Coke Bottles and 3D Printed Caps for Blood Containers

Martin Rognhaug

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Disclaimer

- The views presented in this presentation are my own, and may not represent those of the Norwegian Armed Forces
- I currently have a utility patent application submitted for the 3D printed bottlecap. (BC2L)

Introduction

- Martin Rognhaug
- Bachelor Paramedic
- Msc Expedition & Wilderness medicine
- Working in Norwegian Armed Forces since 2005 (19 years)
- Civilian prehospital Experience from Nor ambulance, 6 years
- Experience from domestic and international deployments

The study

- Proof of concept study
- Did not have ethical approval for drawing blood directly from donor
- 500 ml bags of saline lying down in a 10° angle were used as analogues.

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ORIGINAL RESEARCH

TRANSFUSION

Drawing and storing blood using a 3D printed bottle cap and a disinfected 500 mL drinking bottle: A proof-of-concept study

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Funding information
Haukeland University Hospital; Norwegian Armed Forces (Forsvaret)

Abstract

Background: Today, with wars raging in Ukraine and the Middle East, the demand for blood is high. Despite this, few companies produce the necessary equipment to draw, store, and transfuse whole blood. This study evaluated the safety and performance of a 3D printed bottle cap in conjunction with a water bottle and some available consumables to draw and store fresh whole blood.

Study Design and Methods: Bags of saline, and freshly donated whole blood, was transferred to the water bottle through a 3D printed bottle cap and stored for 72 h. An identical setup, transferring saline to a Terumo blood collection bag was used as control. Performance and safety were evaluated by calculating infusion rate and observing for backflow, respectively. The blood was also tested for hemolysis and bacterial growth at four sampling points.

Results: The cap-and-bottle setup was faster than control in terms of flow rate when transferring saline (1.53 vs. 1.81 mL/s, $p < .001$), and non-inferior to saline control when transfusing blood (1.53 vs. 1.49 mL/s, $p = .641$). We did not observe any risks of causing the donor iatrogenic harm, and there was no evidence of increased hemolysis. However, there were traces of bacterial contamination in three of six bottles.

Conclusion: This study indicates that drawing blood is both feasible and safe, utilizing a 3D printed cap and bottle setup. Flow rate was faster than control, and mechanical properties of the blood were not affected. We were unable to determine the source of bacterial contamination in the blood.

KEYWORDS
3D printing, battlefield, blood, combat casualty, hemorrhage, preparedness, transfusion, trauma, walking blood bank, whole blood

Abbreviations: ATLS, advanced trauma life support; BC2L, Blood Collection Container Lid; CPD, citrate phosphate dextrose; CPDA, citrate phosphate dextrose adenine; CSWB, cold stored whole blood; HCT, hematocrit; HEMS, Helicopter Emergency Medical Services; HGB, hemoglobin; K2EDTA, dipotassium ethylenediaminetetraacetic acid; NoKBlod, Norwegian Coordination Centre for Blood Readiness; P HGB, plasma hemoglobin; REK, (Norwegian) Regional Committee of Medical and health Research Ethics; TC3, Tactical Combat Casualty Care; TCCC, Tactical Combat Casualty Care; WBB, Walking Blood Bank; WFWB, warm fresh whole blood; WWI, First World War; WWII, Second World War.

The study

- ✓ **Primary outcome:**
  - ➢ Evaluating the equipment's effectiveness for the intended purpose defined by:
    - Time of transfer to drinking bottle
    - Mechanical integrity of blood after transfer by hemolysis parameters
- ✓ **Secondary outcome:**
  - ➢ Assess safety profile of the bottle and cap assembly used to draw blood from a standard Terumo blood collection bag.
    - Observe for possibility of iatrogenic dangers for the donor
- ✓ **Tertiary outcome:**
  - ➢ Measuring the blood for bacterial growth for up to 72 hours

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Disinfecting ~~Sterilizing~~ the equipment

