Received: 12 October 2023 | Revised: 11 May 2024 | Accepted: 11 June 2024

DOI: 10.1111/tme.13061

ORIGINAL ARTICLE

TRANSFUSION MEDICINE WILEY

Every minute counts: A comparison of thawing times and haemostatic quality of plasma thawed at 37°C and 45°C using four different methods

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Funding information
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Abstract

Background: Having faster plasma thawing devices could be beneficial for transfusion services, as it may improve the rapid availability of thawed plasma for bleeding patients, and it might remove the need to have extended pre-thawed plasma: thus, reducing unnecessary plasma wastage.

Study Design and Methods: The aims of this study were to assess (a) the thawing times and (b) in vitro haemostatic quality of thawed plasma using Barkey Plasmatherm V (PTV) at 37 and 45°C versus Barkey Plasmatherm Classic (PTC) at 37 and 45°C, Sarstedt Sahara-III Maxitherm (SS-III) at 37°C and Helmer Scientific Thermogenesis Thermoline (TT) at 37°C. Haemostatic quality was assessed using LG-Octaplas at three different time points: baseline (5 min), 24 and 120 h after thawing.

Results: The thawing time (SD) of 2 and 4 units was significantly different between different thawers. PTV at 45°C was the fastest method for both 2 and 4 units (7.06 min [0.68], 9.6 min [0.87], respectively). SS-III at 37°C being the slowest method (24.69 min [2.09] and 27.18 min [4.4], respectively) ($p = < 0.05$).

Baseline measurements for all assays showed no significant difference in the prothrombin time, fibrinogen, FII, FV, protein C activity or free protein S antigen between all methods tested. However, at baseline PTV (both 37°C and 45°C) had significantly higher levels of FVII, FVIII and FXI and shortened activated partial thromboplastin time.

Discussion: PTV was the quickest method at thawing plasma at both 37 and at 45°C. The haemostatic quality of plasma thawed at 45 versus 37°C was not impaired. Thawing frozen plasma at 45°C should be considered.

KEYWORDS
45°C and 37°C, Haemostatic quality, plasma, thawing

1 | INTRODUCTION

Recent studies have shown that during major bleeding time to transfusion resuscitation affects outcomes of bleeding patients.[1,2] Historically, plasma and platelet transfusion were administered later in the course of bleeding, but studies in trauma have shown that early resuscitation of bleeding patients with high ratios of plasma to red cells reduces mortality.[3,4] Due to the need for thawing frozen plasma (i.e., fresh frozen plasma [FFP]), many countries have introduced extended thawed FFP or are using liquid plasma,[5] to allow for the rapid and early delivery of plasma components in bleeding settings. However, in vitro data have shown that haemostatic qualities of extended thawed FFP and liquid plasma components are inferior to the freshly thawed FFP.[5] Therefore, an option that would allow a faster delivery of plasma during major bleeding without compromising its quality, would be faster thawing methods.

There are several methods available for thawing plasma worldwide, with the main ones being water based and dry heat–based methods.[6] Thawing times for plasma vary significantly depending on the method used, volume of component and number of units thawed. In the United Kingdom the national guidelines recommend that the optimal temperature at which plasma components should be thawed is 37°C (33–37°C).[6] Hardly any studies have evaluated the optimal time required for thawing plasma, and the current threshold is likely to be due to concerns in damaging clotting factors at higher temperature. One study in 2019 assessed the thawing times and quality of plasma between Helmer Scientific Thermogenesis Thermoline (an open water-based method) at 37°C versus the Barkey Plasmatherm Classic (PTC) (a closed water-based method) that can thaw plasma at 37 and 45°C temperatures. The results showed that thawing plasma at a higher temperature (45°C) does not impair the haemostatic quality of plasma, and furthermore, it increases the speed at which plasma is thawed.[7]

