Heparin-Induced Thrombocytopenia-Associated Thrombosis in Pediatric Intensive Care Patients

Markus Schmugge, MD*; Lorenz Risch, MD†§; Andreas R. Huber, MD§; Anne Benn, MD∥; and Joachim E. Fischer, MD, MSc¶

ABSTRACT. Background. Heparin-induced thrombocytopenia (HIT), a well-known side effect of heparin therapy, occurs in 1% to 5% of adults exposed to heparin. Of those, about 29% to 88% develop thrombosis. Most data on HIT-associated thrombosis in children are confined to anecdotal reports.

Objective. To determine the incidence of HIT-associated thrombosis in heparin-exposed children.

Methods. We performed a retrospective cohort study on all patients admitted to our pediatric intensive care unit between August 1996 and January 1999. Patients who received heparin for ≥5 days were eligible. Within these patients, we identified all cases of radiologically confirmed thrombosis. Cases of thrombosis were reviewed for fulfillment of clinical HIT criteria. HIT-associated thrombosis was confirmed serologically by determination of levels of antibodies against heparin/platelet factor 4 complexes.

Results. Of 1950 children admitted during the study period, 612 were exposed to heparin for ≥5 days. Thrombosis occurred in 57 patients (9.3%). Plasma samples were available for 38 cases, of which 14 satisfied clinical HIT criteria. Calculated incidence rate for HIT-associated thrombosis: 2.3%, (95% confidence interval: 1.3%–3.9%, for patients exposed to heparin ≥5 days). Nine patients suffered from venous, 2 patients from arterial, and 3 had combined arterial and venous thrombosis. None of the 14 patients died or underwent amputation. Six patients had heparin and platelet factor 4-complex antibody levels above the cutoff level for adults. The remaining 8 patients had significantly higher antibody levels than a matched control group.

Conclusion. Compared with that reported for adults, HIT-associated thrombosis in pediatric intensive care unit patients has a similar incidence but a less severe outcome. Pediatrics 2002;109(1). URL: http://www.pediatrics.org/cgi/content/full/109/1/e10; heparin-induced thrombocytopenia, children, neonates, thrombosis.

ABBREVIATIONS. HIT, heparin-induced thrombocytopenia; HPF4, heparin/platelet factor 4; PICU, pediatric intensive care unit; ELISA, enzyme-linked immunosorbent assay.
Heparin-induced thrombocytopenia (HIT) is regarded as serologically confirmed if HPF4 antibody levels exceed a specific cutoff. HIT is defined as the occurrence of HIT criteria: thrombocytopenia (platelet count below 150 x 10^9/L) and/or a new thrombotic event in the context of a recent heparin exposure. To identify patients with HIT, plasma samples were collected from PICU patients, and the sera were tested for antibodies against HPF4 using a commercially available enzyme-linked immunosorbent assay (ELISA; Asserachrom, Diagnostica Stago, Asnières-sur-Seine, France). Optical densities are expressed as percent of the cutoff values for adults provided from the manufacturer. In adults, the diagnosis of HIT is considered serologically confirmed if HPF4 antibody levels exceed this cutoff.

Because pediatric specific cutoffs for the ELISA test are not available, we compared all identified pediatric HIT patients with thrombosis for whom plasma samples were available, with a control group of 27 patients without clinical evidence of either HIT nor thrombosis. With 1 exception, we were able to identify 2 matching control patients for each case of thrombosis. Controls were matched for age, diagnosis, intervention, duration of heparin administration, and sample storage time. Table 1 compares baseline characteristics for cases and controls. HPF4 antibody levels were compared between the two groups by a nonparametric test.

**TABLE 1.** Characteristics of Patients With HIT and Thrombosis Compared With Controls (PICU Patients Without Clinical Evidence of HIT or Thrombosis)

<table>
<thead>
<tr>
<th>Variable</th>
<th>HIT-Thrombosis</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>14</td>
<td>27</td>
</tr>
<tr>
<td>Median age (mo; interquartile range)</td>
<td>6.5 (1–33)</td>
<td>4.3 (2–19)</td>
</tr>
<tr>
<td>Percentage of males</td>
<td>64%</td>
<td>59%</td>
</tr>
<tr>
<td>Heparin exposure before sample taken (d; mean, SD)</td>
<td>14 ± 10.5</td>
<td>15 ± 9.5</td>
</tr>
<tr>
<td>Storage time before analysis (mo; mean, SD)</td>
<td>17 ± 6.2</td>
<td>19.5 ± 5.5</td>
</tr>
<tr>
<td>Platelet count, mean (range)</td>
<td>58 (27–191)</td>
<td>336 (52–570)</td>
</tr>
</tbody>
</table>

SD indicates standard deviation.

