



Appropriateness of Use of Blood Products in Tertiary Hospitals

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Authors' contributions

All authors have equally contributed in the conceptualization and study design; acquisition, analysis and interpretation of data; and in drafting and critical revision of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aims: This study aimed at evaluating the appropriateness of use of blood products in Northern Philippines and sought to find out if significant differences exist on the appropriateness of use of the blood products among the different departments and the tertiary hospitals.

Methodology: The appropriateness of use was determined by the criteria of the joint initiative of the National Health and Medical Research Council (NHMRC) and the Australasian Society of Blood Transfusion (ASBT). The frequency of utilization and the percentage of appropriateness were determined to compare the use of blood products among the different departments and the tertiary hospitals. Contingence tables were formed to test the associations between the categorical variables. The statistical significance was determined by Chi square test when p value <0.05.

Results: A total of 1,075 transfusion events were evaluated with a mean number of 2.43 transfusions per patient. Forty-one percent (41%) received two transfusions, 22% received one, and 37% received three or more transfusions. Five hundred eighty-three (583) transfusions were in the Medicine, 215 in Surgery, 218 in Obstetrics and 59 in Pediatrics. The overall prevalence of

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appropriate use among the different departments was 65%, and 59% among the tertiary hospitals. Appropriateness of use was statistically different among departments. A significant association also exist between the percentages of appropriate use of the blood products among the tertiary hospitals.

Conclusion: The study revealed that there was substantial variation in the appropriate transfusion practices across study hospitals and appropriateness of use was influenced by the departments regardless of the blood products.

Keywords: Appropriateness of use; blood transfusion; blood products; tertiary hospital.

1. INTRODUCTION

In modern health care today, blood transfusion plays a vital role. Blood transfusion can alleviate health and save life if used appropriately. According to WHO [1], appropriate use of blood products is defined as “the transfusion of safe blood products only to treat a condition leading to significant morbidity or mortality that cannot be prevented or managed effectively by other means”.

There are two crucial factors that determines the safety and effectiveness of transfusions. First is the accessibility(with reasonable cost) and adequacy of supply of safe blood and blood products to meet the national needs; and second, the appropriate clinical use of blood and blood products. However, the clinical use of blood between different hospitals, different clinical specialties and different clinicians with in the same team, evidently showed that there is substantial disparities on the pattern of clinical blood use from every region of the world [2].

High proportion of unnecessary blood transfusions have constantly revealed from various studies despite of published guidelines. The wide variation in the transfusion practice was due to the absence of consensus on the most appropriate criteria for blood transfusion therapy; the differences on blood component therapy guidelines; and the mixed effectiveness on the strategies in changing transfusion practice. Overall, there is difficulty in changing and maintaining the change in practice which is more difficult especially if no sustainability of the strategies [3].

In the Philippines, there is paucity of published papers, studies and data with regard to appropriateness of use of each blood products. Hence, such studies like this should be conducted to evaluate or assess rational and optimal utilization of blood products. Moreover, it would provide data for future studies or

references and may serve as one of the bases in developing a blood management oversight program so as to promote safe and judicious use of blood. Such an oversight program serves to reduce variation in transfusion practice and inappropriate use, and implement more efficient methods to manage patients at risk for transfusion.

A significant function of transfusion committee is to review the appropriateness of use of blood products. Five percent (5%) of all transfusion should be audited on a quarterly basis as a requirement. They are three forms of review that can be used: prospective, concurrent or retrospective review [4]. There is a need for continuous evaluation in blood transfusions and audit of the use of blood products as therapy, mainly in hospitals where no transfusion committee exists. Hence, this study aimed at evaluating the appropriateness of use of blood products among the different tertiary hospitals and sought to find out if significant differences exist on the appropriateness of use of the blood products among the different departments and the tertiary hospitals.

2. MATERIALS AND METHODS

The study employed a retrospective design guided with preset criteria and carried out among the tertiary hospitals in Northern Philippines. All consecutive requests for blood transfusions in a three month period from January to March 2010 were analyzed.

