The Effects of a Computerized Transfusion Decision Support System on Physician Compliance and Its Appropriateness for Fresh Frozen Plasma Use in a Medical Center

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Abstract

Fresh frozen plasma (FFP) transfusion remains a significant issue for blood banks because of a lack of consensus regarding its appropriate use. To study the factors influencing physician compliance, we evaluated FFP transfusion episodes in the year 2008, using a computerized transfusion decision support system. A total of 10,926 episodes were reviewed. The demographic data, physician compliance, and therapeutic efficacy were investigated.

The physician noncompliance rate was 46.5%. The highest number was ordered by the hepatobiliary division, which might be due to the high incidence of liver cirrhosis and hepatoma in Taiwan. Excluding the cases for plasma exchange and emergency surgery, 31.2% of episodes had abnormal coagulation results before transfusions. The therapeutic efficacy is statistically significant in patients with abnormal pretransfusion coagulation tests ($P < .001$*). Computerization may be a favorable trend in medical management systems, but it should be more functional to improve medical quality.*

Fresh frozen plasma (FFP) is widely used in clinical practice,[1] despite indications for the use of this blood component being limited to a few conditions,[2-4] such as the treatment of bleeding associated with an abnormal coagulation test result, patients having a bleeding tendency combined with disseminated intravascular coagulation, clotting-factor deficiencies—congenital or acquired—and some rare bleeding disorders. A variety of adverse effects of transfusion, including nonhemolytic febrile reaction, allergic reaction due to plasma-protein incompatibility, transfusion-transmitted viral diseases, and transfusion-related acute lung injury, may occur during or after FFP transfusion.[5-9] Despite an increased awareness of the risks involved, the prescription of inappropriate transfusions remains a significant problem.[8,9] Owing to the lack of consensus regarding the appropriateness of FFP transfusion, blood banks find it difficult to control the use of FFP clinically. Few studies concerning the appropriate use of FFP in clinical practice have been reported.

Computer-based clinical decision support systems have been shown to improve physician performance and inpatient outcomes.[10,11] We previously reported the appropriateness and physician compliance of platelet use when using a computerized transfusion decision support system (CTDSS), established in September 2004 at Kaohsiung Medical University Hospital (KMUH; Kaohsiung, Taiwan)—an academic medical center with 1,400 beds.[12] In addition, we reported that periodic auditing might change the amount of FFP used and improve the quality of transfusion after the intervention of the computerized system.[13] However, questions regarding the physician compliance with the transfusion guidelines in the CTDSS and the appropriateness of the FFP use remain uncertain. In this study, we investigated physician compliance

and the appropriateness of FFP use by using the CTDSS, thus building up the evidence base regarding current FFP transfusion practice in a medical center.

Materials and Methods

Collection of Data for the Study

We retrospectively reviewed all FFP transfusion data between January and December 2008. The demographic data, including sex, blood type, disease type, patient source, functional unit, and the transfusion indication chosen from the CTDSS, were obtained from the computerized hospital information system (CHIS) of KMUH. The patients' latest coagulation tests, including prothrombin time (PT), international normalized ratio (INR) of PT, and activated partial thromboplastin time (aPTT) before and after transfusions, were retrieved from the laboratory information system database.

Criteria for FFP Use in KMUH

The FFP use criteria established by the KMUH transfusion committee and used as a computerized transfusion guide are as follows: (1) abnormal coagulation test results with INR or aPTT ratio more than 1.5, and bleeding, preoperative status, or undergoing an invasive procedure; (2) need for massive transfusion with blood volume exceeding 1 total blood volume; (3) need for plasma exchange; (4) bleeding tendency due to deficiency of antithrombin III or protein C or S or undergoing anticoagulation treatment; (5) bleeding tendency due to disseminated intravascular coagulation, thrombotic thrombocytopenic purpura, or hemolytic uremic syndrome; (6) emergency heart surgery or other operations without aPTT or PT tests; and (7) other conditions approved by a physician in the blood bank. One of the preceding criteria would be chosen by the physician from the CTDSS before completing an FFP transfusion order.

Appropriateness of FFP Use

An appropriate transfusion order is defined as a blood product ordered with an indication that satisfies the criteria.[8] After excluding the episodes for plasma exchange, for massive transfusion with blood volume exceeding 1 total blood volume, and for patients undergoing emergency heart surgery or other operations without aPTT or PT tests, each FFP request was classified in our study as "indicated," "unknown indication," or "not indicated." An indicated FFP use in our study was determined mainly according to the abnormal coagulation test results before transfusion. An order without sufficient information or coagulation results before ordering was classified as having an unknown indication. A request with sufficient information but that did not meet our FFP transfusion criteria was classified as not indicated. The flow diagram used to determine the appropriateness of FFP transfusion practice is shown in **Figure 1**.

