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Narrative Review of Strategies for Blood Product Shelf-Life Extension

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BACKGROUND

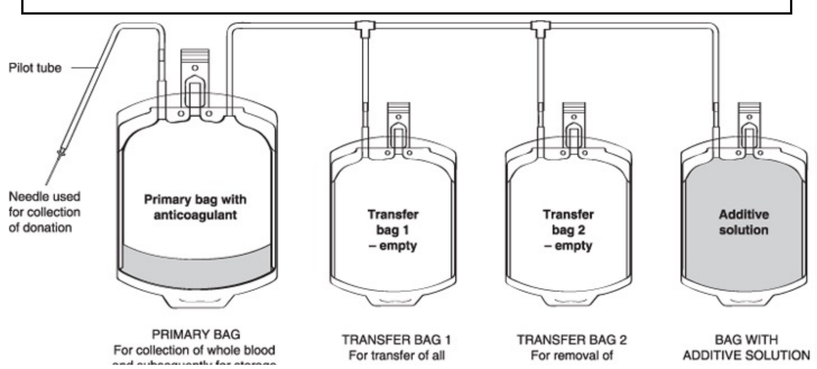
- Over 90% of survivable US battlefield fatalities (2001-2011) were due to severe hemorrhage, highlighting prehospital blood transfusion's crucial role.
- Anticipating rising demand in resource-limited settings during future conflicts, our review explores innovative methods to extend blood product shelf-life for austere environments.

OBJECTIVES

- Reviewed various methods that prolonged the shelf-life of blood components, specifically examining the impact of additives, anticoagulants, deoxygenation/anaerobic storage, cryopreservation/lyophilization of red blood cells, and variable temperature cycling/thermal holding procedures, and assessed their practical application in resource-limited environments.

METHODS

- We performed a literature review spanning from 1959 to 2023 by searching PubMed and government regulation documents using a combination of several keywords. Additional pertinent studies were identified by cross-referencing primary articles. Clinical experience of each author was also considered.



RESULTS

Current U.S. FDA Guidelines for Blood Product Storage Duration		Possible Increase	Storage Parameters
Additive Solutions* (RBCs)	42 days	56 days	1-6ºC
Anticoagulants* (WB)	21 or 35 days	35 days	1-6ºC
Deoxygenation/ Anaerobic Storage* (DAS) (RBCs)	NA	56 days	1-6ºC*
Cryopreservation (RBCs)	10 years	In Efficiency	≤ -65ºC (-80ºC)

Category	Technique	Finding	Utility in Austere Setting
Additive Solutions: (RBCs)	❍ "Additive Solution 7 (AS-7)"	❍ +14 days storage. ❍ 24hrs Room temp hold prior.	❍ Longer storage duration = less restocking of forward bases. ❍ Allows better logistics and planning.
Anticoagulants: (WB)	❍ Mixing FWB/EWB ❍ Ascorbic, Nicotinic acid	❍ Preserves clotting firmness + time. ❍ Higher 2,3 -DPG, less hemolysis.	❍ Decrease strain in Walking Blood Banks. ❍ Cheap implementation and lasts for 3 years of storage.
Deoxygenation/ Anaerobic Storage: (RBCs)	❍ Ar/He gas for deoxygenation and storage	❍ +14 days storage.	❍ Optimized cost, potential for less resupply. Can apply to platelets or plasma.
Variable Temperature Cycling/Thermal Holding: (WB)	❍ Transient exposure to RT ❍ Specialized Containers	❍ No change in cellular quality or hemolysis rates.	❍ Power failure will not harm blood supply. ❍ Allows for cheaper refrigeration.
Cryopreservation /Lyophilization: (RBCs)	❍Closed Loop ❍ Autologous ❍ Trehalose loading	❍ Needs 1.5 hrs. to deglycerolize & thaw	❍ Possible increase in efficiency for deglycerolizing. ❍ None for Lyophilization

CONCLUSIONS/DISCUSSION

- Certain applications may be financially cost prohibited or unsafe for widespread far forward use (Autologous cryopreservation, DAS w/ Pd catalyst) while other techniques would be easier to implement (AS-7, nicotinic/ascorbic acid).
- Certain applications can be role specific to sub specific situations; AS-7 for forward blood collections to storage.
- Optimized techniques exists to increase efficiency of blood storage duration including mixing FWB/EWB and mobile sealed containers.

LIMITATIONS

- Some methods reviewed (lyophilization of RBC) currently lacked clinical data.
- Given Narrative Review application, hard to infer the potential net effects with combination of methods (e.g., AS-7 w/ DAS).

DISCLAIMERS

The opinions expressed in this poster presentation are those of the authors and do not reflect the official policy or position of the US Army Medical Department, Department of the Army, Department of Defense, or the US Government.
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