The Future of Whole Blood: Dried and Frozen Blood Products

James A. Bynum, PhD

Professor Vice Chair of Research Dielmann Chair in Surgery Department of Surgery University of Texas Health San Antonio Executive Director, Trauma Research and Combat Casualty Care Collaborative (TRC4)





Review > Life (Basel). 2024 May 10;14(5):619. doi: 10.3390/life14050619.

Dried Plasma for Major Trauma: Past, Present, and Future

Henry T Peng¹, Kanwal Singh¹, Shawn G Rhind¹, Luis da Luz², Andrew Beckett³⁴

Affiliations + expand

PMID: 38792640 PMCID: PMC11122082 DOI: 10.3390/life14050619



FIGURE 4.—British and Canadian materials and equipment for replacement therapy. A. British (right) and U.S. Army dried plasma units. B. British dispensing set for plasma,







Freeze vs. Spray-Dried Plasma









velico

#velico

2 mil

- Alter

Freeze vs. Spray-Dried Plasma

Parameter	Spray-Dried Plasma	Freeze-Dried Plasma
Highest retention of clotting factors in reference to fibrinogen, FV and FVIII	-18%, +6%, -17%	0%, -3%, -7%
Particle size	Powder from droplets	Bulk material (no droplets)
Rate of formation	Few hours or less	One to several days
Reconstitution time	One to few minutes	Few minutes
Plasma source	Intended for single donor	Single or pooled donors
Autologous plasma	Easy to apply	Possible
Throughput	Low to medium	Medium to high
Equipment	Desk top	Mainframe
Cost	Cheaper, more energy efficient	Two to three times more than frozen plasma
Production sites	Possibly many, distributed	Often few, centralized
Current status	Preclinical development and phase I clinical trial	Well-studied clinical safety and efficacy





FrontlineODP™ System Productivity

Same Day Production: One Operator, 8 Hours, 4 Dryers





What About a WB "Surrogate"?

• 2 paths= Synthetic (mostly **Donor Independent**) or WB components (**Donor Dependent**)





🎖 DesiCorp









Natures Radical Survivors







Killifish
Wood frogs:
Sea monkeys: oxygen for weeks.

months.

embryos: without frozen for dried for decades.

Dried sea monkeys; Game changers for resuscitation?!?!



World's Favorite InstaPet

Since 1960, children of all ages ha been fascinated by comic book featuring the alluring and mysi beings known as Soa M

Michael A. Menze Department of Biology, UofL Molecular Physiology and Bioenergetics

Dry Preservation of Red Blood Cells







Function/Morphology



Post Processing



Cavitation – A Directional Force

The sonoporation method uses ultrasound to make microscopic bubbles cavitate near the surface of cells.



Modified after: https://www.theprocesspiping.com/introduction-to-cavitation/



Dried Red Blood Cell



Rehydrated Red Blood Cells

Trehalose Loading and RBC Recovery Correlates with Microbubble Concentration



Janis et al., 2021, Cryobiology

Dried Blood for Mission to Mars 2035?





Revolutionary Solution? Magnetoporation

No buffers required

Improved cell viability & recovery

No electrical arcing (vs. electroporation)

Drastically reduced cost & time

Scalable to treat massive unmet clinical need



Preliminary data: Magnetoporation of RBCs



Hemaglobin in Supernatant Post-Magnetoporation 100 90 80 % of Hemoglobin in Supernatant 70 60 50 40 30 20 10 Ω Untreated RBCs RBCs + RBCs + Trehalose RBCs + Trehalose + Lysed RBCs **RBC Lysis Buffer** DPBS Magnetoporation Magnetoporation

Intracellular Trehalose Delivery by Magnetoporation. RBCs were washed in DPBS and magnetoporated at 1e6 cells in 20µL of DPBS with 200mM of extracellular trehalose. Cells were incubated for 30 minutes at room temperature before measurement of average intracellular trehalose concentration by Megazyme Trehalose Assay Kit. Intracellular trehalose delivery > 100mM.

Hemoglobin Retention in RBCs Post-Magnetoporation. Hemoglobin levels measured 1 hour post-magnetoporation using a SpectraMax iD3 plate reader at 405 nm. Samples (left to right) include untreated RBCs, RBCs magnetoporated without trehalose, RBCs with trehalose but not magnetoporated, RBCs treated with trehalose and magnetoporated, RBCs lysed in liquid nitrogen as a positive control, RBC Lysis Buffer, and DPBS. Results indicate that magnetoporated RBCs, both with and without trehalose, retain hemoglobin effectively, suggesting that magnetoporation-induced poration is not permanent and RBCs can self-repair, preventing hemoglobin leakage.





Fieldable Solutions for Hemorrhage with bio-Artificial Resuscitation Products





Conclusions

- The development of dried blood products is on the horizon and needed.
- Future studies are necessary to establish the optimum reconstitution solution and fluid volume, potential immunogenicity changes compared to fresh blood products.
- Further modeling and early identification of patients who are most likely to benefit from dried blood are needed.
- Additionally, identifying who will be trained to administer it, along with related logistical considerations, will help to clarify future demand for dried blood in conflicts and civilian settings.
- Finally, clinical evidence on the use of other "adjuncts" (fibrinogen concentrate, PCC, TXA etc.) combined with dried products should be compared with fresh blood products.