Evaluation of the Therapeutic Efficacy of FFP Transfusion

The pretreatment and posttreatment laboratory results, including INR and aPTT ratio from CHIS, were used to evaluate the therapeutic efficacy of FFP transfusion. Treatment with plasma was determined as effective when it corrected or improved previously abnormal coagulation test results. This analysis was carried out for patients for whom pretransfusion and posttransfusion coagulation data were available. Two subgroups were formed: patients with "normal" and "abnormal" pretransfusion coagulation results according to the threshold prolongation of PT and aPTT more than 1.5 times the normal range. The 2 subgroups did not include patients with a diagnosis of thrombotic thrombocytopenic purpura. These factors were analyzed by *t* tests for paired data, and *P* values less than .05 were considered statistically significant.

Results

Characteristics of the Episodes

A total of 10,926 episodes of FFP transfusion were ordered from January to December 2008 for patients enrolled in the study. **Table 1** shows the distribution of the

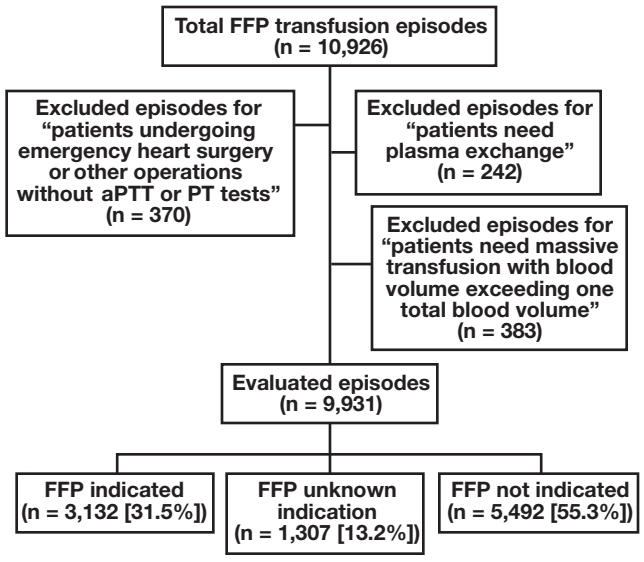

Figure 1 The flow diagram used to determine the appropriateness of fresh frozen plasma (FFP) transfusion practice. aPTT, activated partial thromboplastin time; PT, prothrombin time.

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demographic factors and clinical features. The male/female ratio was about 2:1 (67.2% vs 32.8%), and the O and A blood types were predominant (37.5% and 32.8%, respectively). In terms of the type of service at admission, 91.5% of requisitions were from the inpatient department. More than half of the requisitions (55.9%) were from the internal medicine unit, with most of them under the hepatobiliary division (4,442 [72.7%]). The percentages of episodes ordered by the pediatrics unit, surgery unit, and emergency department were 3.8%, 32.6%, and 7.7%, respectively. In addition, 2,287 episodes with abnormal pretransfusion INR values and 2,150 cases with abnormal pretransfusion aPTT data were also found.

Percentage of Indications From the CTDSS

The percentages of indications for FFP use according to the CTDSS are shown in **Table 2**. The 9,642 episodes chosen (88.2%) had at least 1 indication from the CTDSS when ordering. The most common indication for FFP use was "abnormal coagulation test results with INR or aPTT ratio more than 1.5 and bleeding, preoperative status, or undergoing an invasive procedure" (7,096 [73.6%]). Other indications chosen were no more than 10% of the total. Finally, 1,284 episodes (11.8%) did not show any indication from the CTDSS when ordering.

The Appropriateness of FFP Use

The flow diagram representing the FFP transfusion practice to determine "appropriateness" is shown in Figure 1. In total, 9,931 episodes were evaluated, after excluding the episodes for plasma exchange, massive transfusion with blood volume exceeding 1 total blood volume, and emergency heart surgery or other operations without aPTT or PT tests. Among these evaluated episodes, 3,232 (31.5%) were classified as indicated, 1,307 (13.2%) unknown indication, and 5,492 (55.3%) not indicated.

