Fresh Frozen Plasma Usage in Six New Zealand Hospitals

Final Report

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EXECUTIVE SUMMARY

BACKGROUND
A steady increase in the use of Fresh Frozen Plasma (FFP) has been seen internationally, despite increasing concerns about complications, particularly Transfusion related acute lung injury (TRALI), and the lack of evidence for much of FFP's use.

AIM
The aim of this audit was to investigate the appropriateness of use of FFP, guided by the NHMRC/ASBT guidelines[7], at Auckland City, Starship, Waikato, Palmerston North, Wellington, Christchurch, Christchurch Women's and Dunedin Hospitals by collecting a minimum of fifty episodes of FFP transfusion at each site.

METHOD
An episode is defined as each time the participating blood bank issues one or more units of FFP to a patient. The following data were collected for each episode: demographic data, time of infusion, number of FFP units, prescribed rate and actual duration of infusion, the number of red cells, fresh frozen plasma, platelets, cryoprecipitate units, and/or vials of Prothrombinex®-HT transfused in the previous 12 hours, clinical diagnosis, indication for FFP, rate of bleeding, cardiac status, recent warfarin therapy, relevant co-morbidities, coagulation and blood count test results

Two NZBS Transfusion Medicine Specialists assessed the appropriateness of each episode, based on the NHMRC/ASBT guidelines[7], the principles of use in bleeding patients, and considering Prothrombinex®-HT as an alternative to FFP[12].

RESULTS
The six centres collected 335 episodes involving 867 units of transfused FFP. 79% of episodes were assessed as appropriate or probably appropriate. 50% of transfusions were underdosed, even allowing for those transfusions split over time for heart failure. Underdosing varied significantly between DHBs. Warfarin reversal accounted for 18% of episodes but Prothrombinex®-HT use was minimal. Patients transfused FFP for mildly abnormal INR results showed an average of 0.1 fall in INR, despite a full dose of FFP. Excluding transfusions for TTP, and specific coagulation proteins, coagulation testing was conducted in 98.7% of episodes, within an average of 6.7 hours before transfusion. FFP was prescribed and transfused in under an hour in 90% and 88% of episodes respectively.

COMMENT
The results of this audit compare well with other countries, with appropriate transfusions seen in 63% and 72% in two separate audits in Australia, 27% in Singapore, 30% in Taiwan, and 62-92% in six audits in the UK. Appropriate dosing was not reported as widely but UK audits ranged from 33-84%. Nevertheless the high level of underdosing is of concern, particularly with the strong association between transfusion-related acute lung injury (TRALI) and FFP. While a low dose may argued as reducing the risk of TRALI, an ineffectual dose confers a risk onto the patient with no or reduced corresponding benefit. The variation between DHBs suggests this may be amenable to education. The low level of Prothrombinex®-HT use and the number of episodes that could have been managed better with vitamin K suggest the Australian Society of Thrombosis and Haemostasis (ASTH) warfarin reversal guidelines have not been well embraced. FFP transfusions for mildly abnormal coagulation are considered of doubtful value, as demonstrated by the poor fall in INR in response to FFP.

RECOMMENDATIONS
Recommendations are included concerning education regarding dose, the rate of transfusion, the use of Prothrombinex as the preferred product for warfarin reversal and the lack of effect of FFP when given for mildly abnormal coagulation results pre-operatively.

INTRODUCTION

Fresh Frozen Plasma (FFP) in New Zealand is recovered from whole blood donations. The plasma is leucocyte-depleted and frozen rapidly within 8 hours of collection to a temperature that will maintain the activity of the labile coagulation factors. The volume of each unit is on average 275ml (range:180-340 ml) and is recognised as a rich source of coagulation factors, including factors V and VIII.[1] FFP has therefore been frequently used to[2,3]:

- correct coagulopathy during massive transfusions where there is active bleeding
- reverse the effect of warfarin
- correct coagulation deficiencies in the presence of active bleeding.

Internationally, improvements in FFP collection and storage have made transfusions safer, however there are still risks associated with its administration. These include viral infections, febrile reactions, allergic reactions, circulatory overload, and transfusion related acute lung injury.

A steady increase in the clinical use of FFP has been witnessed internationally[4], despite the limited indications for the use of FFP, a lack of robust clinical evidence of its efficacy[4], and increasing concerns about TRALI[5]. Between 2001 and 2007, FFP use in New Zealand has been stable, although there are significant differences in usage between individual District Health Boards.[6] In the financial year 2006/7 a total of 22,045 units of FFP were used in New Zealand with 63% being issued to the hospitals that will be participating in this audit.