The study included records of all patients aged 12 years old or older from the Medicine, Surgery, Obstetrics, and Pediatrics departments of the different tertiary hospitals who underwent blood transfusion. Selection of hospital departments as the subjects of the study was done through survey with the most blood transfusion cases.

Patient's medical history was reviewed for each request of blood product. Factors including age,

current diagnosis, department, type and amount of blood products, and the reasons or stated indication for the transfusion of a blood product were analyzed using their patient's records. When information was not available or if the reason for the transfusion was unclear, the researchers considered the transfusion as inappropriate. The researchers sought a hematologist for assistance as needed.

Appropriate use of blood products and their therapeutic effect was assessed by using pre-set criteria (Appendix). Violation of the established pre-set criteria was considered as "inappropriate" use of blood product for a particular subject.

The appropriateness of use was determined by the criteria of the joint initiative of the National Health and Medical Research Council (NHMRC) and the Australasian Society of Blood Transfusion (ASBT) [5]. The frequency of utilization and the percentage of appropriateness were determined to compare the use of blood products among the different departments and the tertiary hospitals. Contingence tables were formed to test the associations between the categorical variables. The statistical significance was determined by Chi square test when p value <0.05.

3. RESULTS

A total of 1,075 transfusion events were evaluated among the tertiary hospitals, with a

mean number of 2.43 transfusions per patient. Forty one percent (41%) received two transfusions, 22% received one, and 37% received three or more transfusions. Of the total transfusion events, 583 were from the Medicine, 215 from Surgery, 218 from Obstetrics and 59 from Pediatrics.

Among the selected blood products, packed red blood cells (841) was the most frequently utilized, followed by whole blood (127), platelet concentrates (91) and fresh frozen plasma (16). Although cryoprecipitate was included in study, there was no demand of use that was recorded among the different departments to all the tertiary hospitals. Frequency of utilization of the blood products is shown in Table 1.

The overall prevalence of appropriate use among the different departments was 65%. Along with the department, the Paediatrics had the highest percentage of appropriateness with 86%. It should be pointed out that there was minimal utilization of the different blood products in this department given the reason that the criteria for the evaluation for transfusion in such patients are different from those used in adult patients. The department of Medicine had 75% of appropriateness, Obstetrics with 52% and least to Surgery with 48%. These departments are associated with high inappropriate transfusions especially to Surgery and Obstetrics departments. Percentage of appropriateness of the blood products is shown in Table 2.

Table 1. Frequency of utilization of the blood products among the different departments

Department	Whole blood	Packed red cells	Platelet concentrate	Fresh frozen plasma	Overall
Medicine	58	468	41	16	583
Surgery	56	149	10	*	215
Obstetrics	12	191	15	*	218
Pediatrics	1	33	25	*	59
Overall	127	841	91	16	1075

* no demand

Table 2. Appropriateness of use of the blood products among the different departments

Department	Appropriate	Whole blood	Packed red cells	Platelet concentrate	Fresh frozen plasma
Medicine	75%	54%	67%	79%	100%
Surgery	48%	0%	45%	100%	*
Obstetrics	52%	0%	77%	79%	*
Pediatrics	86%	100%	83%	76%	*
Overall	65%	39%	68%	84%	100%

* no demand

Among the tertiary hospitals, Hospital B had the most prevalence of appropriate use with 75%, Hospital C with 53% and 48% to Hospital A. Neither of the tertiary hospitals projected a good percentage of appropriate use (shown in Table 3). This indicates a high proportion of unnecessary or inappropriate transfusions practices across study hospitals.

Analysis of the data showed that appropriateness of use was statistically different among departments. Moreover, there is significant association exist between the percentage of appropriate use of blood products among the tertiary hospitals as *P* values were .04 and .005 respectively.

