Heparin-Induced Thrombocytopenia: A Review

Bruno Girolami, M.D., Ph.D.,1 and Antonio Girolami, M.D.2

ABSTRACT

Immune heparin-induced thrombocytopenia (HIT) is a relevant adverse drug reaction consisting in a hypercoagulable state caused by an anticoagulant agent. The incidence is ~6.5% in patients receiving unfractionated heparin after orthopedic surgery, and is equal to or lower than 1% in other settings. HIT occurrence is a function of heparin type, duration of heparin administration, patient population, and gender. The pathogenesis is due to an antibody response to the complex heparin/platelet factor 4 in most cases, with secondary activation of platelets and coagulation, and finally increased thrombin generation. Thrombocytopenia, venous or arterial thrombosis, heparin-induced skin necrosis, adrenal hemorrhage, and transient amnesia can characterize the clinical course of HIT. Platelet monitoring in patients receiving heparin is indicated to early detect HIT. A thrombotic event can be the first manifestation of HIT. Laboratory demonstration of heparin-dependent platelet activation confirms the clinical diagnosis; antigenic or functional assays are available. Once HIT is highly likely or confirmed serologically, immediate heparin cessation is mandatory and an alternative therapeutic anticoagulant is needed due to the high risk (or the presence) of thrombotic events. The available nonheparin anticoagulants aim to reduce thrombin generation. Lepirudin, argatroban, and bivalirudin (direct thrombin inhibitors) and danaparoid and fondaparinux (factor Xa inhibitors) represent the current treatment options for HIT. Vitamin K antagonists can be used safely only after a stable platelet count has been obtained.

KEYWORDS: Heparin-induced thrombocytopenia, heparin therapy, review

Of the two identified forms of heparin-induced thrombocytopenia (HIT; Table 1), the immune type (HIT type 2) represents a relevant adverse drug reaction. Although HIT type has a benign course, with platelet counts recovering without heparin withdrawal and no clinical consequences, HIT type constitutes a clinical–pathological syndrome with a strong association with thrombotic events. Immediate heparin withdrawal is required, and in most cases, an alternative anticoagulant must be administered.1,2

HIT type 2, the object of this review, can be defined as an unexplained thrombocytopenia of 50% or more compared with any previous value during exposure to unfractionated heparin (UFH) or low molecular weight heparin (LMWH),3 confirmed by the demonstration of specific antibodies against the heparin–platelet factor 4 (PF4) complex by means of a functional and/or antigenic assay.4,5 In this article, we will refer to HIT type 2 simply as HIT.

EPIDEMIOLOGY

The reported frequencies of HIT vary widely. In a review of prospective trials, the reported estimates ranged from

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1 to 30% among patients receiving UFH and 2% in
patients receiving LMWH. In a more rigorous review,
the estimated incidence was lower than 3% with UFH,
and 0% with LMWH. Considering only prospective
studies in which an appropriate definition of HIT is
present (50% platelet count decrease or thrombotic event
with a positive antibody assay or satisfactory clinical
criteria for HIT), the frequency of HIT results as
reported in Table 2, according to different patient
categories. HIT is more frequent in patients who have had orthopedic
surgery (up to 6.5% when receiving UFH), and is
equal to or lower than 1% in other settings. Notably,
LMWHs are not free of risk in terms of HIT compared
with UFH. HIT occurrence is a function of heparin type
(bovine UFH > porcine UFH > LMWH), duration of
heparin administration (higher risk from days 5 to 14),
gender (female > male), HIT definition, and type of
test used for detecting heparin-dependent antibodies.

In general, antibodies are more likely to form in patients
undergoing cardiac surgery than orthopedic surgery, as
well as in orthopedic surgery patients who receive UFH
instead of LMWH. However, among patients in whom
antibodies do form, orthopedic patients are much more
likely to develop HIT.

