Haemocompatibility testing of catheter materials in ex vivo human blood indicates activation of coagulation and haemolysis in the presence of chlorhexidine coatings

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INTRODUCTION

- Peripherally inserted central catheter (PICC) occlusion remains a clinically important issue affecting patient experience and healthcare expenditure.
- Developing methods to assess differences in catheter material haemocompatibility could help to further improve catheter material design and patient outcomes.

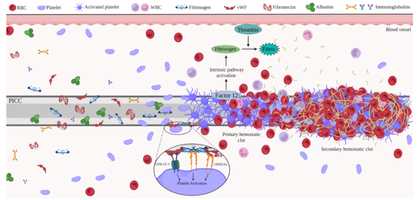


Figure 1. Schematic of blood/vascular catheter interaction within the circulation. Albumin binds, followed by fibrinogen, platelets, leading to platelet activation and coagulation. As red blood cells pass, they are captured within fibrin strands forming a thrombus, which could occlude indwelling vascular access devices.

METHODS

- Human blood collected from 29 individuals (14 F, 15 M)
- Blood was exposed to control (no device), polyurethane (PU), hydrophobic (HPO) and chlorhexidine coasted peripherally inserted catheter materials (PICCs)
- 2hr incubation, 37°C, gentle agitation mimicking blood flow
- Blood analysis before and after PICC exposure

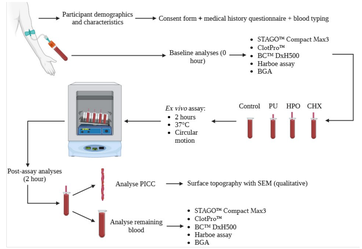


Figure 2. Methods used to assess catheter material haemocompatibility in human blood. Test results before and after 2 hours of exposure were used to calculate the relative change of coagulation proteins and cells within the sample.

RESULTS

Table 1. Participant demographics

Variable	Mean	SD
Age (years)	36.8	14.3
Height (cms)	171.0	10.2
Weight (kgs)	77.4	22.8
BMI	26.1	5.6
Sys BP (mmHg)	111.6	16.0
Dia BP (mmHg)	77.6	11.5
HR (RPM)	66.1	10.5
Temp (°C)	36.7	0.3

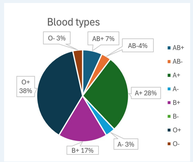


Figure 3. Blood type of participants

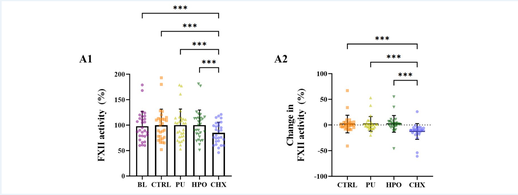


Figure 4. Absolute (A1) and relative change (A2) in Factor 12 activity after 2 hours of PICC/blood incubation. *** P<0.001

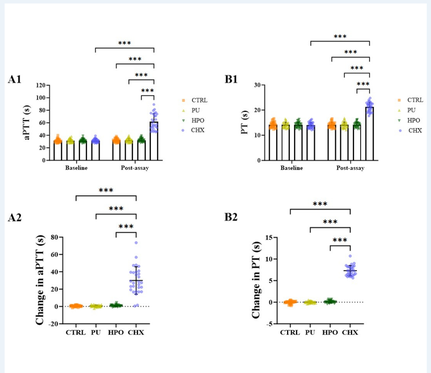


Figure 5. Absolute (A1) and change in (A2) intrinsic coagulation (APTT) and extrinsic coagulation pathways (B1 and B2, respectively) after 2 hours of PICC/blood incubation ***P<0.001

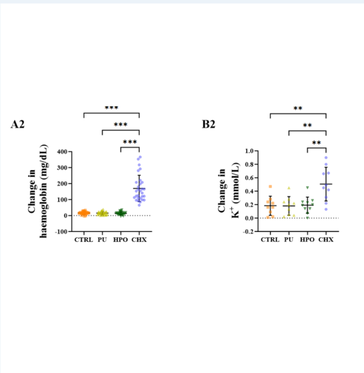


Figure 6. Change in plasma haemoglobin (A2) and plasma K+ (B2) after 2 hours of PICC/blood incubation ** P<0.01; ***P<0.001