Recently, a thawing device (Plasmatherm V, Barkey GmbH & Co. KG) has been developed that uses both 37 and 45°C temperatures to thaw plasma faster than its predecessor (Plasmatherm Classic): however, there have been no studies to compare the new device with the currently used methods. If the Plasmatherm V (PTV) method can reduce the thawing time for plasma further, this could be hugely beneficial, as it may speed up the availability of thawed plasma for patients, and it could remove the need for having to have extended shelf-life thawed FFP on stand-by, and thus, it may reduce unnecessary wastage of plasma if this is not used within the 120 h extended shelf life window.[8]

The aim of this in vitro study was to compare (a) thawing times and (b) plasma quality between Barkey Plasmatherm-V at 37 and 45°C versus current standard methods, which in the UK are: Thermogenesis Thermoline at 37°C, Barkey PTC at 37°C and 45°C and Sarstedt Sahara-III Maxitherm (Sahara) at 37°C.

2 | STUDY DESIGN AND METHODS

The study was completed in 2-stages.

2.1 | Stage 1

Stage 1 aimed at assessing the thawing times of 2 and 4 units of FFP using four different methods, (1) PTV at 37 and 45°C, (2) Thermogenesis Thermoline (TT) at 37°C, (3) PTC at 37 and 45°C and (4) Sahara-III Maxitherm (SS-III). Methods 1 and 3 are dry water-based methods, method 2 is an open water-bath method, while method 4 uses a dry heat method. FFP was used in preference to LG-Octaplas for the measurement of time to thaw due to the variation in volume size seen with FFP components.

The times for thawing 2 and 4 units of FFP were assessed eight times using single FFP supplied by NHS Blood and Transplant (NHSBT). The FFP units were derived from UK whole blood donations (475 mL ± 10%) collected into 66.5-mL anticoagulant citrate phosphate dextrose in top-and-top collection packs (FQE6283LB, MacoPharma) following NHSBT standard operating procedures.[6] FFP volumes ranged from 200 to 320 mL. Assessment of thawing times was performed by the same scientist using visual inspection for the absence of visible ice crystals, as this is the thawing endpoint used in most hospitals. All thawing devices were switched on for 30 min prior to any thawing taking place.

2.2 | Stage 2

Stage 2 aimed at assessing the haemostatic quality of thawed plasma using the three water-based thawing methods (PTV at 37 and 45°C, PTC at 37 and 45°C and TT at 37°C). Data for the haemostatic quality of plasma thawed in the PTC at 37 and 45°C and TT at 37°C were obtained from a previous study[7] performed using the same method and study design. Due to logistical issues with samples and testing we were unable to assess the haemostatic quality of plasma thawed in using the SS-III. As in the previous study, for this stage LG-Octaplas was used instead of single FFP units, as the former product is a pooled plasma of thousands of donors and thus the haemostatic properties of this component are more standardised. Once thawed, LG-Octaplas was stored at 2–4°C and aliquots were taken for haemostatic testing at three different time-points: 5 min after removal from the thawing device (or baseline); 24 and 120 h (see Figure 1). Samples were then stored below −70°C until testing was performed and then thawed in a water bath at 37°C prior to analysis.

2.3 | Haemostatic tests

The following assays were performed: prothrombin time (PT); activated partial thromboplastin time (APTT); fibrinogen (fib); factor (F)II, FV, FVII, FVIII and FXI activity; free protein S antigen (FPS) and protein C activity (PC). All assays were performed on a Sysmex CS-2100 (Siemens) analyser. PT was measured using Siemens Dade Innovin; FII, FV and FVII were measured by one-stage assay using Siemens Dade Innovin and Siemens factor deficient plasmas; APTT was measured using Siemens Dade Actin FS; FXI was measured by one-stage assay

