you should be able to....

- Describe the rationale for different storage requirements, by blood product.
- List shelf-life limits for commonly available blood products.



www.aabb.org

2

2

Primary Goals of Blood Component Preparation and Storage

- Maximum viability and function of cells (or clotting factors)
- Prevent physical changes that would be detrimental to the viability or function
- Minimize bacterial proliferation
- For best inventory management, longest duration while maintaining cell viability and function



www.aabb.org

3

3

Factors that can determine or affect storage conditions

1. Type of cell or constituent to be stored/transfused
2. Changes to the cell during storage → *Storage Lesion*
3. Storage solutions and composition used
4. Storage temperature



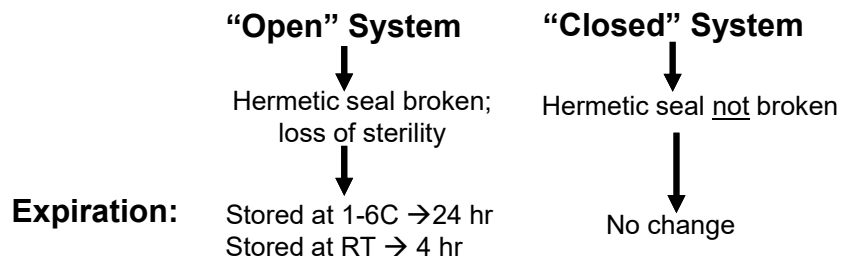
www.aabb.org

4

4

Factors that determine or affect storage conditions

5. “Open” vs “closed” system



www.aabb.org

5

5

Guidelines for Storage Requirements

Regulatory

- FDA (Food and Drug Administration)
- AABB (Standards for Blood Banks and Transfusion Services)

Based on outcomes from research and various studies



www.aabb.org

6

6

Evaluation of WB/RBC Storage Solutions

FDA requirements

- Survival: >75% of RBCs still detectable in circulation 24 hours post transfusion
- Integrity of RBCs: Free hemoglobin must be <1% at end of shelf-life



www.aabb.org

Dumont LJ, AuBuchon JP. Transfusion 2008;48:1053-60.

7

7

Measurement of Viability and Function of Stored Platelets

In-vitro:

- Swirling phenomenon (light-scattering ability of discoid platelets may correlate with platelet viability)
- Maintenance of pH >6.2



In-vivo:

- Measuring pre- and post-transfusion platelet counts



www.aabb.org


Shrivastava M. The platelet storage lesion. Transfus and Apheresis Science 2009;41:105-113.

8

8

Storage Solutions and Requirements by Blood Component

RBCs
Platelets
Plasma
Cryoprecipitate



www.aabb.org

9

9

What happens to red cells stored in the refrigerator?

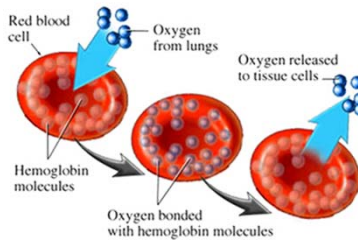


www.aabb.org

10

10

RBC Function and “Storage Lesion”



- Primary function of red blood cells is the delivery of O₂ from the lungs to the tissues.
- Hemoglobin (Hgb) is the main carrier protein for O₂
- Level of 2,3 DPG affects the release of O₂ from Hgb
- As stored RBCs metabolize glucose to lactic acid, pH falls, and 2,3-DPG declines
- Around the 2nd week of storage, pH drops and 2,3 – DPG levels begin to fall



www.aabb.org

11

11

RBC “Storage Lesion”

Metabolism continues and biochemical and structural changes occur.....

Biochemical



Plasma Hgb,
Plasma K⁺



ATP, pH, 2,3-DPG,
plasma Na⁺

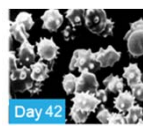
Structural



Day 1



Day 14



Day 42

Changes are correlated with
loss of RBC viability



www.aabb.org

12

12

Prevent or slow down the changes that occur....