**RESULTS**

During the study period, 1950 children were admitted to the PICU (Fig 1). Of these, 612 had received heparin for >5 days. Ninety patients with confirmed arterial and/or venous thrombosis were identified among all admitted patients. In 57 patients, thrombosis occurred after >5 days of heparin. For 38 patients of the latter, plasma samples were available. Fourteen of these (37%) satisfied the clinical HIT criteria as defined above. The age of the 5 girls and 9 boys was 2 weeks to 13 years. Two patients suffered from isolated arterial thrombosis, whereas 9 patients experienced isolated venous thrombosis. Three patients had combined arterial and venous complications. Thrombocytopenia with a platelet count below 150 x 10^9/L occurred in 13 of these patients; the median platelet count nadir was 58 x 10^9/L (range: 27–191 x 10^9/L). Thrombosis was diagnosed after a median of 10 days (range: 5–45 days) after onset of heparin administration.

Of the 14 patients with HIT, 6 patients had been exposed to heparin during previous hospitalizations for cardiac catheterization or major surgery. Eleven of the 14 patients with HIT-associated thrombosis had undergone cardiac surgery; this proportion reflects the distribution of admission diagnoses among patients who were exposed to heparin for >5 days in our institution. None of the patients died or needed limb amputation. Additional details of the patients with HIT-associated thrombosis are presented in Table 2.

Serologic confirmation of HIT using adult cutoff values was achieved in 6 patients. The remaining 8 patients also fulfilled the clinical criteria for HIT, but...
had antibody levels in the range of 26% to 80% of the cutoff for adults (Fig 2). Nevertheless, these 8 patients had significantly higher antibody levels than the controls (P = .004).

Based on 612 exposed patients, the observed incidence of HIT-associated thrombosis was 2.3% (95% confidence interval: 1.3%–3.9%). The proportion of thrombotic events attributed to HIT in patients exposed to heparin for ≥5 days amounted to 37% (95% confidence interval: 22%–54%, 14 of 38 patients).

**DISCUSSION**

This retrospective cohort study provides the first data on the incidence of HIT-associated thrombosis in an at-risk pediatric population. The calculated incidence in infants or children who are exposed to porcine heparin for 5 or more days was 2.3%. Our data indicate that the incidence of HIT-associated thrombosis in PICU patients is similar to that in adults.2,3,8,9 It is possible that the true incidence in our PICU population was even higher, as we only included children with radiologically documented thromboembolism, and had to limit our analysis to those patients for whom plasma samples were available for serologic diagnosis (38 of 57).

We found a similar distribution of arterial and venous thromboses in the pediatric patients as reported for adults, but less severe outcomes.9,10 One possible explanation is the preferential site of thrombosis. In our patients, all events occurred outside the pulmonary vascular bed, whereas in adults, HIT patients often present with pulmonary embolism.9

In this study, we used an ELISA for the determination of HPF4 antibodies. This ELISA has been established for diagnosis of HIT in adult patients and requires only minute amounts of sample.3,19

The majority of our patients with HIT-associated thrombosis were <1 year of age. During the first year of life, plasma levels of clotting factors as well as antibody production are lower than in adults.20–23 Therefore, adult cutoff levels may not be applicable to young children. This is supported by the finding that only 6 patients with clinically suspected HIT-associated thrombosis had HPF4 antibody levels