Guidelines

There are several publications to help guide clinicians in the use of FFP[7,9]. New Zealand Blood Service (NZBS) follows the NHMRC/ASBT guidelines[7]. From these guidelines, the use of FFP is likely to be appropriate for:

Indication *	**Considerations**
Single factor deficiencies	Use specific factors if available
Warfarin Effect	In the presence of life-threatening bleeding. Use in addition to Vitamin-K-dependent concentrates.
Acute DIC	Indicated where there is bleeding and abnormal coagulation. Not indicated for chronic DIC.
TTP	Accepted treatment
Coagulation inhibitor deficiencies (e.g. protein S deficiency)	May be appropriate in patients undergoing high-risk procedures. Use specific factors if available.
Following massive transfusion or cardiac bypass	May be appropriate in the presence of bleeding and abnormal coagulation
Liver Disease	May be appropriate in the presence of bleeding and abnormal coagulation

*****The use of fresh frozen plasma for indications not listed in this table is unlikely to be considered appropriate. Consult the NHMRC/ASBT guidelines for further details. Clinical and laboratory indications should be documented.
Note: Abnormal coagulation is defined here as INR or APTT greater than 1.5 times normal.

Use of FFP in the bleeding patient

The use of FFP in surgical and traumatic bleeding is the subject of much debate. British Committee for Standards in Haematology (BCSH) guidance[8] is that whether and how much FFP should be used for treating a patient with major blood loss should be guided by timely tests of coagulation, including near-patient tests such as thromboelastography (TEG). American Association of Blood Banks (AABB) guidance[9] in the setting of massive transfusion

is to use FFP if the INR is greater than 1.5. In practice, and especially in exsanguinating bleeding, basing the decision to transfuse FFP on coagulation test results may be difficult to achieve. Although the decision to transfuse FFP should not be based on formulae[8], if the laboratory results are not available, it is reasonable to give FFP after replacement of one blood volume while waiting for results[10,11]. For most indications, the standard dose is 15ml/kg. In the setting of a bleeding trauma patient, due to the complexity of the coagulopathy, FFP may be needed before one blood volume is lost and higher doses may be appropriate[10].

Alternatives to FFP

Prothrombinex®-HT in conjunction with FFP is now recommended as an alternative to FFP alone

- by the Australian Society of Thrombosis and Haemostasis (ASTH) in Australia and New Zealand for rapid warfarin reversal[12]
- for prophylaxis and treatment of patients with single or multiple congenital deficiency of factor IX, II or X.[13]

No justification for the use of FFP

BCSH guidelines[8] specify that FFP is not indicated as a simple volume expander, the reversal of a prolonged INR in the absence of bleeding, or in plasma exchange other than TTP (other than to correct haemorrhage due to reduction of coagulation factor concentrations).

This audit

The aim of this audit was to investigate the appropriateness of use of FFP at Auckland City, Starship, Waikato, Palmerston North, Wellington, Christchurch, Christchurch Women's and Dunedin Hospitals by collecting a minimum of fifty episodes of FFP transfusion at each site.

METHOD

Data was collected prospectively by the NZBS Transfusion Nurse Specialists (TNSs).

Specific issues considered were

- Was the indication appropriate?
- Was the decision to transfuse appropriate based on INR result and bleeding status?
- Was the correct dose given, as measured against the NHMRC/ASBT guidelines?

A pilot of ten episodes were collected at each site. An episode was defined as each time the participating blood bank issued one or more units of FFP to a patient. The process and data collection form were reviewed at the end of the pilot, with any changes to data capture made as required.

The following data were collected:

- Demographic data: the patient's initials, Progesa number, NHI number, age, gender, and weight of recipient (where available).
- Product data: time of infusion, number of FFP units, prescribed rate and actual duration of infusion, the number of red cells, fresh frozen plasma, platelets, cryoprecipitate units, and/or vials of Prothrombinex®-HT transfused in the previous 12 hours
- Clinical data: clinical diagnosis, indication for FFP, rate of bleeding (faster or slower than 1L/hour), cardiac status, recent warfarin therapy, relevant co-morbidities
- Laboratory data: coagulation blood test results (pre and post infusion INR, Fibrinogen, APTT), Hb, platelet count

The data were collated in a Microsoft Access database with restricted access, located on the NZBS internal network. Only the TNSs and the Transfusion Medicine Specialists (TMSs) directly overseeing the audit had access to the identifying data.