4. DISCUSSION

4.1 Whole Blood

In an Indian tertiary care hospital audit, there was an increased prevalence of inadequate use of whole blood [6]. In the evaluation done using pre-set criteria, the study found that the overall percentage of appropriate use is 40.7; it was unnecessary in 19.2% of cases (hemoglobin >11 g/dl). In 16.5% of cases, blood was transfused despite the absence of any of these indications, on the advice of the anaesthetist or surgeon responsible for the patient (clinician choice).

In our study, there are 127 transfusion cases of whole blood. Overall, 39% of these were classified as “appropriate”. The primary trigger for transfusion was low haemoglobin. Without taking the post transfusion hemoglobin as another criterion for appropriateness, there is an increase in the percentage of appropriate use (43%). In 23% of these cases, blood was used appropriately but the response therapeutically was non-efficacious. Other triggers for transfusion were active bleeding and some were no indication at all but rather a clinician choice. The study of Niraj et al. [6], substantiated that

this group of transfusions had a very high rate of inappropriate use (52%).

Using both pre-set criteria, blood was used inappropriately in 61% of cases. In 52% of these cases, the transfusion triggers were inappropriate however, the post hemoglobin results among these cases showed therapeutically efficacious. On the other hand, 15% of cases were transfused appropriately but was therapeutically non-efficacious. Moreover, 33% of cases were inappropriately used and were non-efficacious at the same time.

The departments of Medicine and Surgery have the most number of consumption with 58 and 56 units utilized, respectively. However, results showed that Surgery and Obstetrics departments had high percentage of inappropriate use of whole blood. In fact, all transfusions in both departments were inappropriate. The department of Medicine had 54% while in Pediatrics all uses were considered as appropriate (100%) though there was only 1 unit of whole blood utilized in this department. The study of Marti-Carvajal et al. [7], on the appropriate use of blood products in paediatrics patients, found out that whole blood had the most prevalence of appropriate use (83%). The result is comparable to the findings of this study as they both projected a good and high percentage of appropriateness. This reflects a rational and judicious use of whole blood to paediatric patients.

Among the tertiary hospitals, the study showed an overall low percentage of appropriate use (23%). In one of the tertiary hospital (Hospital A), all transfusion cases were classified as inappropriate despite of the very minimal number of utilization (6 units). It is noticeable also that the other two hospitals had increased number of utilization however; the prevalence of appropriate use was low with 38% to Hospital B and 30% to Hospital C.

Table 3. Appropriateness of use of the blood products among the tertiary hospitals

Department	Appropriate	Whole blood	Packed red cells	Platelet concentrate	Fresh frozen plasma
Hospital A	48%	0%	66%	78%	—
Hospital B	75%	38%	61%	100%	100%
Hospital C	53%	30%	76%	—	—
Overall	59%	23%	68%	89%	100%

— no demand

The objective of blood transfusion, as specified by the American Society of Anesthesiologists (ASA) [8] guidelines, is to improve inadequate oxygen delivery secondary to anemia. The primary trigger for transfusions of whole blood is low hemoglobin. The other two common but inappropriate triggers are hypovolemic and the clinician choice. The use of whole blood as a volume substitute, though inappropriate, is still being practiced. The reason for this may be the availability of blood, and the belief that complications of transfusion occur infrequently and are usually benign [6].

Unfortunately, there are hospitals in the study which have no oversight programme for monitoring quality of transfusion practices, which may be one of the reasons for having such a low percentage of appropriate use yet, with high number of utilization. There might be a so called transfusion committee but does not work efficiently or effectively. There might be a need to evaluate the program in order to assess its effectiveness. Grindon et al. [9] pointed out that the presence of a transfusion committee assures consultation in haemotherapy: It evaluates effectiveness of transfusion practices with blood products. Blood safety survey of WHO [10] found that only 25% hospitals performing transfusions in developing countries and 33% hospitals in transitional countries have a transfusion committee to monitor transfusion practices and to review blood utilization; as compared to 88% hospitals in developed countries.