PATHOGENESIS

Heparin administration can trigger an antibody re-
sponse, given that antibodies are produced against the
heparin–PF4 complex in some patients, depending on heparin molecular weight. PF4 is the most
important antigen, but the neutrophil-activating peptide 2 and interleukin 8 may also be involved. After
heparin binds to PF4, a conformational change within
PF4 determines the exposition of epitopes, and
immunoglobulin M (IgM), IgA, or IgG antibodies are
produced consequently. Clinically, only the IgG class
antibodies are pathogenic and associated with throm-
bosis. The heparin–PF4–antibody complex binds to the
platelet surface FcγRIIa receptor. Cross-linking of
FcγRIIa results in activation of platelets and the coag-
ulation cascade with thrombin generation (a potent
platelet activator). Because additional PF4 is released, a
positive-feedback loop enhances the process. Activated
platelets aggregate and are removed prematurely from the
circulation, leading to thrombocytopenia and, in
some patients, to venous or arterial thrombosis. In
summary, HIT pathogenesis can be described as a
three-step process: first, the antibodies are generated (immune response); second, platelets are activated and
thrombin generation is increased (hypercoagulable state); third, in some unpredictable patients, thrombosis
occurs (clinical–pathological syndrome).

CLINICAL MANIFESTATIONS

Thrombocytopenia typically occurs 5 to 10 days after
initiation of heparin. However, in the particular case of
an early re-exposure to heparin in patients who developed

<table>
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<tr>
<th>Table 1 Main Features of the Two Different Forms of Heparin-Induced Thrombocytopenia (HIT)</th>
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<td>Feature</td>
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<td>Frequency</td>
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<td>Pathogenesis</td>
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<td>Thrombosis</td>
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PF4, platelet factor 4.

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<tr>
<th>Table 2 Prospective Studies Evaluating the Incidence of Immune HIT in Different Patient Populations, Receiving UFH or LMWH</th>
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<tr>
<td>Reference</td>
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<tr>
<td>After orthopedic surgery, UFH</td>
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<td>Ganzera et al</td>
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<td>Mahlfield et al</td>
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<td>Warkentin et al</td>
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<tr>
<td>After orthopedic surgery, LMWH</td>
</tr>
<tr>
<td>Ganzera et al</td>
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<tr>
<td>Marx et al</td>
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<tr>
<td>Mahlfield et al</td>
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<tr>
<td>Warkentin et al</td>
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<tr>
<td>After heart surgery, UFH</td>
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<tr>
<td>Warkentin et al</td>
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<tr>
<td>After general or vascular surgery, UFH and LMWH</td>
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<td>Calaitges et al</td>
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<td>Lindhoff-Last et al</td>
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<td>Medical patients, UFH</td>
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<td>Kappers-Klunne et al</td>
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<td>Lindhoff-Last et al</td>
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<td>Girolami et al</td>
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<tr>
<td>Medical patients, LMWH</td>
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<tr>
<td>Lindhoff-Last et al</td>
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<td>Prandoni et al</td>
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Study inclusion criteria: prospective (randomized studies, single- or
double-cohort studies), declared adequate definition of HIT, labora-
tory demonstration of antibodies, or presence of stringent clinical
criteria. HIT, heparin-induced thrombocytopenia; UFH, unfractionated hepar-
in; LMWH, low molecular weight heparin.
anti-PF4–heparin antibodies in the previous 100 days, onset may be earlier and rapid. In general, an onset of thrombocytopenia after 2 weeks is unusual. However, a delayed onset of HIT also has been described in which thrombocytopenia developed after heparin withdrawal. In general, thrombocytopenia rarely is severe, with median nadir platelet counts of \( \sim 60 \times 10^9/L \) and it is rarely associated with bleeding.

Thrombosis, venous and/or arterial, is the major clinical problem associated with HIT. The prothrombotic state associated with HIT is due to thrombin generation, platelet activation, and endothelial cell activation. The frequency of venous thrombosis in HIT patients reaches 90% in patients after orthopedic surgery, whereas arterial thrombosis occurs less frequently. Approximately one half of patients with HIT are recognized only after the occurrence of a complicating thrombotic event. The risk of thrombosis after HIT is higher than 50% in the first 30 days. Deep vein thrombosis and (fatal) pulmonary embolism are the most relevant thrombotic events in HIT patients. Other thrombotic manifestations include venous limb gangrene, cerebral sinus thrombosis, and upper extremity deep vein thrombosis. Arterial thrombosis can lead to stroke, myocardial infarction, limb ischemia from peripheral arterial occlusion, and bowel or kidney infarction. Heparin-induced skin necrosis may occur in fat-rich areas or in distal extremities and the nose; erythema is followed by purpura and hemorrhage, leading to necrosis. Other unusual complications of HIT include adrenal hemorrhage and transient global amnesia.