Two NZBS TMSs reviewed the data to seek a consensus on the appropriateness of each episode, based on the NHMRC/ASBT guidelines[7], the principles of use in bleeding patients discussed above, and considering Prothrombinex®-HT as an alternative to FFP[12]. Episodes assessed as probably appropriate are reported with the appropriate transfusions for readability. Similarly, probably inappropriate transfusions are reported with the inappropriate transfusions.

The report was issued as a draft to the Hospital Transfusion Committees of the hospitals involved for comment. Following this, the report has now been finalised and issued back to the Hospital Transfusion Committees and Demand Management contacts for all DHBs. All patient identifying data has been removed prior to reporting.

RESULTS

The six centres collected a total of 335 episodes over three months, involving 867 units of FFP. All sites captured the minimum of fifty episodes, although two episodes from Palmerston North were merged into one, on the recommendation of the clinical reviewers.

Table 1: *Number of episodes collected per site*

Hospital	No of episodes
Auckland	77
Christchurch	50
Dunedin	58
Palmerston North	49
Waikato	50
Wellington	51
Total	335

Demographics

The median age of the 190 patients was 59 years (range: 0 –92 years), and 62% were male. The mean number of episodes per patient was 1.8 (range: 1 – 15) and the mean number of units of FFP transfused per patient in the audit was 4.6 (range: 1 – 64).

Appropriateness of Transfusion

Two experienced Transfusion Medicine Specialists, blinded to the location of episodes, assessed the appropriateness of each FFP transfusion episode. The assessment considered the whole context of the patient drawing upon all the data provided by the audit. Overall 79% of transfusions were considered appropriate, but with variation between indications and qualifiers as defined by the NHMRC/ASBT guidelines (table 2). The small number of episodes for each indication makes statistical comparison problematic.

A few cases highlighted some concerns around the indication for transfusion. In one case it appeared FFP was being used to maintain a patient's blood pressure, a clearly inappropriate use of FFP where much safer alternatives such as Albumex, other colloids and saline exist. Although this is easier to identify after the fact, several instances occurred where clinicians were misled by incorrect laboratory results, possibly diluted or clotted samples. Lastly, although the transfusion of FFP was appropriate at the time of transfusion, had alternative

strategies been used earlier, particularly around warfarin reversal, FFP transfusion could have been avoided or minimised.

Table 2: *Appropriateness of transfusion by indication*

Indication	Qualifier	Appropriate %	n
Acute DIC	Bleeding with abnormal coagulation tests	91%	43
	Chronic DIC (e.g. in malignancy)	0%	1
	Not bleeding	25%	4
Coagulation inhibitor deficiencies	Not undergoing high risk procedure	67%	3
Massive transfusion or cardiac bypass	Bleeding	84%	100
	Not bleeding	64%	11
Liver disease	Bleeding	92%	25
	Not bleeding	86%	7
Single factor deficiency	Specific factor available (e.g. Biostate)	83%	6
	Specific factor not available	83%	6
TTP	No plasma exchange	100%	6
	With plasma exchange	100%	11
Warfarin effect	In the presence of life-threatening haemorrhage	93%	15
	No life threatening haemorrhage	75%	44
Other	Bleeding	52%	33
	Bypass priming	0%	1
	Intra-/post-op with abnormal coagulation	55%	11
	Pre-op with abnormal coagulation	86%	7
	Prophylaxis - high risk surgery, normal coagulation	0%	1
Overall		79%	335

Some variation was seen when comparing appropriateness per indication between the different DHBs involved in the audit (table 3). Some indications stand out for particular institutions as having lower than average percentages. The variation across DHBs for each DHBs overall percentage of appropriate transfusions reached statistical significance (p=0.049)

