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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Key Words: Physician compliance; Fresh frozen plasma use; Transfusion; Computerized transfusion decision support

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. 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 as indicated, unknown indication, or 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](https://example.com) The flow diagram used to determine the appropriateness of fresh frozen plasma (FFP) transfusion practice. aPTT, activated partial thromboplastin time; PT, prothrombin time.
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.

### 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
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 inappropriate use 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 applications25; hence, no consensus exists for its use in these cases. Nevertheless, the patients received most of

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 2.06 ± 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).

Evaluation of the Therapeutic Efficacy of FFP Transfusion*

<table>
<thead>
<tr>
<th>Coagulation Test Result</th>
<th>Before FFP Transfusion</th>
<th>After FFP Transfusion</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abnormal (n = 2,339)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PT INR &gt; 1.5 (n = 1,735)</td>
<td>2.06 ± 1.13</td>
<td>1.79 ± 0.73</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>PT INR &gt; 1.5; aPTT ratio &lt; 1.5 (n = 478)</td>
<td>1.77 ± 0.44</td>
<td>1.62 ± 0.42</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>PT INR &gt; 1.5; aPTT ratio &gt; 1.5 (n = 856)</td>
<td>2.28 ± 1.33</td>
<td>1.91 ± 0.90</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>PT INR &gt; 1.5; aPTT ratio &gt; 1.5; no aPTT data (n = 402)</td>
<td>1.93 ± 1.11</td>
<td>1.73 ± 0.54</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>aPTT ratio &gt; 1.5 (n = 604)</td>
<td>1.99 ± 0.93*</td>
<td>1.68 ± 0.57*</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>PT INR &lt; 1.5; aPTT ratio &gt; 1.5 (n = 596)</td>
<td>1.99 ± 0.91*</td>
<td>1.68 ± 0.56*</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Normal (n = 3,774)</td>
<td>2.35 ± 0.93*</td>
<td>1.58 ± 0.26*</td>
<td>.077</td>
</tr>
<tr>
<td>PT INR &lt; 1.5; aPTT ratio &lt; 1.5 (n = 2,557)</td>
<td>1.21 ± 0.15</td>
<td>1.23 ± 0.22</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>PT INR &lt; 1.5; aPTT ratio &gt; 1.5 (n = 1,211)</td>
<td>1.27 ± 0.13</td>
<td>1.29 ± 0.18</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>No PT data; aPTT ratio &lt; 1.5 (n = 6)</td>
<td>1.23 ± 0.11*</td>
<td>1.25 ± 0.13*</td>
<td>.619</td>
</tr>
</tbody>
</table>

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).
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 to evaluate the subsequent efficacy of treatment. Iorio et al16 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 tests29 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 al11 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 results. FFP transfusion showed no further shortening of the INR and 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 tests29 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.

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