Drawing blood

Results

✓ Tertiary outcome:

- Measuring the blood for bacterial growth for up to 72 hours

Bottle #	0 hours	24 hours	72 hours
#1	Micrococcus Luteus	Negative	Chryseobacterium species
#2	Negative	Negative	Negative
#3	Negative	Negative	Negative
#4	Propionibacterium species	Negative	Negative
#5	Negative	Negative	Micrococcus Luteus
#6	Negative	Negative	Negative

HAEMOLYSIS (%)	0,14 (0,05 - 0,25)	0,16 (0,06 - 0,25)	0,21 (0,11 - 0,32)	0,21 (0,11 - 0,31)

Follow-up study Pre-Conference

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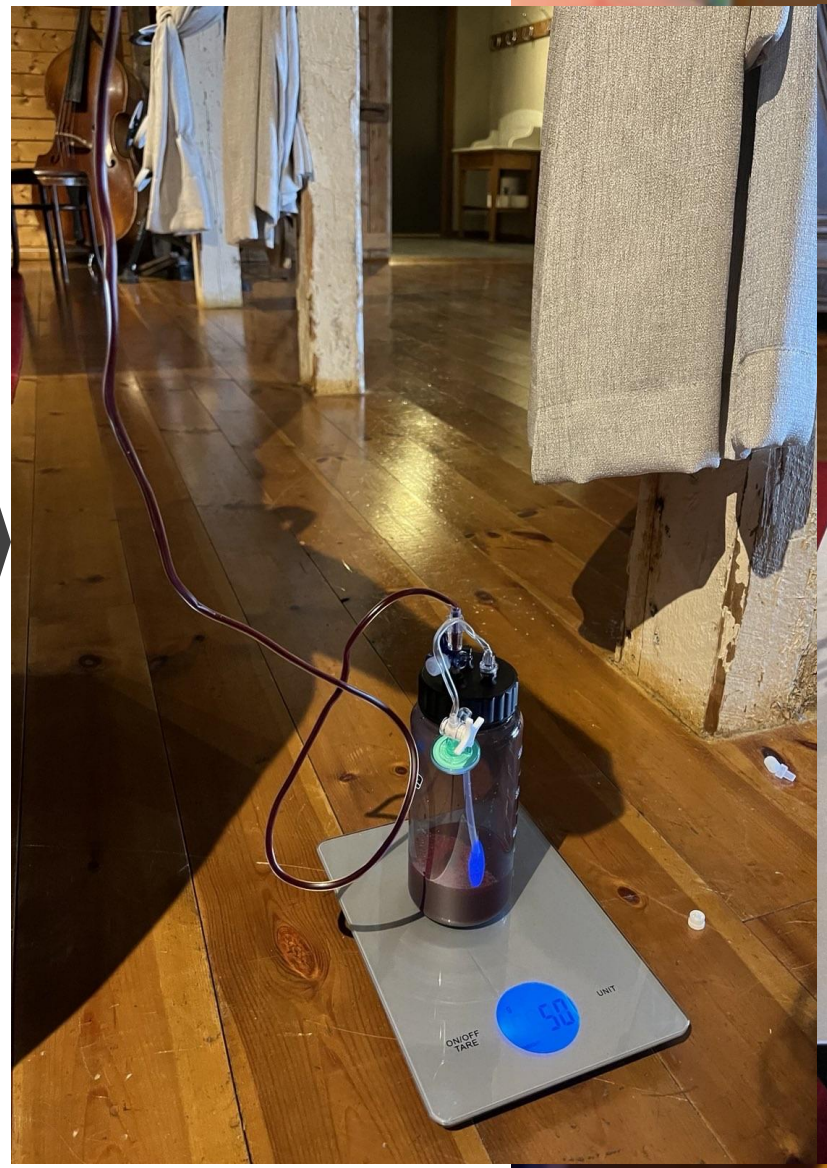

Questions?