Table 3: *Appropriateness of transfusion by indication and DHB*

Indication	Auckland	Christchurch	Dunedin	Palmerston North	Waikato	Wellington	Overall
Acute DIC	83% (12)	86% (7)	100% (10)	100% (5)	75% (4)	80% (10)	88% (48)
Coagulation inhibitor deficiencies		67% (3)					67% (3)
Liver disease	100% (11)		90% (10)	100% (2)	86% (7)	50% (2)	91% (32)
Massive transfusion or cardiac bypass	57% (30)	100% (13)	100% (11)	89% (18)	94% (17)	82% (22)	82% (111)
Single factor deficiency		100% (1)	67% (3)		100% (7)	0% (1)	83% (12)
TTP	100% (10)	100% (5)		100% (2)			100% (17)
Warfarin effect	100% (5)	100% (8)	91% (11)	63% (16)	100% (8)	55% (11)	80% (59)
Other	44% (9)	38% (13)	69% (13)	33% (6)	86% (7)	60% (5)	55% (53)
Overall	74% (77)	76% (50)	88% (58)	76% (49)	92% (50)	71% (51)	79% (335)

Common features to inappropriate transfusions

Transfusions that were assessed as inappropriate, compared with appropriate, tended to have a lower INR and APTT and higher fibrinogen levels, tended not to be bleeding and

tended to have had fewer components (red cells, platelets cryoprecipitate and FFP) transfused in the preceding 12 hours (table 4). However, no individual parameter provided a 1:1 correlation as the assessment took a holistic view of the patient and the FFP transfusion. Only 5.7% of episodes had no coagulation testing.

Table 4: *Comparison of appropriate vs not appropriate transfusion by laboratory parameters and preceding transfusions (mean ± standard deviation)*

		FFP not appropriate	FFP appropriate
Components transfused in preceding 12 hours	FFP	0.8 ± 1.5	2.3 ± 4.1
	Platelets	0.5 ± 0.7	0.7 ± 1.1
	Cryo	0.2 ± 0.8	0.4 ± 1.2
	Red cells	1.9 ± 2.1	4.0 ± 6.3
Pre-transfusion lab values	Hb	97 ± 22	95 ± 27
	Plt	172 ± 112	151 ± 114
	INR	1.5 ± 0.7	2.3 ± 1.8
	APTT	47 ± 38	54 ± 31
	Fibrinogen	3.4 ± 1.7	2.5 ± 1.7
	n	68	267

Dose

The reviewing Transfusion Medicine Specialists also conducted an assessment of the dose transfused at the same time as the appropriateness assessment. Recognition was given to those patients who had heart failure and for whom FFP had to be given slowly and for whom FFP was therefore requested several times, generating several episodes at a lower dose.

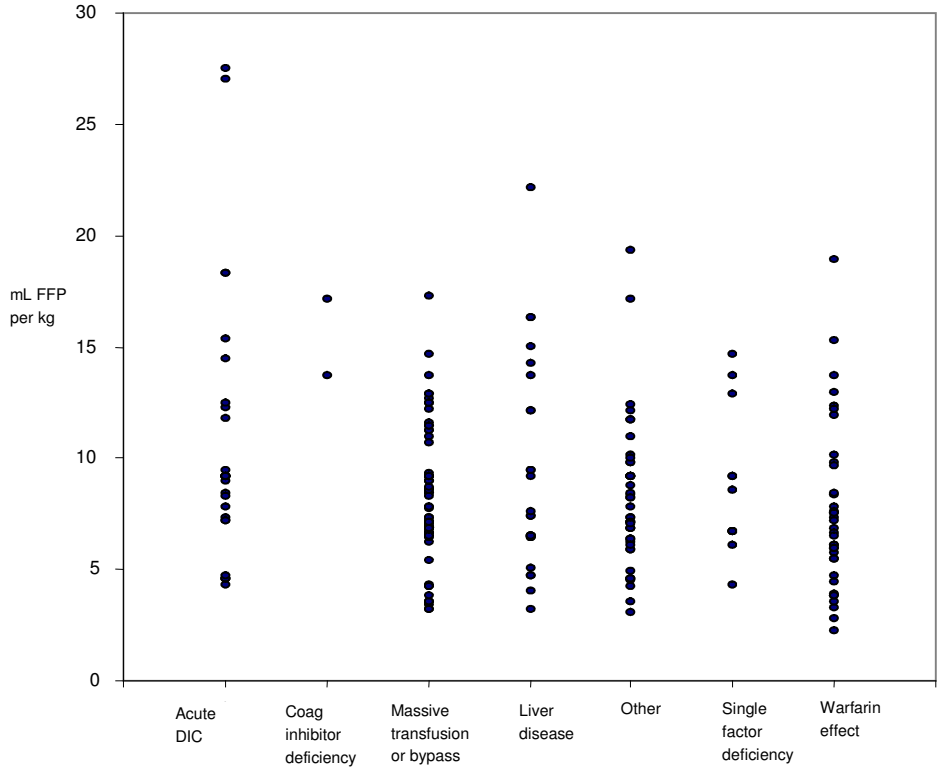

Figure 1: *Dose of FFP transfused per episode by indication*

The spread of doses by indication (figure 1) excluded children under 20kg for whom only a portion of the unit may have been transfused and was only calculated for those patients for

