Background: Heparin-induced thrombocytopenia (HIT) is a common, often catastrophic, syndrome that produces the most hypercoagulable of states. Emerging therapeutic strategies use alternative anticoagulants; warfarin’s place is being reexamined. Early in the course of warfarin therapy, there may be net procoagulant effects because of the inhibition of protein C. With HIT, it has been suggested that unopposed warfarin can precipitate venous limb gangrene. There are also reports of warfarin-induced skin necrosis. We seek to confirm and increase awareness of the risks of warfarin with HIT.

Methods: We describe 6 patients with HIT seen at 3 medical centers in whom frank or impending venous limb gangrene, central skin necrosis, or both were temporally related to warfarin initiation.

Results: At warfarin initiation, 5 patients had recognized HIT and 1 had it recognized later. Complications emerged after 2 to 7 days, and consisted of warfarin-induced skin necrosis (n = 5) and venous limb gangrene (n = 2); 1 patient had both. This emerged with unopposed warfarin in 4 patients and as a direct thrombin inhibitor was being withdrawn in 2. All had supratherapeutic international normalized ratios. One patient required leg and breast amputations, and another one died.

Conclusions: Because of the early effects on protein C, warfarin can precipitate venous limb gangrene and/or skin necrosis in the extreme hypercoagulable milieu of HIT. With HIT, unopposed warfarin should be avoided and caution is needed during transition from a direct thrombin inhibitor. Warfarin should be initiated at modest doses in patients with HIT after platelet recovery. Implications extend to warfarin initiation with other thrombotic diatheses.
A 58-year-old man had traumatic vertebral fractures requiring surgery. Postoperatively, he experienced femoral vein thrombosis and pulmonary emboli. Intravenous unfractionated heparin therapy was started, with a platelet count of $441 \times 10^3/\mu L$. Warfarin, 10 mg/d, was added on day 9. Heparin was discontinued when the platelet count decreased to $120 \times 10^3/\mu L$ and to $83 \times 10^3/\mu L$ on days 10 and 11, respectively. Warfarin therapy was continued. On day 14, a necrotic ulcer appeared on the thigh (Figure, A). The prothrombin time was 21 seconds (estimated INR, 4.0); the platelet count was $133 \times 10^3/\mu L$, the fibrinogen level was normal, and fibrin split products were mildly elevated. Warfarin was discontinued, but the skin necrosis progressed and the patient died of septicemia.

PATIENT 2

After knee trauma and surgery, a 50-year-old woman had purulent material drained from her knee. Antibiotics were given via a central venous catheter flushed with unfractionated heparin. The platelet count was $318 \times 10^3/\mu L$. She was readmitted on day 8 for symptomatic venographically demonstrated thromboses in the right arm. Intravenous heparin was administered. The readmission platelet count of $109 \times 10^3/\mu L$ decreased the next day to $43 \times 10^3/\mu L$, then to a nadir of $17 \times 10^3/\mu L$. Heparin was discontinued, HIT was confirmed by an enzyme-linked immunosorbent assay, and lepirudin therapy was begun. Rapidly progressing arm cyanosis mandated alteplase for 2 days. A ventilation/perfusion scan showed a moderate probability of a pulmonary embolism. Lepirudin therapy was resumed, but the arm remained pregangrenous and the platelet count remained about $100 \times 10^3/\mu L$. Warfarin therapy was started at 5.0 mg/d on day 23, and increased to 7.5 mg/d on day 25. On day 26, lepirudin was discontinued (INR, 3.1). A painful 10-cm black lesion with surrounding ecchymoses appeared on the left breast on day 28. The INR was 4.5, and the platelet count was $87 \times 10^3/\mu L$. Warfarin was discontinued, vitamin K was administered, and lepirudin therapy was resumed. The breast improved over several days, as the platelet count increased to $240 \times 10^3/\mu L$. Low-dose warfarin, 2.5 mg/d, was reinstated and lepirudin was eventually discontinued. Protein C and S levels were normal.

PATIENT 3

A 55-year-old man underwent coronary artery bypass surgery and received intravenous heparin for 3 days postoperatively for atrial fibrillation. The platelet count on hospital discharge (day 7) was $224 \times 10^3/\mu L$, but was $47 \times 10^3/\mu L$ on readmission 4 days later, with right leg deep vein thrombosis. Enzyme-linked immunosorbent and serotonin release assays confirmed HIT, and lepirudin therapy was initiated. Warfarin, 21 mg, was given for the next 3 days. On day 9, the INR was 2.7, the platelet count was $45 \times 10^3/\mu L$, and lepirudin was discontinued. The leg worsened. Lepirudin therapy was restarted with warfarin. On day 13, the INR was 3.3 and warfarin therapy was continued alone. Thrombocytopenia persisted. On day 14, worsening cyanosis of the leg gave the appearance of impending venous limb gangrene. The INR was 5.8. Lepirudin therapy was resumed, warfarin was discontinued, and vitamin K was administered. Signs of gangrene resolved over 2 days, as the platelet count increased to normal. The patient was discharged to continue taking danaparoid sodium.