- ***To maintain optimal viability....RBCs are stored at 1-6°C for specific # of days as determined by the preservative solution used***
- ***Composition of the preservative solution for storing WB/RBCs***



www.aabb.org

13

13

Anticoagulant-Preservatives Solutions

- Purpose:
 - Prevent clotting
 - Maintain the RBC (or platelet) viability and functionality during storage
- Basic Composition
 - Anticoagulant
 - Sugar or dextrose
 - Phosphate
 - Adenine (some types)



www.aabb.org

14

14

Anticoagulant-Preservative Solutions – Basic Ingredients

Ingredient	Main Function
Sodium citrate	Anticoagulant- Citrate interferes with calcium-dependent steps of coagulation
Citric acid	Maintains anticoagulated state
Dextrose	Supports generation of ATP; provides nutrients for cell metabolism
Sodium phosphate	Serves as buffer to minimize effects of declining pH during storage
Adenine (some types)	Improves synthesis of ATP for cell metabolism



www.aabb.org

15

15

Current FDA-Approved Anticoagulant-Preservative Solutions

	ACD-A	CPD	CP2D	CPDA-1
Trisodium Citrate	22.0 g/L	26.3 g/L	26.3 g/L	26.3 g/L
Citric acid	8.0 g/L	3.27 g/L	3.27 g/L	3.27 g/L
Dextrose	24.5 g/L	25.5 g/L	51.1 g/L	31.9 g/L
Monobasic Sodium Phosphate	0	2.22 g/L	2.22 g/L	2.22 g/L
Adenine	0	0	0	0.275 g/L
FDA-APPROVED SHELF-LIFE	21 days	21 days	21 days	35 days

Apheresis

Whole Blood



www.aabb.org

16

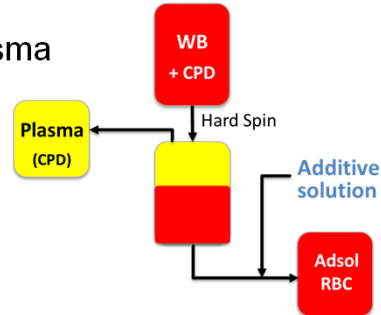
16

Additive Solutions (AS) - RBCs

- Added after removal of plasma

Advantages

- Extend the shelf-life to 42 days
- Harvest more plasma (and platelets) from WB unit
- Lowers viscosity of RBC product (Hct 60%); easier to infuse



Approved AS in US

- AS-1
- AS-2
- AS-5
- AS-7



www.aabb.org

17

17

Common FDA-Approved Additive Solutions: Biochemical Changes

	AS-1 (Adsol)	AS-3 (Nutricel)	AS-5 (Optisol)
FDA approved Shelf-life	42 days	42 days	42 days
24-hour survival (%)*	83	85.1	80
Hemolysis (%)**	0.5	0.7	0.6
pH (measured at 37C)	6.6	6.5	6.5
AP (% of initial)	68	67	68.5
2,3-DPG (% of initial)	6	6	5

Per FDA requirements: *24-hr survival >75%; **Hemolysis <1%



www.aabb.org

Modified from: Harmening DM, Brown MR. Red blood cell and platelet preservation: historical perspectives and current trends. Harmening DM (editor). Modern blood banking & transfusion practices. 7th Ed. FA Davis Co. 2019:1-23.

18

18

**In the US most RBC units are
stored in additive solution (AS-1,
AS-3, AS-5).....**

**At 1-6°C
for up to 42 days**



www.aabb.org

19

19

Storage Solutions and Requirements by Blood Component

RBCs
Platelets
Plasma
Cryoprecipitate



www.aabb.org

20

20

Platelets: 2 types

91% of All Platelets
Distributed in US in 2017



Whole-blood derived
 $\geq 5.5 \times 10^{10}$ platelets in 40-70
mL plasma



Single Donor Apheresis
 $\geq 3.0 \times 10^{11}$ platelets



Jones JM, et al. Slowing decline in blood collection and transfusion in the United States – 2017. Transfusion March 2020.

21

Platelets: Anticoagulant-Preservatives

- Apheresis Platelets
 - Collected with ACD-A
- WB-derived platelet
 - Same anticoagulant as for WB collection (e.g. CPD)
- Contain citrate to prevent clotting and maintain proper pH; dextrose as an energy source
- Platelet storage bag: needs to be gas permeable



www.aabb.org

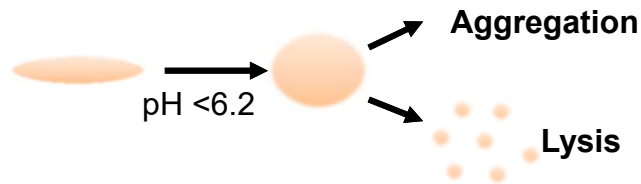
22

22

Platelet “Storage Lesion”

When O₂ ↓↓...