whom a weight was recorded in the notes (72%). Half of all transfusions where an assessment could be performed were considered to have too low a dose (table 5).

Table 5: *Dose of FFP transfused by indication and qualifier*

Indication	Qualifier	Can't comment	Correct	OK as part of more	Too low	n
Acute DIC	Bleeding, abnormal coagulation	2%	37%	35%	26%	43
	Chronic DIC				100%	1
	Not bleeding		50%		50%	4
Coagulation inhibitor deficiencies	No high risk procedure		100%			2
Massive transfusion or cardiac bypass	Bleeding		39%	18%	42%	99
	Not bleeding		18%		82%	11
Liver disease	Bleeding		32%	12%	56%	25
	Not bleeding		14%	29%	57%	7
Single factor deficiency	Specific factor available	17%	17%		67%	6
	Specific factor not available		67%	17%	17%	6
TTP	No plasma exchange		100%			6
	With plasma exchange		91%	9%		11
Warfarin effect	Life-threatening bleeding		47%		53%	15
	No life-threatening bleeding	2%	16%	7%	75%	44
Other		2%	18%	16%	64%	55
Total		1%	34%	16%	49%	335

Comparing the proportion of patients with correct doses between DHBs (table 6) shows statistically significant differences ($p<0.0001$). A similar comparison of correct doses overall between the indications was also highly significant ($p<0.0001$).

Table 6: *Proportion (and number) of epsiodes with the correct dose by indication and DHB, excluding those the reviewers could not assess*

Indication	Auckland	Christchurch	Dunedin	Palmerston North	Waikato	Wellington	Overall
Acute DIC	83% (12)	71% (7)	90% (10)	100% (4)	25% (4)	40% (10)	70% (47)
Coagulation inhibitor deficiencies		100% (3)					100% (3)
Massive transfusion or cardiac bypass	57% (30)	31% (13)	82% (11)	83% (18)	35% (17)	41% (22)	54% (111)
Liver disease	82% (11)		40% (10)	0% (2)	14% (7)	0% (2)	44% (32)
Single factor deficiency		100% (1)	100% (3)		29% (7)		55% (11)
TTP	100% (10)	100% (5)		100% (2)			100% (17)
Warfarin effect	40% (5)	25% (8)	9% (11)	47% (15)	25% (8)	27% (11)	29% (58)
Other	22% (9)	31% (13)	62% (13)	17% (6)	29% (7)	0% (4)	33% (52)
Overall	65% (77)	48% (50)	59% (58)	62% (47)	28% (50)	33% (49)	

Comparing the dosing of the different DHBs can be seen in the graph below (figure 2).

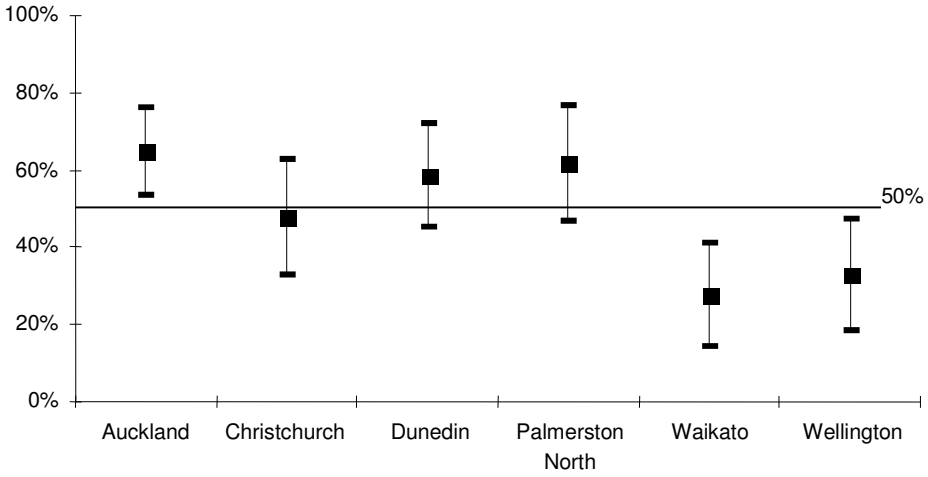

Figure 2: *Proportion of patients with correct dose by DHB, with 95% confidence intervals.*