**DIAGNOSIS**

The diagnosis of HIT initially is clinical. An awareness of the syndrome is necessary to suggest HIT in cases of unexplained thrombocytopenia during heparin exposure, in the case of (new or worsening) thrombosis during heparin prophylaxis or treatment, or even in the case of thrombocytopenia or thrombosis after heparin withdrawal. Furthermore, the assays with the highest sensitivity and specificity are not available in many centers, and are time consuming and expensive. Clinical scores have been developed in the past to support the clinical diagnosis of HIT. These scoring systems are able to stratify patients as unlikely, likely, or highly likely to have HIT, on the basis of several parameters (platelet decrease, temporal aspects of platelet decrease, platelet recovery after heparin withdrawal, presence of cutaneous reactions, or thrombosis or other causes of thrombocytopenia). Recently, a pretest probability score has been developed to suggest HIT and it is listed briefly in Table 3. Early diagnosis is also dependent on the frequency of platelet monitoring. It is recommended to perform platelet counts every other day in patients receiving therapeutic dose of UFH or in postoperative patients receiving UFH prophylaxis, whereas in medical patients receiving prophylactic UFH or LMWH, postoperative patients receiving LMWH prophylaxis, platelet counts can be performed every 2 or 3 days.

Once a high suspicion of HIT has been formulated, the diagnosis should be confirmed with the demonstration of heparin-dependent platelet activation. The most specific diagnostic tests for HIT include platelet aggregation tests, serotonin release assays, heparin-induced platelet aggregation assays, and solid-phase immunoassays (enzyme-linked immunosorbent assay [ELISA]). The main features of the available assays are listed in Table 4. The serotonin release assay represents the gold standard of the diagnostic tests for HIT and has been validated with a prospective study; however, it is costly and requires technical expertise. The

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**Table 3 Pretest Probability of HIT According to Thrombocytopenia, Timing of Platelet Decrease, Presence of Thrombosis, and Other Causes of Platelet Count Decrease**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Points for Each of the Four Parameters</th>
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<tbody>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Thrombocytopenia</td>
<td>&gt; 50% decrease or nadir ( 20\sim100 \times 10^9/L )</td>
</tr>
<tr>
<td>Timing of platelet decrease</td>
<td>Onset between days 5 and 10 (or less than 1 d if heparin exposure within previous 100 d)</td>
</tr>
<tr>
<td>Thrombosis or other sequelae</td>
<td>New thrombosis; skin necrosis; post-heparin bolus acute systemic reaction</td>
</tr>
<tr>
<td>Other causes of thrombocytopenia</td>
<td>No evidence</td>
</tr>
</tbody>
</table>

Pretest probability score: 6–8, high; 4–5, intermediate; 0–3, low.

HIT, heparin-induced thrombocytopenia.

ELISA assay, which has a lower sensitivity (it detects only IgG/IgM antibodies), should be used in conjunction with a functional assay. If the two tests are negative, HIT is ruled out.

TREATMENT

The increased thrombin generation present in HIT is the target of drug therapy. In fact, available agents aim to reduce thrombin generation directly (direct thrombin inhibitors) or by means of factor (F) Xa inhibition (danaparoid and fondaparinux). The evidence supporting the use of these drugs comes mainly from prospective cohort studies (lepirudin and argatroban) or retrospective studies (danaparoid). Table 5 summarizes the main features of these compounds. Isolated seroconversion without thrombocytopenia or thrombosis does not require any treatment or heparin withdrawal. In contrast, confirmed HIT without thrombosis (isolated HIT) requires heparin cessation and an alternative form of anticoagulation, given that the patients remain at risk for thrombosis in the short term, and heparin withdrawal alone does not protect these patients from thrombotic complications. LMWH should be avoided because of cross-reactivity and risk of induction of heparin-dependent IgG antibodies. Therapy with non-heparin anti-FXa or anti-FIIa inhibitors should be continued for at least 2 to 3 months. Table 6 lists the main issues in the management of patients with HIT, with or without thrombosis.