- ↑ lactic acid, ↓ pH, ↓ ATP
- When pH <6.2 → irreversible shape change



- Lead to ↓ platelet viability and function



www.aabb.org

23

23

Platelets - Unique Storage Conditions

- Stored in large flat bags (high surface to volume ratio for better gas exchange)
- Stored with **agitation** to facilitate O₂-CO₂ gas exchange*
- Shelf-life of platelets stored at RT (20-24C) is generally only 5 days



**FDA allows platelets to be stored without agitation for up to 24 hrs*



www.aabb.org

24

24

- Platelets can be stored up to 7 days **IF**....
 - Use a container cleared or approved by the FDA for 7-day storage **AND**
 - Individual platelet units are subsequently tested for bacteria using a bacterial detection device cleared by FDA and labeled for use as a “safety measure”.



www.aabb.org

25

25

Quality Requirements for Platelet Collection and Storage

At time of collection:

- Actual platelet yield (platelet count x volume) → $\geq 3.0 \times 10^{11}$ platelets
- Residual WBC count → 95% of units samples contain $< 5 \times 10^6$
- Bacterial detection testing (as specified by storage container manufacturer) → negative

At end of storage:

- Actual platelet yield (platelet count x volume) → 90% of samples contain $\geq 3.0 \times 10^{11}$ platelets
- pH → 90% of units sampled ≥ 6.2



www.aabb.org

26

26

Platelet Additive Solutions (PAS) for Platelet Storage

- Residual plasma reduced to 1/3 of its original volume
- Advantages:
 - Reduce plasma-associated transfusion reactions (e.g. allergic)
 - Mitigates any adverse event related to transfusion of ABO-incompatible platelets
 - Potentially reduces bacterial contamination/growth
 - Conserves plasma for other purposes
- Results related to improved platelet quality and in vivo survival are mixed



www.aabb.org

Alhumaidan H, Sweeney J. Current status of additive solutions for platelets. J Clin Apheresis 2012;27:93-98.

27

27

Storage Solutions and Requirements by Blood Component

RBCs
Platelets
Plasma
Cryoprecipitate



www.aabb.org

28

28

Frozen Plasma Products

Plasma	Frozen w/in:	Store at:	Exp. from Collection:
FFP	8 hrs @ 1-6C	-18C or colder	12 months
PF24	24 hrs @ 1-6C	-18C or colder	12 months
PF24RT24	24 hrs @ RT	-18C or colder	12 months

FFP = Fresh Frozen Plasma

PF24 = Plasma Frozen within 24 Hrs after phlebotomy

PF24RT24 = Plasma Frozen within 24 Hrs after Phlebotomy Held at Room Temperature up to 24 Hrs after Phlebotomy



Circular of Information for the Use of Human Blood and Blood Components, Revised October 2017

29

Plasma Products

WB-derived

- Same anticoagulant-preservative as used for WB collection
- Majority of anticoagulant-preservative solution from primary WB bag ends up in the plasma

Apheresis

- Collected in ACD-A



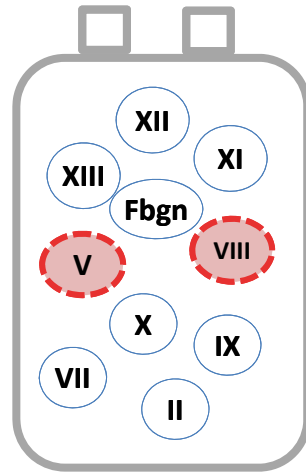
www.aabb.org

30

30

Plasma Products

- Source of all clotting factors
- Limiting factor is the stability of certain clotting factors
 - Factor V and VIII are “labile factors”
- Plasma is frozen to -18C or colder within 24 hrs to preserve these factors at clinically effective level



www.aabb.org

31

31

Plasma Products

- Temperature – primary storage condition
 - Store at -18C or colder to maintain clotting factor levels
 - Needs to be frozen within time limits based on type of plasma
 - Control of temperature is vital to maintain the shelf-life
- Stored frozen for 12 months from day of collection
- Published studies guide industry changes



www.aabb.org

32

32

Preparing Plasma Products for Transfusion

- FFP/PF24/PF24RT24 products considered clinically equivalent
- At hospital: thawed at 30-37C
- Once thawed, 24 hr expiration when stored at 1-6°C
- **All can be converted to Thawed Plasma*:**
 - Expiration is 5 days from date of thaw
 - Advantages: reduces wastage, more readily available for massively bleeding patients



*Collected in closed system

33

Liquid Plasma (*Never-frozen plasma*)