4.2 Packed Red Cells

Several studies showed that the bloods with greatest prevalence of inappropriate use were packed red cells and fresh frozen plasma [7,11,12]. In an evaluation of red blood cell transfusion practices with the use of pre-set criteria, Ghali, Palepu & Paterson [13], found that in 55.3% of cases packed red cells was transfused unnecessarily.

Similar result was obtained in our study. Packed red cells and whole blood had the most prevalence of inappropriate use. Of 721 transfusions with packed red cells, 68% of these were considered as appropriate. Triggers for transfusion were symptomatic anaemia and low haemoglobin (including preoperative haemoglobin). Without considering the therapeutic effect criteria, appropriate transfusion trigger showed a higher percentage of 78%. The study of Schot & Steenssens [12] also found out

that 4% of packed red cells were inappropriate in terms of effectiveness of transfusion. Similarly, from 78% appropriate use, only 15% of these cases were non-efficacious using the pre-set therapeutic effect criteria.

The study also found several cases of transfusions with a single unit of packed red cells, and of these, 66% belonged to the group of inappropriate use. Metz et al. [14], also found a high proportion of inappropriate use of single-unit transfusion. Transfusion of a single unit of packed red blood cells (PRBC) should not be considered inappropriate by itself; however, its use without an appropriate clinical judgement is not acceptable.

Following the guidelines, only the department of Paediatrics present a good percentage of appropriateness (83%). The departments of Medicine and Obstetrics showed a high percentage of appropriateness with 67% and 77% respectively however, low percentage to Surgery department (45%). The study of Marti-Carvajal et al. [7] also found that a high proportion of inappropriate use to Surgery department (62%). Preference of alleviation of symptoms over prevention of latter complications has been postulated as one of the causes of this phenomenon. In many instances a low haematocrit count is used to determine a request for a transfusion of PRBC; the correct approach is to combine the laboratory criteria with the symptoms of the patient. The New South Wales study also found that more of red blood cells were used inappropriately for surgical than for other admissions [15].

Among the tertiary hospitals, the study showed an overall of 68% of appropriate use. Noticeably, percentage of appropriateness among these hospitals was quite close and comparable to each other. Hospital A has 66% of appropriateness of use; Hospital B has 61% while Hospital C has 76%. Neither of the hospitals obtained a good percentage of appropriateness. Thus, reflecting a high proportion of inappropriate transfusions of such blood products across study hospitals.

Similar to the findings with whole blood, the same reason can be given as explanation for the high percentage of inappropriate use of this blood product. Consistent with the findings in whole blood, Surgery is likely associated with higher risk of inappropriate used. It is likely that Surgery was responsible of this phenomenon.

Marti-Carvajal et al. [7] affirmed in their study that Surgery was associated with higher risk of inappropriate transfusion than the Medicine department.

From a general point of view, a decision to transfuse should always be based on an analysis of risk and benefit, and should consider two factors: (1) evaluation of the physiological needs of the patient; and (2) transfusing only blood products that satisfy those physiological needs [16]. As in Metz et al. [14], the study found that many inappropriate transfusions of packed red cells were carried out on asymptomatic patients in the perioperative period, although there is no evidence that mild or moderate anaemia contributes to perioperative morbidity and mortality [17,18].

4.3 Platelets

According to pre-set criteria, this study showed overall high percentage of appropriate use of platelets (84%). This reflects good knowledge on the rational use of this blood product, as unnecessary platelet transfusion poses health risks and there are precise indications for its use. The main indication for platelets transfusion is to prevent bleeding in patients with marrow failure. There is a hypothesis that, regardless of the weight of the recipient, transfusion of over 2 platelet units would be excessive [19]. When deciding to transfuse platelets, physician must consider other factors that increase the risk of bleeding in patients with thrombocytopenia and might suggest reduction in the use of platelets [20]. Ancliff and Machin [21] reviewed data about the threshold for prophylactic platelet transfusion and pointed out that a threshold of $10 \times 10^9/l$ is safe in stable patients. However, according to Contreras [22] there is a need to define precise indications for use of platelet transfusion and this could be achieved by conducting randomized trials and effective and efficient audit.