Looking at the location within hospitals (table 8), revealed no particularly outstanding areas. Comparing recipients whose first dose was low with those who received the correct dose, showed a no significant difference in the number of episodes of FFP transfusion (1.3±0.8 vs 1.4±1.0).

Infusion times

The audit included review of the duration the FFP was prescribed, as well as infused. 90% of prescriptions, counting "stat" as 0 minutes, were for under an hour and 88% were transfused in under an hour (figure 3).

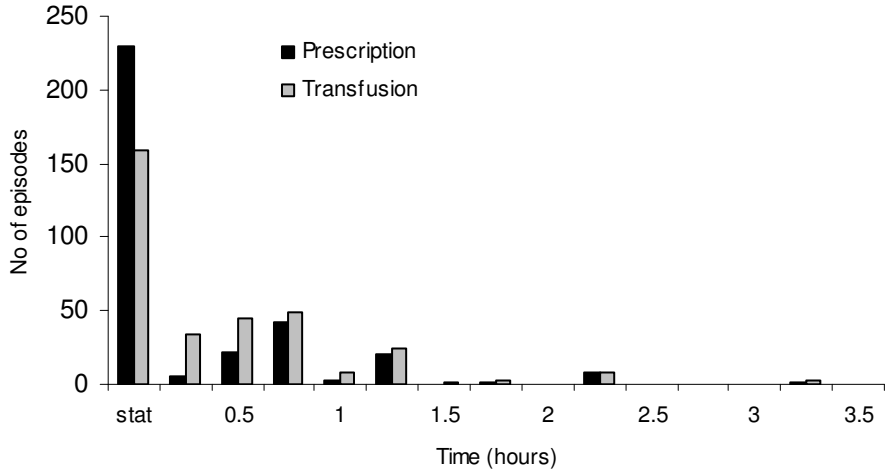

Figure 3: *Prescribed and transfused duration per unit.*

Warfarin Reversal

Prothrombinex®-HT was used on four occasions in the 59 episodes where warfarin effect was the indication for FFP transfusion. Three of these were in the presence of life-threatening haemorrhage. Vitamin K was used on 33 occasions, on average 23 (±43) hours prior to giving FFP. The average oral dose was 15 mg (range:10-20) (n=2). The average parenteral dose was 5.2 mg (range 0.5 to 10) (n=31). The last dose of warfarin was given on average 67 (±61) hours prior to giving FFP.

From the clinical review it was apparent that many instances of FFP transfusion could have been avoided with timely use of vitamin K. Similarly, there were many occasions where it was considered that Prothrombinex®-HT, either alone[24] or with FFP, might have been a better agent for warfarin reversal.

Using FFP for near normal INR levels

The response to FFP was assessed in patients given the correct amount of FFP but where the INR was less than 1.7. This was limited to those patients who had pre and post INR results available from within 24 hours of the FFP transfusion (n=23). In this group, the average fall in INR was 0.11 ± 0.16.

Pre-transfusion coagulation testing

Excluding episodes where the indication was TTP or replacement of a specific protein (clotting factor or inhibitor), 98.7% of episodes had coagulation tests performed prior to the administration of FFP. The average interval between the sample being taken and the transfusion was 6.5 ± 20.6 hours

LIMITATIONS

It is accepted that an audit provides only a snap shot of activity over a determined period.

Blood banks have certain limits on the issuing of FFP before medical consultation with a Haematologist or Transfusion Medicine Specialist is required. This oversight affects the use of FFP and may vary from site to site.

Incomplete data sets limited certain aspects of the analysis. Patient weights were not documented in a quarter of patients and coagulation studies were not taken within 24 hours either side of the transfusion in almost 20% of episodes. Together, this excluded over a third of episodes from the analysis of response to FFP. Related to this, the audit did not formally look for thromboelastograph (TEG) results as an indicator of platelet function, partly because of the difficulty of tracking down these results. This may have provided additional information about appropriateness of use.