Table 1
Distribution of FFP-Transfusion Episodes (n = 10,926)

Characteristic	No. (%) of Episodes
Sex	
Male	7,342 (67.2)
Female	3,584 (32.8)
ABO type	
O	4,101 (37.5)
A	3,587 (32.8)
B	2,586 (23.7)
AB	652 (6.0)
Source	
Emergency department	840 (7.7)
Inpatient department	9,992 (91.5)
Outpatient department	94 (0.9)
Functional units	
Internal medicine	6,111 (55.9)
Hepatobiliary medicine division	4,442
Pediatrics	416 (3.8)
Surgery	3,560 (32.6)
Hepatobiliary surgery division	907
Emergency	839 (7.7)
INR before FFP	
No data	1,606 (14.7)
≤1.5	7,033 (64.4)
>1.5	2,287 (20.9)
aPTT ratio before FFP	
No data	3,730 (34.1)
<1	812 (7.4)
1-1.5	4,234 (38.8)
>1.5	2,150 (19.7)

aPTT, activated partial thromboplastin time; FFP, fresh frozen plasma; INR, international normalized ratio.

Evaluation of the Therapeutic Efficacy of FFP Transfusion

To study the therapeutic efficacy of FFP transfusion, cases with pretreatment and posttreatment coagulation results (INR or aPTT ratio) were retrieved from the CHIS for evaluation. The pretransfusion and posttransfusion data were measured in 1.22 ± 1.42 days (range, 1-5 days) and 2.13 ± 1.22 days (range, 1-5 days), respectively. The results are shown in

Table 2
Indications for FFP Use From the Computerized Transfusion Decision Support System (n = 10,926)

Indication	No. (%) of Episodes
Valid	9,642 (88.2)
Abnormal coagulation test results with an INR or aPTT ratio >1.5 and bleeding, preoperative status, or undergoing invasive procedure	7,096 (73.6)
Need for massive transfusion with blood volume exceeding 1 total blood volume	383 (4.0)
Need for plasma exchange	242 (2.5)
Bleeding tendency due to antithrombin III or protein C or S deficiency or anticoagulation treatment	755 (7.8)
Bleeding tendency due to disseminated intravascular coagulation, thrombotic thrombocytopenic purpura, or hemolytic uremic syndrome	496 (5.1)
Emergency heart surgery or other operation without aPTT or prothrombin time tests	370 (3.8)
Other conditions approved by physician in blood bank	300 (3.1)
Invalid	1,284 (11.8)

aPTT, activated partial thromboplastin time; FFP, fresh frozen plasma; INR, international normalized ratio.

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Table 3. There were 1,735 episodes with a pretransfusion INR value greater than 1.5 (mean ± SD, 2.06 ± 1.13), including 478 cases with an aPTT ratio less than 1.5, 855 with an aPTT ratio greater than 1.5, and 402 without aPTT data. The mean ± SD posttransfusion INR of these cases was 1.79 ± 0.73, which was significantly lower than the pretransfusion INR ($P < .001$). Similar results were also observed in the 604 episodes having a pretransfusion aPTT ratio greater than 1.5 (Table 3). It is interesting that for cases with a PT INR or aPTT less than 1.5, our results showed a mildly increased posttransfusion PT INR or aPTT ratio, respectively (Table 3).

Discussion

Among the 10,926 FFP transfusion episodes, 1,284 (11.8%) were performed without choosing any indication from the CTDSS when ordering (Table 2), and 3,786 (34.7%) episodes used the indication of abnormal coagulation test results with an INR or aPTT ratio of more than 1.5 and bleeding, preoperative status, or undergoing an invasive procedure, although the patients showed normal coagulation results (results not shown). We define these episodes as poor physician compliance in our study, the noncompliance rate being 46.5%. However, a noncompliant transfusion order does not always mean inappropriate use. A noncompliant but appropriate episode may occur when the clinical status satisfies the FFP use criteria but the physician does not pick any indication from the CTDSS when ordering, probably because of the urgent or unstable nature of the emergency department entrants or surgical patients. The rate of appropriate use under noncompliance is 28.1% in our study.