- Separated from whole blood and infused no later than 5 days after WB unit expires
 - CPD or CP2D: $21 + 5 = 26$ days
 - CPDA-1: $35 + 5 = 40$ days
- Stored at 1-6°C
- Indications: initial treatment of patients with life-threatening massive bleeding




Circular of Information for Use of Human Blood and Blood Components,
October 2017

34

Storage Solutions and Requirements by Blood Component

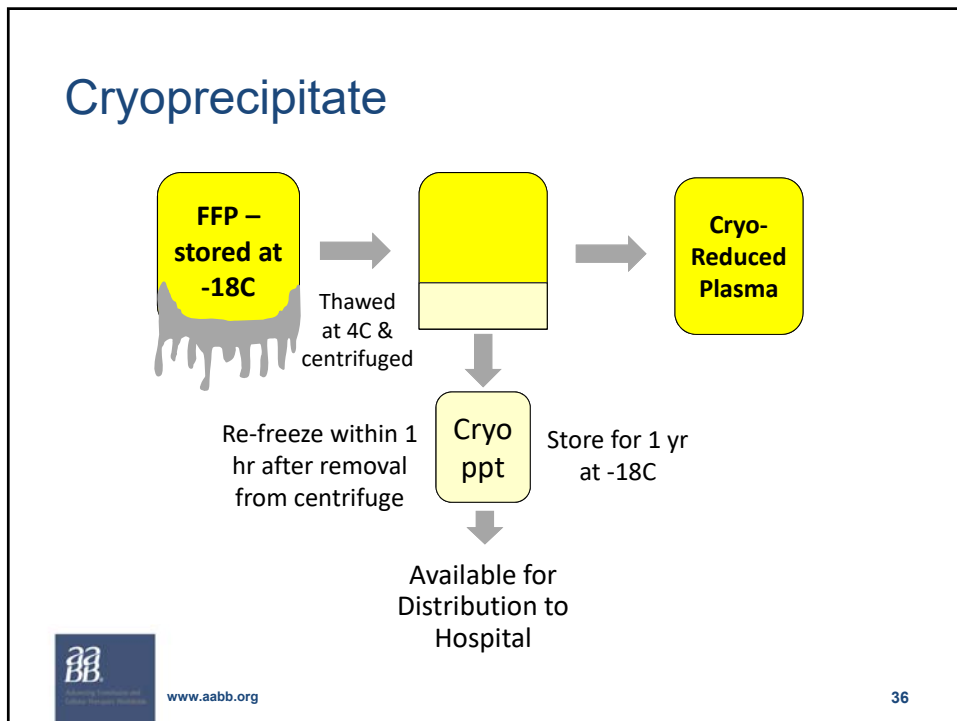
RBCs
Platelets
Plasma
Cryoprecipitate



www.aabb.org

35

35



36

Cryoprecipitated AHF

- Source of fibrinogen, FVIII, FXIII, vWF, fibronectin
- At hospital: thawed at 30-37C
- Once thawed: store at RT
- Duration: 6 hrs if closed system (single or pooled); 4 hrs if open system (pooled)
 - FVIII is labile clotting factor & bacterial contamination risk
- Why RT once thawed?
 - If stored at 1-6C, may lead to formation of precipitate (clotting factors)



www.aabb.org

37

37

Quality Control Requirements for Cryoprecipitate

- Per single unit
 - Minimum 80 IU Factor VIII
 - Minimum 150 mg Fibrinogen
- For pools (e.g. 5 pool)
 - Minimum 80 IU Factor VIII X # of units in pool (or 400 IU)
 - Minimum 150mg Fibrinogen X # of units in pool (or 750mg)
- Test each month 1% of products manufactured (or minimum of 4)



www.aabb.org

38

38

Summary

- Proper storage conditions including optimal storage solutions and ideal temperature results in safe and efficacious products for the patient
- Regulatory requirements are defined for the storage of blood products
- Each “blood component” has unique requirements to provide safe and quality product



www.aabb.org

39

39

Summary Table

Component	Temperature	Duration
RBC	1-6°C	42 days
Platelets	20-24°C	5-7days
Plasma (frozen)	-18°C	12 months
Plasma (thawed)	1-6°C	5 days
Cryo (frozen)	-18°C	12 months
Cryo (thawed)	20-24°C	6 hrs*

*single unit or pooled closed system; if open system, 4 hrs



www.aabb.org

40

40

Questions?

Contact
AABB eLearning Team
eLearning@aabb.org



www.aabb.org

Program is copyright 2020 by AABB with All Rights Reserved

41

41