There were six Transfusion Nurse Specialists collecting data. This permitted a national audit to be performed, but an inherent problem with multiple collectors is that when an episode requires a comment, various interpretations can be placed on that comment. An attempt to reduce this from occurring was made with the format of the form used to collect data and regular telephone and face to face meetings to clarify problems raised during the audit period.

The Transfusion Medicine Specialist review was conducted using the information provided by the audit. While key points were sought, the data is inevitably not as complete as a full review of each patient's clinical record. This introduces a level of assumption into the assessment of appropriateness. Potential for bias exists, as the two specialists were actively involved in the management of some of the audit episodes, although the episodes were blinded for location at the time of review.

The audit design included more episodes from Auckland than from other DHBs, reflecting that Auckland DHB is the largest consumer of FFP nationally. Although of itself, this introduces an element of skewing, it does partly correct the overrepresentation of lower use DHBs.

Lastly, this audit did not assess the clinical outcome other than limited post-FFP changes to the INR. While desirable, this would have added considerably to the complexity of the audit,

beyond the resources available. Similarly, it was not possible to assess the morbidity or mortality prevented by episodes assessed as inappropriate. Assessments were therefore made in line with international best practice guidelines and clinical experience.

COMMENT

This audit looked at 335 episodes of fresh frozen plasma transfusions across six of New Zealand's larger hospitals. Together these hospitals use two thirds of the country's FFP[6]. Internationally, New Zealand is a relatively low user of FFP (5.3 units per 1000 population per annum), compared with Germany (15.8), USA (13.9) and the UK (6.4)[14]. An alternative measure, which aims to reflect the appropriateness of use of FFP, is the FFP: red cell transfusion ratio. When compared to twelve European countries, with a median ratio of 5.4 units of red cells per unit of FFP transfused, New Zealand is an average user, with a ratio of 5.6.[25]

The audit found that overall 79% of transfusions were appropriate or probably appropriate after clinical review and guided by the NHMRC/ASBT guidelines. This compares well with other published audits – 63% and 72% in two separate audits in Australia[15,16], 27% in Singapore[17], 68% in Northern Ireland[18],30% in Taiwan[19], and 62-92% in six audits in the UK[20].

The dose transfused was assessed as correct in only 50% of cases, even allowing for delayed transfusions, and hence separate episodes, for patients with heart failure. Poor dosing showed significant variation between different DHBs, suggesting that this was not a function of the auditing process and a problem that could be amenable to education. When comparing with other reports, published audits seldom refer to dose but one UK report showed a wide range in correct dosing over three audits (33-84%)[20].

The relevance of appropriateness and dose is the high incidence of TRALI reported in New Zealand[21] (one case in every 2119 recipients), with FFP being the component most strongly associated with this complication of transfusion[5]. While a low dose may be argued as reducing the risk of TRALI, an ineffectual dose confers a risk onto the patient with no or reduced corresponding benefit.

Warfarin reversal accounted for 18% (n=59) of FFP transfusions while Prothrombinex®-HT was used in only four of these. Although the ASTH[12] guidelines acknowledge a role for FFP alone for warfarin reversal, Prothrombinex®-HT is the preferred product for emergency reversal with its better safety profile. However vitamin K or warfarin withdrawal are the mainstay of warfarin reversal and the clinical review noted that strategies to implement this would have reduced the number of patients requiring FFP. This audit did not look at patients managed for warfarin reversal using Prothrombinex®-HT, vitamin K or warfarin withdrawal without FFP, so it is not possible to comment whether this is a significant problem. However FFP use for warfarin reversal (extrapolated from warfarin reversal data in this audit) is 3.5 time the use of Prothrombinex (unpublished NZBS data), suggesting the ASTH guidelines have not been well embraced.

Using FFP outside of the NHMRC/ASBT (or BCSH) guidelines for correcting mildly abnormal coagulation studies prior to a surgical procedure is of doubtful value[22,23]. This audit supports this conclusion, with an average fall of only 0.1 in patients given a full dose of FFP for an INR of less than 1.7. What little evidence has been published suggests at worst a lack of efficacy combined with the risks of exposure to transfusion, or at best a large number of patients transfused for little gain. Further, the INR may be raised despite normal thrombin generation in liver disease[24], resulting in unnecessary FFP transfusions.