After excluding the episodes for plasma exchange, massive transfusion with blood volume exceeding 1 total blood volume, and emergency heart surgery or other operations without aPTT or PT tests, there were 5,492 (55.3%) evaluated FFP transfusion episodes classified as not indicated. Most of them showed normal laboratory coagulation results and did not show any evidence of need for FFP. Some of the episodes chosen as no indication or other conditions approved by a physician in the blood bank are also classified as not indicated because the FFP use seemed unnecessary after evaluating the clinical status documented in the CHIS. Moreover, 1,307 episodes (13.2%) were classified as unknown indication because they did not have sufficient information or coagulation results to make a decision regarding FFP transfusion. If these 2 subgroups (not indicated and unknown indication) are defined as inappropriate FFP use, the percentage of inappropriate use in our study is 68.5%. This finding is similar to the results published in other studies.[14-16] However, as discussed previously, assessment of the appropriateness of FFP use by reviewing the CHIS could be limited by incomplete documentation, which may have resulted in missing important clinical information to judge the appropriateness of FFP use.[12] In addition, our evaluation of the appropriateness of FFP use excluded the episodes for plasma exchange, massive transfusion with blood volume exceeding 1 total blood volume, and emergency heart surgery or other operations without aPTT or PT tests, which may have resulted in a lower proportion of inappropriate orders. In addition, another limitation in our study is that the definition of inappropriateness did not take into account the dose of FFP given.

About 50% of the FFP transfusion episodes were in the hepatobiliary division (40.7% internal medicine and 8.3% surgery). This might be due to the high incidence of liver cirrhosis and hepatoma in Taiwan that is related to the epidemics of hepatitis B and C.[17-21] However, there is little evidence of the efficacy of FFP in liver cirrhosis,[22-24] hypoproteinemia, or nutritional applications[25]; hence, no consensus exists for its use in these cases. Nevertheless, the patients received most of

Table 3
Evaluation of the Therapeutic Efficacy of FFP Transfusion*

Coagulation Test Result	Before FFP Transfusion	After FFP Transfusion	*P*
Abnormal (n = 2,339)			
PT INR >1.5 (n = 1,735)	2.06 ± 1.13	1.79 ± 0.73	<.001
PT INR >1.5; aPTT ratio <1.5 (n = 478)	1.77 ± 0.44	1.62 ± 0.42	<.001
PT INR >1.5; aPTT ratio >1.5 (n = 855)	2.28 ± 1.33	1.91 ± 0.90	<.001
PT INR >1.5; no aPTT data (n = 402)	1.93 ± 1.11	1.73 ± 0.54	<.001
aPTT ratio >1.5 (n = 604)	1.99 ± 0.93†	1.68 ± 0.57†	<.001
PT INR <1.5; aPTT ratio >1.5 (n = 596)	1.99 ± 0.91†	1.68 ± 0.56†	<.001
No PT data; aPTT ratio >1.5 (n = 8)	2.35 ± 0.93†	1.58 ± 0.26†	.077
Normal (n = 3,774)			
PT INR <1.5; aPTT ratio <1.5 (n = 2,557)	1.21 ± 0.15	1.23 ± 0.22	<.001
PT INR <1.5; no aPTT data (n = 1,211)	1.27 ± 0.13	1.29 ± 0.18	<.001
No PT data; aPTT ratio <1.5 (n = 6)	1.23 ± 0.11†	1.25 ± 0.13†	.619

aPTT, activated partial thromboplastin time; FFP, fresh frozen plasma; INR, international normalized ratio; PT, prothrombin time.
* Data are given as mean ± SD.
† The numbers indicate the aPTT ratio (patient/control).

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the FFP requests in KMUH. Consensus on the use of FFP in such cases to facilitate appropriate use is needed in addition to further prospective research in this area.

By using the threshold prolongation of PT and aPTT more than 1.5 times the normal range in the retrospective studies and the criteria set by the College of American Pathologists in 1994,[26,27] we evaluated the efficacy of FFP transfusion in our cases. In real-world clinical practice, it is difficult to get the results of coagulation tests just before and after FFP transfusion and to evaluate the subsequent efficacy of treatment. Iorio et al[16] noted a significant improvement in INR after FFP transfusion. Our results showed that patients with abnormal pretransfusion coagulation data had significant improvement in the INR and aPTT ratio after FFP transfusion ($P < .001$). However, in patients with normal pretransfusion coagulation results, FFP transfusion showed no further shortening of the PT or aPTT. On the contrary, there was a significant threshold prolongation of PT or aPTT in this subgroup. Although the main purpose of FFP transfusion is to provide coagulation factors to patients with coagulation factor deficiency, there is insufficient evidence to conclude that abnormal coagulation results can predict bleeding. Multiple observational studies point to a lack of predictive effects for bleeding risk in patients with mild or moderate abnormalities determined in coagulation tests[28] and, thus, indicate that coagulation results are only crude predictors of surgical bleeding.[29,30] Our results provide a further basis to try to understand the manner in which physicians request blood transfusions and, thus, collect further evidence of the efficacy of FFP use.