There are 91 transfusion cases of platelet concentrates included in the study. Common transfusion triggers were the following: Active bleeding with thrombocytopenia; prophylactic administration with severe thrombocytopenia; and thrombocytopenia in patients undergoing surgery on critical area or in patients undergoing invasive procedure. Overall, 84% of transfusions were deemed appropriate. However, with no consideration to therapeutic effect criteria for appropriateness, there was even higher percentage of appropriate use (91%). In 14% of

these cases, blood was used appropriately but the therapeutic response was non-efficacious. This implies a poor response to platelet transfusion therapy. Percentage of appropriateness among the different departments is as follows: 79% in Medicine and Obstetrics, 100% in Surgery, 76% in Pediatrics.

Using both pre-set criteria, this blood product was used inappropriately in 16%. In 18% of these cases, the transfusion trigger was inappropriate however, the therapeutic effect was efficacious. On the other hand, 59% of cases was transfused appropriately but the response was non-efficacious. Moreover, 23% of cases was transfused inappropriately and were non-efficacious at the same time.

Among the tertiary hospitals, the study showed an overall good percentage of appropriate use (89%). In Hospital A, 78% of transfusion cases were classified as appropriate. In Hospital B, all transfusions were deemed appropriate (100%). However, in Hospital C, there was no demand of transfusion of this product. The high percentage of appropriateness reflects a good transfusion practice of such blood product.

4.4 Fresh Frozen Plasma

Despite clear guidelines, requests for fresh frozen plasma (FFP) are the most frequent inappropriate orders received by the blood bank. Many authors found in their studies a greater prevalence of inadequate use of FFP [11,12,14]. This reflects little knowledge about the rational use of this blood product, as FFP has risks and there are precise indications for its use [18]. The most frequent reason for these inappropriate orders, accounting for at least a third of them, is for correction of a prolonged International Normalized Ratio (INR) in the absence of bleeding [23-26]. This prophylactic correction of minor laboratory coagulation abnormalities continues in the absence of evidence of its benefit [27]. Segal and Dzik [28] had suggested that inappropriate FFP orders occur because of 3 assumptions: (1) Elevation of the prothrombin time (PT)/INR will predict bleeding in the setting of a procedure. (2) Preprocedure administration of FFP will correct the prolonged clotting time results. (3) Prophylactic transfusion results in fewer bleeding events.

Conversely in this study, following both the pre-set criteria, all uses of this blood product were classified as appropriate (100%). The main

reason for transfusion was prolonged PT/INR. However, there was very minimal number of use (16 units) to this blood product as observed among the different tertiary hospitals. The possible explanation to this could be due to unavailability of this blood product at that time of the study or could be due to little knowledge on its rational use. In addition, it was found out that during the conduct of the study, the nearest blood center was not preparing such component because of equipment problem concerning their blood bank freezer.

The study of Brein, Butler & Inwood [29] in a Canadian General Teaching Hospital, found out that 95% of the units of fresh frozen plasma was transfused appropriately in 90% of the transfusion episodes and that the transfusions were appropriate in 85% or more of the episodes on the various services.

In this study, the percentage of appropriateness among the different departments was as follows: Medicine 95%, Surgery 85%, Obstetrics 89%, and Paediatrics 100%. The study by Ali and colleagues [26], 70% of the transfusion episodes with fresh frozen plasma was considered appropriate. Other studies found that 62% to 70% of transfusions of fresh frozen plasma was deemed appropriate [25,30-32]. The high percentage of appropriate transfusions in this study can be attributed to several factors. First, the minimal availability of this blood product hence, it was only requested as deemed necessary and appropriate. Second, it reflects that clinicians have good orientation on the rational and optimal use, as FFP transfusions poses risks to patients.