<table>
<thead>
<tr>
<th>Gender, Age at Admission</th>
<th>Admission Diagnosis</th>
<th>Site of Thrombosis</th>
<th>Hep Exp</th>
<th>Previous Hep</th>
<th>Platelet Decline (%)</th>
<th>Platelet-Nadir × 10^9/L</th>
<th>HPF4-AB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female, newborn</td>
<td>Open heart surgery</td>
<td>Left common iliacal artery; Right femoral artery; vena</td>
<td>6</td>
<td>No</td>
<td>51</td>
<td>191</td>
<td>153</td>
</tr>
<tr>
<td>Female, 6 mo</td>
<td>Open heart surgery</td>
<td>Superior vena cava</td>
<td>5</td>
<td>Yes</td>
<td>88</td>
<td>46</td>
<td>134</td>
</tr>
<tr>
<td>Male, 10 mo</td>
<td>Open heart surgery</td>
<td>Right subclavian vein</td>
<td>10</td>
<td>Yes</td>
<td>55</td>
<td>46</td>
<td>112</td>
</tr>
<tr>
<td>Female, 15 mo</td>
<td>Open heart surgery</td>
<td>Left subclavian vein; inferior vena cava; left and right external iliac veins</td>
<td>16</td>
<td>Yes</td>
<td>65</td>
<td>123</td>
<td>104</td>
</tr>
<tr>
<td>Male, 13 y</td>
<td>Embolisation of aorto-pulmonary shunts after lung bleeding</td>
<td>Left external iliac vein</td>
<td>19</td>
<td>No</td>
<td>67</td>
<td>55</td>
<td>135</td>
</tr>
<tr>
<td>Male, 13 y</td>
<td>Meningococcal sepsis</td>
<td>Left external iliac vein</td>
<td>10</td>
<td>No</td>
<td>73</td>
<td>27</td>
<td>101</td>
</tr>
<tr>
<td>Male, newborn</td>
<td>Open heart surgery</td>
<td>Right external iliac vein</td>
<td>15</td>
<td>No</td>
<td>52</td>
<td>55</td>
<td>68</td>
</tr>
<tr>
<td>Male, 3 mo</td>
<td>Open heart surgery</td>
<td>Right femoral artery</td>
<td>7</td>
<td>Yes</td>
<td>56</td>
<td>37</td>
<td>54</td>
</tr>
<tr>
<td>Male, newborn</td>
<td>Open heart surgery</td>
<td>Right femoral artery; right femoral vein; superior vena cava; right renal vein</td>
<td>9</td>
<td>No</td>
<td>78</td>
<td>29</td>
<td>43</td>
</tr>
<tr>
<td>Female, 3 mo</td>
<td>Open heart surgery</td>
<td>Right subclavian vein; inferior vena cava; left femoral vein</td>
<td>16</td>
<td>No</td>
<td>60</td>
<td>60</td>
<td>58</td>
</tr>
<tr>
<td>Male, 7 mo</td>
<td>Abdominal surgery</td>
<td>Left external iliac vein</td>
<td>5</td>
<td>Yes</td>
<td>73</td>
<td>43</td>
<td>26</td>
</tr>
<tr>
<td>Male, 17 mo</td>
<td>Open heart surgery</td>
<td>Right internal iliac vein</td>
<td>25</td>
<td>Yes</td>
<td>61</td>
<td>80</td>
<td>83</td>
</tr>
<tr>
<td>Female, 4 y</td>
<td>Open heart surgery</td>
<td>Left external iliac vein</td>
<td>8</td>
<td>No</td>
<td>70</td>
<td>93</td>
<td>38</td>
</tr>
</tbody>
</table>

Hep Exp indicates heparin exposure before diagnosis (days); Previous Hep, heparin administration during preceding 6 months; HPF4-AB, percentage of adult cutoff value of ELISA optical density.

**TABLE 2.** Characteristics of 14 Patients With HIT-Associated Thrombosis

![Fig 2. HPF4 antibody levels in patients with HIT and thrombosis (N = 14) and controls (N = 27). Data are presented as percent of cutoff optical density values for adults. The bar indicates the median value for each group. In 8 HIT-thrombosis patients with results below the cutoff for adults (100%), values were significantly higher than in controls (P = .004, Mann Whitney U test).](http://www.pediatrics.org/cgi/content/full/109/1/e10)
above the adult cutoff. However, the other 8 patients had significantly higher HPF4 antibody levels than their matched controls.

Several limitations of this study should be acknowledged. First, because of the design of this retrospective cohort study, we only included cases of thrombosis that were confirmed by radiology. Second, plasma was not available in all patients. In addition, minimizing iatrogenic blood loss is an imperative in neonatal and pediatric critical care; as a result, we were restrained to use plasma left over from daily routine requests. However, it is unlikely that a prospective study that would require informed consent for additional sampling for the purpose of HIT diagnosis would have attained a similar accrual rate of potentially eligible patients (38 of 57; 67%). Third, in adults the gold standard of serologic confirmation of HIT includes a functional test, ie, the [14C] serotonin release test. Because of the design of the study, and because the functional assay has not been established for pediatric patients, we were unable to perform this test. However, in the presence of clinical criteria for HIT, a positive ELISA alone suffices for confirmation. Overall, we believe these limitation do not invalidate our estimate of the incidence of HIT-associated thrombosis.

To establish a cutoff criterion for positive HPF4 antibody levels, a prospective cohort study in pediatric patients with both the ELISA and the functional test should be conducted. Such data are necessary to determine the incidence of HIT without thromboembolic complications. A prospective study should also elucidate the frequency and relevance of HPF4 antibodies in pediatric patients after cardiac surgery, a controversial issue in adult patients. We conclude that physicians caring for children should be aware of HIT-associated thrombosis as a severe side effect of heparin administration. Critically ill newborns and children represent a high-risk group. Our retrospective analysis suggests that in these patients, HIT-associated thrombosis occurs at similar frequency as in adults. This syndrome may account for one third of all cases of thromboembolism during heparin administration. Clinicians may therefore consider reducing the use of unfractionated heparin for catheter flushing. In addition, we speculate that alternative anticoagulants (eg, low molecular weight heparin) may provide an opportunity to lower the incidence of HIT and HIT-associated thrombosis in pediatric patients. This, however, has to be substantiated in prospective, controlled trials.

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REFERENCES

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