Salem-Schatz et al[31] showed the computerized decision system as an effective tool to improve physician performance, compliance with criteria, and patient outcome. Although there is a well-established CTDSS in KMUH to help physicians order FFP appropriately and improve transfusion quality, it has no power to reject inappropriate transfusion requisitions. Transfusion episodes without any indication or sufficient evidence such as abnormal coagulation data when ordering FFP use are still accepted. Thus, 3,786 FFP units (34.7%) were transfused to patients with normal pretransfusion coagulation tests. This implies that the acceptance of the CTDSS and an understanding of a physician's ordering behavior are important issues to improve the medical management quality in FFP transfusion. We suggest that an indication must be chosen before completing the transfusion order in the CTDSS and that pretransfusion coagulation results should be shown on the requisition form when ordering, except for patients requiring plasma exchange or who have some other life-threatening conditions. If even one of the aforementioned criteria remains unsatisfied, the transfusion requisition could be rejected by the CTDSS. If the ordering physician chooses the indication as other conditions approved by a physician in the blood bank, the blood bank should contact the ordering physician to evaluate the appropriateness of transfusion. This might make the CTDSS more flexible and practical. Some studies have shown that inappropriate FFP use is more common in university hospitals than in smaller, peripheral hospitals,[32,33] which is because of the greater complexity of cases and the greater use of blood components in the university hospitals. Both factors could limit the possibility of adherence to guidelines.

Previous studies have found widespread deficiencies in physicians' knowledge regarding transfusion indications and risks.[31] Interventions such as educational conferences or multifaceted interventions are considered most effective in promoting changes in physician behavior.[34,35] Education about transfusion medicine should be arranged for all medical staff, and the CTDSS should be designed to be more powerful and effective enough to intervene in the appropriateness of transfusion practice. Appropriate transfusion practice may reduce the overuse of blood components, avoid transfusion risks, and decrease unnecessary health care costs, as we reported previously.[12] Further studies are warranted to investigate the significance and efficacy of the CTDSS application for making decisions regarding clinical FFP transfusion.

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References

1. Triulzi DJ. The art of plasma transfusion therapy. *Transfusion*. 2006;46:1268-1270.
2. Agence Française de Sécurité Sanitaire des Produits de Santé. Transfusion of fresh coagulated plasma: products, indications: general methods and recommendations [in French]. *Transfus Clin Biol*. 2002;9:322-332.
3. Crosby E, Ferguson D, Hume HA, et al. Guidelines for red blood cell and plasma transfusion for adults and children. *Can Med Assoc J*. 1997;156(Suppl):S1–12.
4. O'Shaughnessy DF, Atterbury C, Bolton MP. Guidelines for the use of fresh-frozen plasma, cryoprecipitate and cryosupernatant. *Br J Haematol*. 2004;126:11-28.
5. Alter HJ, Klein HG. The hazards of blood transfusion in historical perspective. *Blood*. 2008;112:2617-2626.
6. McPherson RA, Pincus MR, eds. *Henry's Clinical Diagnosis and Management by Laboratory Methods*. 21st ed. Philadelphia, PA: Saunders; 2006:677-679.
7. Popovsky MA, Moore SB. Diagnostic and pathogenetic considerations in transfusion-related acute lung injury. *Transfusion*. 1985;25:573-577.