Among the different departments included in this study, only Medicine had the demand of use for this blood product and all uses were classified as appropriate and efficacious. Before examining the effect of FFP on mildly elevated INRs, one must consider the effect of medical treatment without FFP on mildly prolonged coagulation test results. The findings in the study of Holland and Brooks [33] suggest that the natural course of high-normal to mildly elevated INRs (1.3-1.6) is to decrease with supportive care and treatment of the underlying condition alone. The exact reasons for this natural correction are unclear but could relate to correction of the following: (1) dehydration causing hypoperfusion of the liver, (2) anemia causing systemic hypoxia, and/or (3) metabolic disturbances causing pH changes.

Although cryoprecipitate was included in the study, there was no recorded demand of use of this blood product to any of the tertiary hospitals. The possible reasons for this were the same as those described for FFP: problems on the access of blood product at that time of study due to unavailability of this blood product at the nearest blood center and insufficient or limited knowledge on its rational use. This blood product is indicated for use only in specific illnesses.

In summary, results of the study showed that overall, only the Paediatrics department had obtained a good percentage of appropriateness among the different department. Surgery and Obstetrics departments were associated with higher risk of inappropriate transfusion than Medicine and Paediatric departments. Similar results were found in the study of Marti-Carvajal et al. [7] showing that Surgery, Emergency and Obstetrics departments were associated with higher risk of inappropriate transfusion than the Medicine department. In contrast, Mozes et al. [11] reported no relationship between inappropriate transfusion in the Surgery, Medicine and Paediatrics departments.

4.5 Significant Associations on the Appropriateness of Use among the Different Departments and among the Tertiary Hospitals

Clinicians at different departments and specialties may vary on how they use blood products clinically. The European Community (EC) reports found substantial differences in the clinical use of blood components in Australia, New Zealand and overseas [5]. On the report given, EC identified three main problems: (1) significant variability in the use of blood in the same clinical situations, implying that there is both overuse and potential under-use of blood; (2) misuse of blood components (with the rate of transfusion errors being higher than that of transfusion-transmitted viral diseases); and (3) lack of documentation about the process, rationale and outcomes of blood component therapy.

Similarly, this study found that appropriateness of use was statistically different among the different departments and that a significant association exist between the percentages of appropriate use of blood products among the tertiary hospitals. Thereby, further claim that appropriateness of use is influenced by the hospital department regardless of the blood

products. It strongly asserts, as well, that appropriate use of blood products varies among tertiary hospitals. The study of Rubin, Schofield, Dean, Shakeshaft, & Frommer [15], concluded that there was substantial variation in inappropriate practice across study hospitals. Substantiated further by several studies in Australia and New Zealand, they found that the amount of blood used and the percentage of admissions involving the use of blood components vary across different types of hospitals, even for the same procedure or diagnosis, and that the percentage of use that can be classed as inappropriate was unacceptably high. These results were consistent with studies from Europe and the United States [5].

Along with the departments, Paediatrics has the highest percentage of appropriateness. In fact it is only the department which revealed a good percentage of appropriateness. On the other hand, Surgery is significantly associated with higher risk of inappropriate transfusion. Statistical data imply that Obstetrics and Paediatrics have better transfusion practices as compared to Surgery. Tertiary hospitals have comparable transfusion practices as revealed by data in the study. In terms of appropriateness of use among blood products, a significant association was found in the use of whole blood and packed red cells implying variation of transfusion practices to such blood products among the different departments.

Differences in transfusion practices between different departments among the tertiary hospital could be explained by the following reasons: The difficulty in evaluating appropriate use of blood products in patients with bleeding in different surgical services; Differences among clinicians transfusion practice in different departments, at different fields of specialty; The differences in existing guidelines reflect the difficulty in defining clear evidence-based parameters as a uniform trigger. Lastly, the lack of orientation, updates and/or little knowledge according to the most current clinical transfusion practice guidelines on the rational use of blood products [5].