It was reassuring to note that almost all episodes, other than for plasma exchange and specific clotting factor or inhibitor replacement, had pre-transfusion coagulation studies to guide management.

A surprising finding was how fast most units of FFP were transfused, with almost all units transfused in under an hour. Because the severity of reactions is proportional to the rate of infusion, and because allergic reactions are not uncommon with FFP, it is suggested that other than in rapid massive transfusions, each unit FFP should be transfused more slowly at the outset to monitor for allergic reactions.

In conclusion, the comparatively high compliance with NHMRC/ASBT guidelines is reassuring but the high level of underdosing and the inference that warfarin reversal guidelines have not been taken up well are of concern.

RECOMMENDATIONS

There appears to be a need to provide education to clinical staff regarding

- The correct dose of FFP (12-15 mL/kg bodyweight) for a therapeutic dose. To encourage this, it is recommended that FFP prescriptions are calculated in mL and then rounded to the nearest unit of FFP.
- The rate of transfusion of FFP, with regard to the incidence and severity of adverse reactions as well as the risks of volume overload in relation to cardiovascular status
- The use of Prothrombinex as the preferred product for warfarin reversal
- The lack of effect of FFP when given for mildly abnormal coagulation results pre-operatively.

The relatively high level of appropriate indications suggests that training in this regard is working well and should continue.
There appears to be a need to provide education to blood bank staff in relation to appropriate dosage.

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Statistical analysis

Means, standard deviations and confidence intervals were calculated using Microsoft Excel 97. Chi-squared tests were performed using OpenEpi (http://www.openepi.com) [cited 2007 September 05].

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Abbreviations

AABB	American Association of Blood Banks	INR	International Normalised Ratio
APTT	Activated partial thromboplastin time	NHMRC	National Health & Medical Research Council
ASBT	Australasian Society of Blood Transfusion	NZBS	New Zealand Blood Service
ASTH	Australasian Society of Thrombosis and Haemostasis	TEG	Thromboelastograph
BCSH	British Committee for Standards in Haematology	TMS	Transfusion Medicine Specialist
DHB	District Health Board	TNS	Transfusion Nurse Specialist
DIC	Disseminated Intravascular Coagulation	TRALI	Transfusion related acute lung injury
FFP	Fresh frozen plasma	TTP	Thrombotic Thrombocytopenic

Hb	Haemoglobin concentration		Purpura

APPENDICES

Appendix 1: *Percentage and number of appropriate transfusions by indication and location within hospital*

Indication	Delivery	ED	HDU/Post-op	ICU	OpTh	Ward	Overall
Acute DIC		50% (2)	100% (1)	100% (18)	100% (13)	64% (14)	88% (48)
Coagulation inhibitor deficiencies						67% (3)	67% (3)
Liver disease		100% (9)	0% (1)	86% (56)	77% (43)	50% (2)	82% (111)
Massive transfusion or cardiac bypass			67% (3)	92% (12)	100% (10)	86% (7)	91% (32)
Single factor deficiency					75% (4)	88% (8)	83% (12)
TTP						100% (17)	100% (17)
Warfarin effect		100% (14)		33% (3)	100% (6)	72% (36)	80% (59)
Other	50% (2)		100% (1)	54% (13)	52% (25)	58% (12)	55% (53)
Overall	50% (2)	96% (25)	67% (6)	83% (102)	78% (101)	76% (99)	80% (335)

Appendix 2: *Percentage and number of episodes with the correct dose by indication and hospital location, excluding those the reviewers could not assess*

Indication	Delivery	ED	HDU & Post-op	ICU	OpTh	Ward	Overall
Acute DIC		50% (2)	100% (1)	72% (18)	69% (13)	69% (13)	70% (47)
Coagulation inhibitor deficiencies						100% (3)	100% (3)
Liver disease			33% (3)	33% (12)	70% (10)	29% (7)	44% (32)
Massive transfusion or cardiac bypass		89% (9)	0% (1)	61% (56)	40% (43)	50% (2)	54% (111)
Single factor deficiency					100% (4)	29% (7)	55% (11)
TTP						100% (17)	100% (17)
Warfarin effect		43% (14)		0% (3)	50% (6)	23% (35)	29% (58)
Other	0% (2)		0% (1)	38% (13)	36% (25)	27% (11)	33% (52)
Overall	0% (2)	60% (25)	33% (6)	55% (102)	49% (101)	47% (95)	50% (331)