Lepirudin, recombinant hirudin, is approved in the United States for treatment of HIT with thrombosis and is effective in preventing new thromboses in HIT patients without thrombosis, according to prospective studies. In a prospective cohort of 82 patients with confirmed HIT, lepirudin led to a rapid platelet count recovery in 89% of patients and a significant decrease of a combined end point (death, amputation, and new thromboembolic events) compared with historical controls (25 versus 52%), with no differences in terms of bleeding complications. Given that the drug is cleared by the kidneys and no antidote is available, the dosage of lepirudin needs to be decreased in nephropathic patients.

Argatroban, a synthetic direct thrombin inhibitor, is approved in the United States for the treatment of HIT regardless of the presence of thrombosis and during angioplasty when heparin is contraindicated. Because argatroban is metabolized mostly by the liver and excreted in the bile, a lower starting dosage is suggested in patients with hepatic dysfunction. A pooled analysis of two prospective cohort studies and a historical control group showed a significant 14% decrease in the primary outcome (all-cause death, all-cause amputation, new thrombosis) in patients with HIT with or without thrombosis and treated with argatroban. The positive result is due mainly to a decrease in new (venous) thrombosis. No differences in terms of bleeding were observed.

Bivalirudin, a recent and promising synthetic hirudin analogue, has been used in patients with HIT, but only uncontrolled case series are available. It is not well defined, but in view of the high risk of thrombosis within 30 days of the diagnosis of HIT, warfarin anticoagulation probably

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Table 4 Assays Available for the Laboratory Diagnosis of HIT

<table>
<thead>
<tr>
<th>Assay Type</th>
<th>Components</th>
<th>Measure</th>
<th>Advantages</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functional assays</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Platelet aggregation tests</td>
<td>Test plasma, donor platelet-rich plasma, heparin</td>
<td>Platelet aggregation</td>
<td>Easy, specific</td>
<td>Variability, low sensitivity</td>
</tr>
<tr>
<td>14C-serotonin release assay</td>
<td>Test plasma, donor 14C-serotonin-radiolabeled washed platelets, heparin</td>
<td>14C-serotonin release from platelets</td>
<td>Sensitive</td>
<td>Radionuclide, expensive</td>
</tr>
<tr>
<td>Heparin-induced platelet aggregation</td>
<td>Test plasma, donor washed platelets or platelet-rich plasma, heparin</td>
<td>Platelet aggregation</td>
<td>Easy, sensitive</td>
<td>Variability</td>
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<tr>
<td>Immunooassays</td>
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<tr>
<td>PF4/heparin ELISA</td>
<td>Test plasma, PF4–heparin complexes coated on microtiter plates</td>
<td>Presence of heparin-dependent antibodies</td>
<td>Easy, fast, sensitive</td>
<td>Detects only antibodies against the PF4–heparin complex</td>
</tr>
</tbody>
</table>

HIT, heparin-induced thrombocytopenia; ELISA, enzyme-linked immunosorbent assay; PF4, platelet factor 4.
Danaparoid, a heparinoid (dermatan sulfate and low-sulfated heparan sulfate), is used in Europe, Canada, and New Zealand for HIT with or without thrombosis, and in patients with a history of HIT who require cardiopulmonary bypass surgery. In a non-randomized comparison study, danaparoid was as effective as lepirudin in preventing death, amputation, or new thromboembolic complications with a lower risk of bleeding. Whether the 10% in vitro cross-reactivity between danaparoid and the antibody responsible for HIT is of clinical significance is uncertain. No reversing agent is available.

Fondaparinux has a theoretical role in the treatment and/or prevention of HIT, given that the drug does not appear to interact with platelets or PF4. Only case reports on its use in patients with HIT are available.

To prevent HIT, the following strategies can be suggested: limit heparin use, avoid bovine UFH, overlap warfarin as soon as possible to limit heparin exposure, and use LMWHs, particularly in the orthopedic setting. Patients with a history of HIT can be re-exposed safely to UFH if assays for antibodies are negative; this generally occurs 100 days after HIT.

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