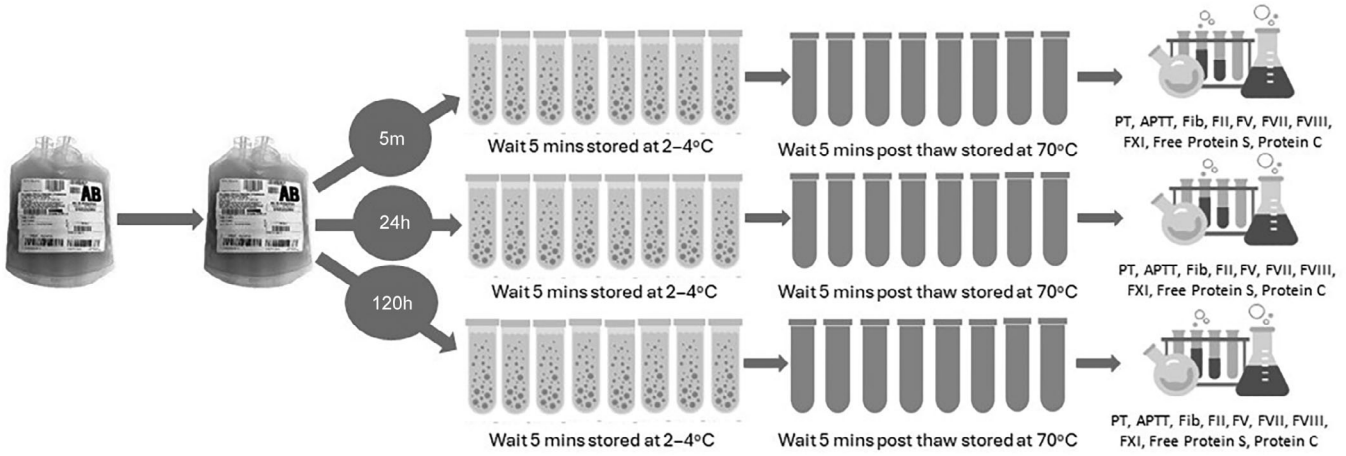

FIGURE 1 Image representation of the methods used to assess the Haemostatic quality of thawed plasma. Depicting the three different time-points: 5 min after removal from the thawing device (or baseline); 24 h; and 120 h and the haemostatic assays performed. APTT, activated partial thromboplastin time; factor (F)II, FV, FVII, FVIII and FXI activity; fib, fibrinogen; FPS, free protein S antigen; PC, protein C activity; PT, prothrombin time.

TABLE 1 Thawing times and volumes for six different thawing methods.

	TT 37°C	SS-III 37°C	PlasmaTherm Classic		PlasmaTherm V	
			37°C	45°C	37°C	45°C
	2 Units					
N	16	16	16	16	16	16
Time (min) mean [SD]	13.44 [3.12]	24.69 [2.09]	12.50 [0.82]	10.56 [0.63]	8.88 [0.62]	7.00 [0.82]
Volume (mL) Mean [SD]	280.81 [44.90]	259.56 [19.48]	254.19 [24.53]	260.75 [15.44]	259.44 [23.19]	267.56 [19.18]
	4 Units					
N	32	32	32	32	32	32
Time (min) mean (SD)	12.38 [2.13]	27.19 [4.41]	16.56 (1.37)	13.78 (0.97)	11.25 (0.76)	9.63 (0.87)
Volume (mL) Mean (SD)	284.0 [45.49]	265.94 [15.21]	264.81 (14.14)	267.31 (12.50)	265.78 (14.89)	267.28 (17.77)

Abbreviations: SS-III, Sarstedt Sahara-III Maxitherm; TT, Thermogenesis Thermoline.

using Siemens Dade Actin FS and Siemens factor deficient plasma; FVIII assay was measured using Hyphen Biomed Biophen VIII chromogenic assay; PC was measured using Siemens Berichrom Protein C chromogenic assay; FPS was measured using Siemens INNOVANCE Free PS latex immunoassay and fibrinogen was measured by the Clauss method using Siemens Thrombin. All reagents were supplied by Sysmex UK (Milton Keynes, UK).

2.4 | Statistical analysis

Data have been summarised as means and standard deviations. Analysis of variance (ANOVA) was conducted to determine if the thawing times of 2 units and then 4 units of FFP were different when thawed using a different thawer and also for comparing concentration of each factor across arms and over time. For haemostatic assays Tukey's multiple comparisons test was used. For all tests a p value of below 0.05 indicated a statistically significant difference.