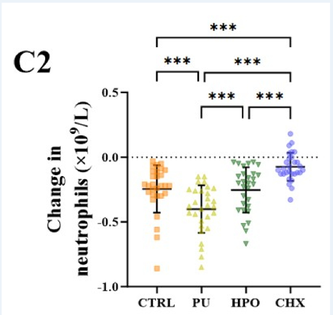
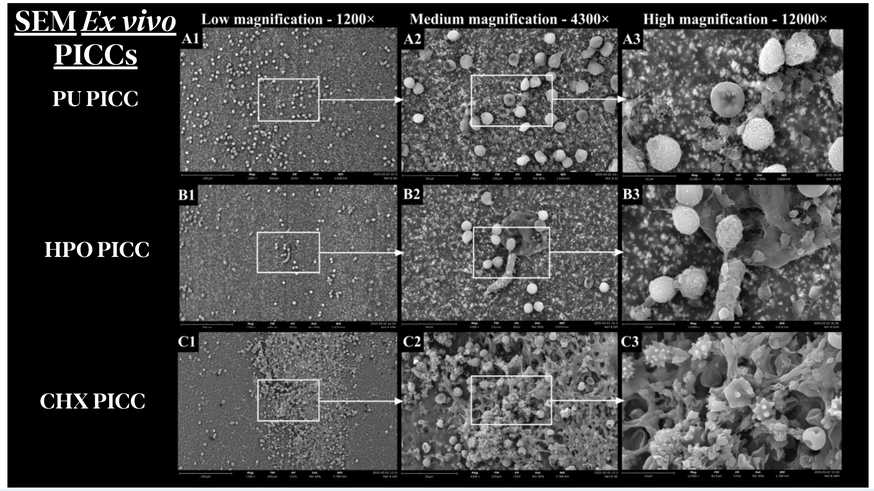


Figure 7. (above) Change in neutrophils within blood after 2 hours of PICC/blood incubation *** P<0.001

Figure 8. (right) Scanning electron microscopy images of PU, HPO and CHX PICCs after exposure to a volunteers blood sample. N.B. Low magnification shows increased cell binding to PU catheters. CHX high magnification, shows focal red blood cell crenation and amorphous protein coagulation/aggregation.



CONCLUSION

- Chlorhexidine coated PICCs induced prolongation of coagulation times, decreased Factor 12 activity, increased haemolysis/RBC crenation and deposition of haemolysed cells and coagulation at sites of chlorhexidine accumulation.
- Polyurethane catheters generally bound more white and red blood cells and depleted blood of neutrophils, compared to other catheters.
- A limited sample (n=1 per catheter type) of PICCs retrieved from patients demonstrated similar features to ex vivo testing.
- This fast, inexpensive, highly sensitive testing method can determine differences in catheter haemocompatibility.

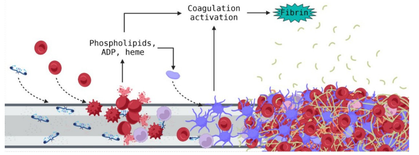


Figure 9. Hypothesis for the mechanism of CHX induced interfacial coagulation. Albumin/fibrinogen and RBCs interact with catheter surface inducing crenation/ haemolysis. Phospholipids release induces intrinsic coagulation/fibrin formation.

Limitations/Acknowledgement

- This work was conducted in blood removed from humans, in isolated conditions.
- The results provide insight into potential **mechanisms of action** of different PICC materials. They do not necessarily imply similar effects occur during clinical use.
- Prolongation of coagulation times and reduced factor 12 activity could indicate consumption of factors or the inhibition of coagulation proteins by chlorhexidine.
- Current imaging is obtained from a sub-sample of participant PICCs. Further imaging is required to document variations in interface effects.
- Despite the limitations above, this testing method is conducted in human blood and is sufficiently sensitive to determine differences in catheter material haemocompatibility.
- This work is currently in preparation for publication.
- Authors acknowledge Medical Specialties Australasia for the donation of HPO PICCs
- Griffith Univ. Human Research Ethics Approval (2021/589)