5. CONCLUSION

In the light of the foregoing findings of this study, a high prevalence of inappropriate use of blood products was found among the tertiary hospitals. Higher risk of inappropriateness was observed in the Medicine, Surgery and Obstetrics

departments while Pediatrics revealed a good percentage of appropriateness. There was substantial variation in the appropriate transfusion practices across tertiary hospitals and appropriateness was influenced by the departments.

6. STUDY LIMITATIONS

This was a retrospective review on the appropriateness of transfusion of blood products. Appropriateness was reviewed based only on the information available in the medical charts, thus, percentage of inappropriateness may be overestimated. However, we believe that this was the first audit that has been carried out, more strongly that several tertiary hospitals were involved. Results may serve as an initial basis for the improvement of transfusion practices. The study proposes that a quality monitoring system such as medical audit and continuing medical education be initiated into each hospital.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX

APPROPRIATENESS CRITERIA

Whole Blood

Appropriate if any one of the following applicable, likely to be inappropriate if none applicable:

- Hb is <80 g/L
- Hb<100 g/L in patients with medical co-morbidities (such as coronary artery disease, renal dysfunction, left ventricular dysfunction, and chronic obstructive airway disease)
- Blood loss >20% of blood volume when more than 1000 ml

Red Blood Cells

Appropriate if any one of the following applicable, likely to be inappropriate if none applicable:

- Hb is <70g/L.
- Hb range of 70–100g/L during surgery associated with major blood loss
- Hb range of 70–100g/L during surgery with signs or symptoms of impaired oxygen transport
- Hb is <80g/L in a patient on a chronic transfusion regimen or during marrow suppressive therapy

Platelets

Appropriate if any one of the following applicable, likely to be inappropriate if none applicable:

- Prophylaxis for major surgery or invasive procedure and platelet count < $50 \times 10^9/L$
- Massive haemorrhage/transfusion and platelet count < $50 \times 10^9/L$
- Bone marrow failure and platelet count < $10 \times 10^9/L$
- Bone marrow failure and platelet count < $20 \times 10^9/L$ with risk factors
- Bleeding or massive hemorrhage

Fresh Frozen Plasma

Appropriate if any one of the following applicable, likely to be inappropriate if none applicable:

- INR or APTT high* and liver disease before major surgery or invasive procedure
- INR or APTT high and liver failure
- INR or APTT high and acute disseminated intravascular coagulation
- INR or APTT high and excessive bleeding
- INR or APTT high before an invasive procedure
- INR or APTT high before, during or after major surgery
- INR high and warfarin effect present and massive blood loss or emergency surgery
- Correction of single factor deficiency when a specific factor was not available
- Treatment of thrombotic thrombocytopenic purpura.

Cryoprecipitate

- Appropriate if fibrinogen test result available and fibrinogen level < 1.0 g/L and where there is clinical bleeding or trauma or invasive procedure or disseminated intravascular coagulation.

APTT - activated partial thromboplastin time. INR - International normalised ratio of prothrombin time.

** "High" - above the hospital's normal range*

Adapted from the literature of NHMRC/ASBT Clinical Practice Guidelines on the Appropriate Use of Blood and Blood Products [5].

THERAPEUTIC EFFECT CRITERIA

Whole Blood

- Increase of 3% hct level or 1g/dL on hb level per unit (increase may not be apparent for 48 to 72 hours).

Red Blood Cells

- Increase of 3% hct level per unit

Platelets

- Increase of 5000-8000 platelet count per concentrate

Fresh Frozen Plasma

- Increase of 20-30% in coagulation factor activity per dose of 10-15ml of plasma per kg body weight

Cryoprecipitate

- Increase of 50-100 units of factor VIII per unit (about 10 ml volume)
- Increase plasma fibrinogen concentration by approximately 50 mg/dL

Adapted from the book of Sacher, & McPherson Widmann's Clinical Interpretation of Laboratory Tests [34].

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