3 | RESULTS

3.1 | Time to thaw

Table 1 provides details of thawing times and plasma volumes for both 2 and 4 units. Thawing times for 2 units of FFP were significantly different between thawers, with PTV being fastest at both 45°C (mean 7.06 min, [SD 0.68]) and 37°C (8.88 min, [0.62]), followed by PTC (45°C = 10.56 min, [0.63]; 37°C = 12.5 min, [0.82]) and TT (12.88 min, [2.39]) and SS-III (24.69 min, [2.09]).

Similar findings were observed with thawing times for 4 units of FFP, PTV being the fastest at 45°C (9.63 min [0.87]) and SS-III 37°C being slowest (27.18 min [4.4]). The difference between TT at 37°C and PTC showed that the former was slightly faster (12.37 min [2.1]) than the latter (45°C = (13.78 min [0.97]), 37°C (16.56 min [1.36])), although this was not statistically significant ($p = 0.692$).

TABLE 2 Baseline values for all haemostatic assays activated partial thromboplastin time (APTT); prothrombin time (PT); fibrinogen (fib); factor (F)II, FV, FVII, FVIII and FXI activity; free protein S antigen (FPS); and protein C activity (PC) from plasma thawed using the six different thawing methods.

Haemostatic Assay	Reference range	TT WaterBath 37°C Mean [SD]	Plasmatherm Classic 37°C Mean [SD]	Plasmatherm Classic 45°C Mean [SD]	Plasmatherm V 37°C Mean [SD]	Plasmatherm V 45°C Mean [SD]
APTT (s)[a]	21–31	28.26 [0.60]	28.78 [0.85]	29.05 [0.42]	27.55 [0.59]	27.88 [0.34]
PT (s)	8.8–11.7	10.83 [0.25]	11.01 [0.32]	11.05 [0.18]	11.13 [0.31]	10.85 [0.12]
Fibrinogen (g/L)	1.56–4.00	2.44 [0.41]	2.15 [0.37]	2.29 [0.23]	2.32 [0.34]	2.53 [0.18]
FII (IU/dL)	70–146	89.65 [10.28]	99.74 [4.37]	90.78 [6.16]	87.83 [4.71]	91.95 [1.79]
FV (IU/dL)	62–150	92.49 [12.3]	98.46 [6.79]	96.61 [7.74]	104.63 [13.47]	118.17 [9.50]
FVII (IU/dL)[a]	67–143	84.61 [10.30]	96.93 [5.00]	87.25 [6.23]	98.68 [13.39]	98.53 [7.68]
FVIII (IU/dL)[a]	52–153	57.66 [12.91]	75.95 [7.67]	56.93 [6.97]	82.3 [9.03]	75.65 [5.26]
FXI (IU/dL)[a]	58–148	64.91 [7.86]	76.38 [4.46]	68.04 [5.63]	82.37 [7.08]	82.40 [5.78]
PC (IU/dL)	72–162	88.96 [8.46]	94.14 [8.10]	91.38 [5.09]	97.30 [10.25]	98.92 [6.84]
FPS (IU/dL)	67–140	90.01 [5.37]	84.95 [7.64]	91.49 [3.54]	86.57 [7.94]	83.55 [5.74]

[a]Indicates the haemostatic assays that showed a statistically significant difference between Plasmatherm V at both 37°C and 45°C and all other methods.

3.2 | Haemostatic assays

Baseline measurements for all assays with each thawing method were within the normal reference ranges for a healthy adult. The baseline measurements demonstrated that there was no significant difference between PT, fibrinogen, FII, FV, PC or FPS between all methods tested. However, there was a significant difference in baseline APTT, FVII, FVIII and FXI between PTV versus other methods, with PTV at 37 and 45°C having a higher level of each of these factors and a shortened APTT at the baseline when compared with other methods (Table 2).