DOI: 10.1309/AJCP0ECFNHMGJ8EA

8. Goodnough LT, Brecher ME, Kanter MH, et al. Transfusion medicine: first of two parts: blood transfusion. *N Engl J Med*. 1999;340:438-447.
9. Corwin HL. Transfusion practice in the critically ill: can we do better [editorial]? *Crit Care Med*. 2005;33:232-233.
10. Hunt DL, Haynes RB, Hanna SE, et al. Effects of computer-based clinical decision support systems on physician performance and patient outcomes: a systematic review. *JAMA*. 1998;280:1339-1346.
11. Garg AX, Adhikari NK, McDonald H, et al. Effects of computerized clinical decision support systems on practitioner performance and patient outcomes: a systematic review. *JAMA*. 2005;293:1223-1238.
12. Lin YC, Chang CS, Yeh CJ, et al. The appropriateness and physician compliance of platelet usage by a computerized transfusion decision support system in a medical center [published online ahead of print June 23, 2010]. *Transfusion*. 2010;50:2565-2570. doi: 10.1111/j.1537-2995.2010.02757.x.
13. Yeh CJ, Wu CF, Hsu WT, et al. Transfusion audit of fresh-frozen plasma in southern Taiwan. *Vox Sang*. 2006;91:270-274.
14. Chng WJ, Tan MK, Kuperan P. An audit of fresh frozen plasma usage in an acute general hospital in Singapore. *Singapore Med J*. 2003;44:574-578.
15. Chaudhary R, Singh H, Verma A, et al. Evaluation of fresh frozen plasma usage at a tertiary care hospital in North India. *ANZ J Surg*. 2005;75:573-576.
16. Iorio A, Basileo M, Marchesini E, et al. Audit of the clinical use of fresh-frozen plasma in Umbria: study design and results of the pilot phase. *Blood Transfus*. 2008;6:211-219.
17. Hsu HM, Lu CF, Lee SC, et al. Seroepidemiologic survey for hepatitis B virus infection in Taiwan: the effect of hepatitis B mass immunization. *J Infect Dis*. 1999;179:367-370.
18. Lin HH, Wang LY, Hu CT, et al. Decline of hepatitis B carrier rate in vaccinated and unvaccinated subjects: sixteen years after newborn vaccination program in Taiwan. *J Med Virol*. 2003;69:471-474.
19. Sun CA, Chen HC, Lu CF, et al. Transmission of hepatitis C virus in Taiwan: prevalence and risk factors based on a nationwide survey. *J Med Virol*. 1999;59:290-296.
20. Wang JT, Wang TH, Sheu JC, et al. Hepatitis C virus infection in volunteer blood donors in Taiwan: evaluation by hepatitis C antibody assays and the polymerase chain reaction. *Arch Pathol Lab Med*. 1993;117:152-156.
21. Beasley RP. Hepatitis B virus, the major etiology of hepatocellular carcinoma. *Cancer*. 1988;61:1942-1956.
22. Stanworth SJ, Brunskill SJ, Hyde CJ, et al. Is fresh frozen plasma clinically effective? a systematic review of randomized controlled trials. *Br J Haematol*. 2004;126:139-152.
23. Lerner RG, Nelson J, Sorcia E, et al. Evaluation of solvent/detergent-treated plasma in patients with a prolonged prothrombin time. *Vox Sang*. 2000;79:161-167.
24. Williamson LM, Llewelyn CA, Fisher NC, et al. A randomized trial of solvent/detergent-treated and standard fresh-frozen plasma in the coagulopathy of liver disease and liver transplantation. *Transfusion*. 1999;39:1227-1234.
25. Kakkar N, Kaurt R, Dhanoa J. Improvement in fresh frozen plasma transfusion practice: results of an outcome audit. *Transfus Med*. 2004;14:231-235.
26. Ciavarella D, Reed RL, Counts RB, et al. Clotting factor levels and the risk of diffuse microvascular bleeding in the massively transfused patient. *Br J Haematol*. 1987;67:365-368.
27. McVay PA, Toy PTCY. Lack of increased bleeding after paracentesis and thoracentesis in patients with mild coagulation abnormalities. *Transfusion*. 1991;31:164-171.
28. Segal JB, Dzik WH; and the Transfusion Medicine/Hemostasis Clinical Trials Network. Paucity of studies to support that abnormal coagulation test results predict bleeding in the setting of invasive procedures: an evidence-based review. *Transfusion*. 2005;45:1413-1425.
29. Ewe K. Bleeding after liver biopsy does not correlate with indices of peripheral coagulation. *Dig Dis Sci*. 1981;26:388-393.
30. McGill DB. Predicting hemorrhage after liver biopsy. *Dig Dis Sci*. 1981;26:385-387.
31. Salem-Schatz SR, Avorn J, Soumerai SB. Influence of clinical knowledge, organizational context and practice style on transfusion decision making: implications for practice change strategies. *JAMA*. 1990;264:476-483.
32. Soutar RL, Jobanputra S, Tait RC. A two-phase audit of fresh frozen plasma: a regional approach [letter]. *Transfus Med*. 2004;14:75-76.
33. Liumbruno GM, Sodini ML, Grazzini G. Tuscan study on the appropriateness of fresh-frozen plasma transfusion (TuSAPlaT). *Blood Transfus*. 2007;5:75-84.
34. Tinmouth A, Macdougall L, Fergusson D, et al. Reducing the amount of blood transfusion: a systematic review of behavioral interventions to change physicians' transfusion practice. *Arch Intern Med*. 2005;165:845-852.
35. Eisenstaedt RS. Modifying physicians' transfusion practice. *Transfusion Med*. 1997;11:27-37.

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