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

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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 is the standard therapy for the prevention and treatment of venous thromboembolism in adults and children. Immune-mediated, heparin-induced thrombocytopenia (HIT) is a well-known side effect of heparin therapy. HIT is one of the most frequent causes of drug-induced thrombocytopenia and can cause thrombosis. In adults, HIT occurs after heparin has been administered for at least 5 days. Patients with HIT present with a drop in their platelet count of ≥50%, often below 150 × 10⁹/L.1–4

In the majority of patients, immune-mediated HIT is caused by antibodies against complexes of heparin/platelet factor 4 (HPF4).3 The antibody-HPF4 complex binds to platelets via the platelet Fc γ-receptor IIA. It cross-links these receptors, thus ultimately activating platelets, leading to thrombosis and thrombocytopenia.3,6 The antibody also activates endothelial cells by binding to surface heparin/platelet factor 4 complexes and as a result increases expression of tissue factor and generation of thrombin.7

The incidence of HIT in adults has been reported to be between 1% and 5%. Reported incidences depend on the type of heparin used and the population studied.2,8,9 About 29% to 88% of adults with HIT develop arterial or venous thrombosis, with venous thrombosis being the more common complication.1,4,9,10 HIT-induced thrombosis is associated with a high risk of mortality.9,10 Although HIT occurs mainly in patients given therapeutic doses of heparin or systemic prophylaxis, it has also been reported in adults who were only exposed to heparin for “flushes” to maintain patency of intravenous lines,11 and in patients previously sensitized with heparin-coated catheters only.12 Although there are sufficient data regarding HIT and its thromboembolic complications in adults, little is known about the incidence of HIT in children.

HIT-associated thrombosis may develop particularly in critically ill pediatric patients and neonates who receive heparin for prevention and therapy of thrombosis or who are exposed to heparin for maintaining patency of vascular access. Most data on HIT in children are confined to case reports.13–17 To date, only 1 prospective study has evaluated the incidence of HIT in newborns: Spadone et al18 found an inci-
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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 150×10^9/L occurred in 13 of these patients; the median platelet count nadir was 58×10^9/L (range: 27–191×10^9/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 2. Characteristics of 14 Patients With HIT-Associated Thrombosis

<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 $\times 10^9/L$</th>
<th>HPF4-AB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female, newborn</td>
<td>Open heart surgery</td>
<td>Left common iliacal artery</td>
<td>6</td>
<td>No</td>
<td>51</td>
<td>191</td>
<td>153</td>
</tr>
<tr>
<td>Female, newborn</td>
<td>Open heart surgery</td>
<td>Right femoral artery</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>Superior vena cava</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>Right subclavian vein</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 subclavian vein; inferior vena cava; left and right external iliac veins</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, newborn</td>
<td>Abdominal surgery</td>
<td>Right subclavian vein</td>
<td>16</td>
<td>No</td>
<td>60</td>
<td>60</td>
<td>58</td>
</tr>
<tr>
<td>Male, 3 mo</td>
<td>Open heart surgery</td>
<td>Right femoral vein</td>
<td>45</td>
<td>No</td>
<td>77</td>
<td>43</td>
<td>57</td>
</tr>
<tr>
<td>Male, 7 mo</td>
<td>Open heart 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.

**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).

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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 \([^{14}\text{C}]\) serotonin release test.\(^3\) 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.\(^3,24,25\) 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.\(^6,26,27\) 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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