Data on all haemostatic assays is presented in Figure 2. Over time clotting factors reduced with all methods. For the second time point of 24 h post thaw there was no statistically significant difference between APTT, PT, fibrinogen, FII, FV, FVII, FVIII, PC or FPS between all methods. There was however a statistically significant difference between FXI in units thawed with the TT versus those thawed using PTV at both 37 and 45°C, with the PTV at 37 and 45°C being higher. At the final time point of 120 h there was no statisitically significant difference between APTT, PT, fibrinogen, FII, FV, FVII, FVIII, PC or FPS between all methods. However, there was a statically significant difference between PTV at 45°C and all other methods with FV, with the PTV at 45°C being higher.

4 | DISCUSSION

In this study we set to compare the thawing time of four different devices (1) PTV (PTC) at 37 and 45°C, (2) TT at 37°C, (3) PTC at 37 and 45°C and (4) Sarstedt Sahara-III Maxitherm (SS-III) at 37°C, and evaluate the in vitro haemostatic quality of plasma when thawed at 45°C versus 37°C using PTV. We showed that the PTV provides a faster thawing time (for both 2 and 4 units), particularly at 45°C and that the SS-III had the slowest thawing time. Thawing plasma at 45°C with PTV had no impact on haemostasis compared to PTV at 37°C thawing or other methods. At baseline, PTV (both 37 and 45°C) had significantly higher levels of FVII, FVIII and FXI and shortened APTT when compared to other methods.

In the last decade transfusion resuscitation in major bleeding has changed significantly, with studies in trauma showing that early resuscitation with plasma transfusion reduces mortality in both military and civilian settings,[1–3,9–11] with national guidelines now recommending a 1-to-1 ratio of plasma with red blood cells transfusion.[12,13] For many hospitals, early provision of plasma is a challenge due to the need for thawing. Indeed, the UK major haemorrhage audit in 2018 and other recent clinical trials have shown that the median time to delivering FFP transfusion can be over an hour,[14–17] which in the setting of ongoing bleeding, could be considered a substandard treatment.

Having extended thawed plasma on standby to mitigate this, has created a new problem for transfusion services, in that extended thawed plasma, not used within 5 days is wasted. Moreover, it is well known that the clotting factors in the extended thawed plasma reduce over time,[5] something we also observed in this study, thus, making the argument that better options should be explored to improve the early availability of plasma, without it having an impact on precious resources or the quality of plasma. The use of other products like freeze dry plasma could be a solution to not having to thaw plasma on demand, however, these products do come at a higher cost for clinical services, they are supplied in glass bottles, which is not ideal in an emergency situation, and lastly, like the extended thawed FFP, the quality of plasma is impaired by different treatments.[5]

In this study we demonstrated that PTV at 45°C was the fastest method at thawing 2 and 4 units of FFP compared to all methods assessed, with the mean thaw-time being 7.06 and 9.63 min, respectively. This is approximately 4 min shorter than PTC and TT and 20 min shorter than SS-III. Further, thawing times and clotting results

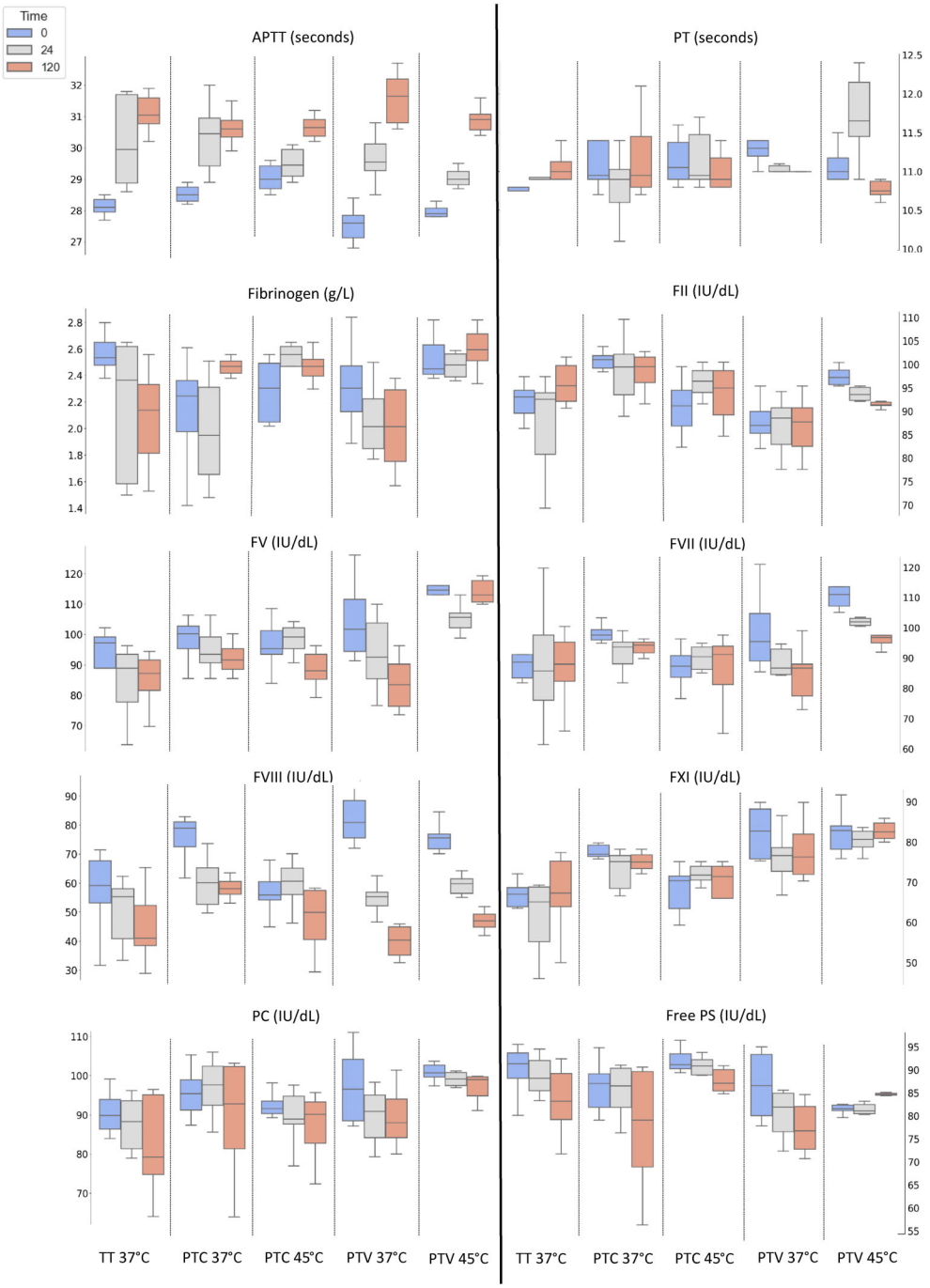

FIGURE 2 Boxplots of all haemostatic assays performed on LG-Octaplas thawed over 3 different time points: Baseline (0), 24 h post thaw (24) and 120 h post thaw (120) using different thawing methods: Thermogenesis Thermoline (TT), PlasmaTherm Classic (PTC) at 37 and 45°C and PlasmaTherm V (PTV) at 37 and 45°C.

with PTV had overall fewer variabilities than other methods. Considering that other variables in our study remained constant and the same for different methods, we believe that the difference in thaw time can only be explained by the differences that exist between different methods. The SS-III method is a dry thawing method that does not use water, instead the air surrounding the plasma is heated, whereas the PTC and the PTV are also both classified as dry heating systems, but they contain two large cushions filled with water that is heated and both contain a paddle to gently agitate the plasma to speed up thaw time. From the results of this study the water-based methods demonstrate a quicker time to thaw. The dry water methods (PTC and PTV) also offer major advantages compared to the open water bath method (TT) as these devices are smaller, meaning that they require less laboratory space, and maintenance is less cumbersome than that of TT where water needs to be changed more frequently.

The overall haemostatic quality of plasma as measured by the current clotting factor assays, was not impaired by the 45°C of PTV, but rather FVII, FVIII and FXI were higher at baseline with PTV compared to other methods, shortening the APTT. Previously, we demonstrated similar results with thawing plasma using PTC at 45 versus 37°C.[7] It is believed that higher thawing temperatures might impair the viability

of plasma proteins,[18] however in most studies that have evaluated the plasma quality, higher temperatures have been used (>55°C) with the focus being the viability of FVIII for treatment of haemophilia patients. Currently, in the UK, and in most developed countries, plasma transfusion is administered to replace the global deficiency of clotting factors that occurs during bleeding, and in most cases FVIII deficiency is not a major concern, although in this study FVIII was higher at baseline with PTV at 45°C.

Going forward, as the technology of plasma thawers continues to improve, international agreement on the evaluation of novel plasma thawing devices may be required, including which plasma proteins should be measured. Until such guidance becomes available, and based on this study, we would recommend the use of water based thawing methods.

Our study has strengths and limitations. The strengths are (a) the ability to evaluate several thawing methods at once that are current standards for most UK hospitals, and (b) a comprehensive haemostatic assessment of plasma thawed at different temperatures for these methods, using tests that are currently believed to reflect the quality of plasma. One of the limitations of this study is the retrospective assessment of plasma quality for the TT and PTC methods, which makes the results less reliable that if they were all performed at the same time. However, for both retrospective and prospective haemostatic assessment we used the same methods for all clotting assays we evaluated, the same analyser and the same scientist for both studies, thus minimising any variations that may have occurred over time. Another limitation is the inability to assess plasma quality using Sahara method: this was due to logistical issues with samples and testing; however, we would not recommend its use for thawing plasma in an emergency, due to the significant delays in thawing time compared with all other methods. Finally, we were unable to assess the quality of samples using Thrombin Generation or Viscoelastic testing which would have strengthened the in vitro haemostatic analysis.

In conclusion, Plasmatherm-V at 37 and 45°C provided a faster thawing time (for both 2 and 4 units), particularly at 45°C, while Sahara methods has the longest thawing time. Thawing plasma at 45°C with PTV had no impact on haemostasis compared to PTV at 37°C thawing or other methods, and thus thawing frozen components at 45°C should be considered by laboratories to improve the rapid availability of plasma and reduce plasma wastage due to provision of extended thawed plasma.

AUTHOR CONTRIBUTIONS

JM and LG designed the study, reviewed the manuscript and made all subsequent revisions. JM collected the data, performed the analysis and drafted the manuscript. SP contributed to the data collection, data analysis and writing of the manuscript. JL, CB and PR contributed to the data collection and writing of the manuscript. All authors read and approved the final manuscript.

ACKNOWLEDGEMENTS

Authors would like to acknowledge Sara Hall and Tobias Mapulanga for their support with thawing.

FUNDING INFORMATION

Funding for consumables was obtained from Barkey GmbH & Co. KG. The funders had no involvement in the writing of the manuscript or interpretation of the results.

CONFLICT OF INTEREST STATEMENT

The authors have no competing interests.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

REFERENCES

1. Holcomb JB, Tilley BC, Baraniuk S, et al. Transfusion of plasma, platelets, and red blood cells in a 1:1:1 vs. a 1:1:2 ratio and mortality in patients with severe trauma. *JAMA*. 2015;313(5):471. doi:10.1001/jama.2015.12
2. Sperry JL, Guyette FX, Brown JB, et al. Prehospital plasma during air medical transport in trauma patients at risk for hemorrhagic shock. *N Engl J Med*. 2018;379(4):315-326. doi:10.1056/NEJMoa1802345
3. Borgman MA, Spinella PC, Perkins JG, et al. The ratio of blood products transfused affects mortality in patients receiving massive transfusions at a combat support hospital. *J Trauma*. 2007;63(4):805-813. https://journals.lww.com/jtrauma/Fulltext/2007/10000/The_Ratio_of_Blood_Products_Transfused_Affects.13.aspx
4. Shackelford SA, Del Junco DJ, Powell-Dunford N, et al. Association of Prehospital Blood Product Transfusion during Medical Evacuation of combat casualties in Afghanistan with acute and 30-day survival. *JAMA*. 2017;318(16):1581-1591. https://pubmed.ncbi.nlm.nih.gov/29067429/
5. Cardigan R, Green L. Thawed and liquid plasma—what do we know? *Vox Sang*. 2015;109(1):1-10. https://pubmed.ncbi.nlm.nih.gov/25833464/
6. Green L, Bolton-Maggs P, Beattie C, et al. British Society of Haematology Guidelines on the spectrum of fresh frozen plasma and cryoprecipitate products: their handling and use in various patient groups in the absence of major bleeding. *Br J Haematol*. 2018;181(1):54-67. http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1365-2141
7. Platton S, Elegbe O, Bower L, et al. Thawing times and hemostatic assessment of fresh frozen plasma thawed at 37°C and 45°C using water-bath methods. *Transfusion*. 2019 Nov;59(11):3478-3484. https://pubmed.ncbi.nlm.nih.gov/31618455/
8. National Comparative Audit. Audit of the Management of Major Haemorrhage National Comparative Audit of Blood Transfusion. 2018 https://nhsbtdbe.blob.core.windows.net/umbraco-assets-corp/19130/2018-major-haemorrhage-audit-full-report.pdf
9. Cole E, Weaver A, Gall L, et al. A decade of damage control resuscitation. *Ann Surg*. 2019;273(6):1215-1220.
10. Rehn M, Weaver A, Brohi K, et al. Effect of prehospital red blood cell transfusion on mortality and time of Death in civilian trauma patients. *Shock*. 2019;51(3):284-288.
11. Tucker H, Brohi K, Tan J, et al. Association of red blood cells and plasma transfusion versus red blood cell transfusion only with survival for treatment of major traumatic hemorrhage in prehospital setting in England: a multicenter study. *Crit Care*. 2023;27(1):25.
12. Stanworth SJ, Dowling K, Curry N, et al. A guideline for the haematological management of major haemorrhage: a British Society for Haematology Guideline. *Br J Haematol*. 2022;198(4):1-14.
13. Callum JL, Yeh CH, Petrosoniak A, et al. A regional massive hemorrhage protocol developed through a modified Delphi technique. *CMAJ Open*. 2019;7(3):E546-E561. https://www.cmajopen.ca/content/7/3/E546

14. Curry N, Rourke C, Davenport R, et al. Early cryoprecipitate for major haemorrhage in trauma: a randomised controlled feasibility trial. *Br J Anaesth [Internet]*. 2015;115(1):76-83. https://pubmed.ncbi.nlm.nih.gov/25991760/
15. Green L, Roberts N, Cooper J, et al. Prothrombin complex concentrate vs. fresh frozen plasma in adult patients undergoing heart surgery—a pilot randomised controlled trial (PROPHESY trial). *Anaesthesia*. 2021;76(7):892-901. https://pubmed.ncbi.nlm.nih.gov/33285008/
16. Green L, Daru J, Gonzalez Carreras FJ, et al. Early cryoprecipitate transfusion versus standard care in severe postpartum haemorrhage: a pilot cluster-randomised trial. *Anaesthesia [Internet]*. 2022 Feb;77(2):175-184. https://pubmed.ncbi.nlm.nih.gov/34671971/
17. Green L, Brohi K, Allen E, et al. UK audit of the management of major bleeding and time taken to deliver blood products. *Br J Anaesth*. 2022;129(5):e111-e114. https://pubmed.ncbi.nlm.nih.gov/36031419/
18. Batty P, Hart DP, Platton S. Optimization of pre-analytical heat treatment for inhibitor detection in haemophilia a. *Int J Lab Hematol*. 2018;40(5):561-568. doi:10.1111/ijlh.12862

How to cite this article: McCullagh J, Booth C, Lancut J, Platton S, Richards P, Green L. Every minute counts: A comparison of thawing times and haemostatic quality of plasma thawed at 37°C and 45°C using four different methods. *Transfusion Medicine*. 2024;1-7. doi:10.1111/tme.13061