**Patient Summaries**

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Indication for Heparin</th>
<th>Warfarin Initiation (After HIT), d</th>
<th>Overlap of Warfarin and a Thrombin Inhibitor</th>
<th>Time to Onset of Complications (While Taking Warfarin), d</th>
<th>Signs of Complications</th>
<th>Maximum Recorded INR</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DVT (postoperatively)</td>
<td>–1</td>
<td>None</td>
<td>6</td>
<td>WISN of thigh</td>
<td>4.0*</td>
<td>Sepsis and death</td>
</tr>
<tr>
<td>1</td>
<td>Catheter flushes and DVT</td>
<td>14</td>
<td>4 d (lepirudin)</td>
<td>6</td>
<td>WISN of left breast</td>
<td>4.5</td>
<td>Healed and discharged from the hospital while taking warfarin</td>
</tr>
<tr>
<td>2</td>
<td>Coronary bypass and atrial fibrillation</td>
<td>0</td>
<td>6 d (lepirudin)</td>
<td>7</td>
<td>VLG of right leg</td>
<td>5.8</td>
<td>Healed and discharged from the hospital while taking danaparoid sodium</td>
</tr>
<tr>
<td>3</td>
<td>Cardiac catheterization and pulmonary embolus</td>
<td>–3</td>
<td>None</td>
<td>3</td>
<td>WISN of breasts</td>
<td>3.2</td>
<td>Surgical debridement</td>
</tr>
<tr>
<td>4</td>
<td>Pulmonary embolus</td>
<td>–2</td>
<td>None</td>
<td>2</td>
<td>WISN of calves</td>
<td>6.1</td>
<td>Surgical debridement and discharged from the hospital while taking warfarin</td>
</tr>
<tr>
<td>6</td>
<td>Acute MI, coronary bypass, and atrial fibrillation</td>
<td>0*</td>
<td>None</td>
<td>4</td>
<td>WISN of breast and VLG of leg</td>
<td>6.4</td>
<td>Mastectomy and amputation</td>
</tr>
</tbody>
</table>

Abbreviations: DVT, deep venous thrombosis; HIT, heparin-induced thrombocytopenia; INR, international normalized ratio; MI, myocardial infarction; VLG, venous limb gangrene; WISN, warfarin-induced skin necrosis.

*Estimated from available data.
PATIENT 4

A 53-year-old woman was treated with intravenous heparin for a pulmonary embolism. Warfarin, 10 mg/d, was added on day 3. The platelet count decreased to $86 \times 10^3/\mu L$ on day 7, the INR was 3.2, and heparin was discontinued. The result of an enzyme-linked immunosorbent assay for heparin-induced antibodies was positive. Three days later, violaceous discoloration of both breasts developed and progressed to full-thickness skin necrosis (Figure, B). Warfarin was discontinued and lepirudin therapy was instituted as the platelet count reached a nadir of $22 \times 10^3/\mu L$. Extensive surgical debridement of both breasts was performed. Warfarin therapy was later resumed at 1 mg/d, and increased gradually until the INR was therapeutic; then, lepirudin was discontinued. The patient had normal protein C and S levels and negative hypercoagulability panel results.

PATIENT 5

A 24-year-old woman with systemic lupus erythematosus received intravenous heparin for a pulmonary embolism. Warfarin, 10 mg/d, was added on day 3. The platelet count decreased from $247 \times 10^3/\mu L$ at baseline to $83 \times 10^3/\mu L$ on day 5, the INR was 6.1, and painful purpuric lesions of both calves appeared, progressing to full-thickness necrosis. HIT was diagnosed based on clinical variables and a positive enzyme-linked immunosorbent assay result. Heparin and warfarin were discontinued, as vitamin K, fresh frozen plasma, and danaparoid were given. The patient required grafts to both legs. Recurrent pulmonary emboli were believed to be due to cross reactivity of antibodies with danaparoid (dose, 1500 U subcutaneously twice a day; the result of serotonin release for cross reactivity was positive). Argatroban therapy was substituted. Warfarin was reintroduced at 1 mg/d, and escalated slowly, overlapping with argatroban for 15 days. A hypercoagulability evaluation revealed only an elevated anti–cardiolipin IgG level (without a lupus anticoagulant).

PATIENT 6

A 72-year-old woman received alteplase and heparin for an acute myocardial infarction. The platelet count was $190 \times 10^3/\mu L$. She underwent coronary artery bypass grafting several days later. Warfarin was given for postoperative atrial fibrillation. Four days postoperatively, she developed pain and discoloration of the left breast, right leg, and left foot (Figure, C). The INR was 6.4 and the platelet count was $68 \times 10^3/\mu L$. The breast and venous leg lesions rapidly progressed. She required a mastectomy and a below-the-knee amputation, and eventually a left transmetatarsal amputation. Five weeks later, she was readmitted with upper extremity swelling. Ultrasonography confirmed axillary-subclavian and femoral venous thromboses. The platelet count decreased from $126 \times 10^3/\mu L$ to $26 \times 10^3/\mu L$ after 3 days of intravenous heparin therapy. Subcutaneous enoxaparin sodium therapy produced the following acute systemic reaction: flushing, tachycardia, and tachypnea. An inferior vena cava filter was placed, and argatroban was given for 2 weeks. A hypercoagulability profile showed anti–cardiolipin antibodies and a low protein S level.

COMMENT

Warkentin et al described the syndrome of venous limb gangrene complicating HIT and related it to warfarin use. Compared with unaffected patients, those with venous limb gangrene had higher prothrombin INRs, lower protein C activities, and persistently elevated thrombin-antithrombin complexes. This syndrome caused more limb amputations with HIT than did arterial thromboses. It occurred in 12% of patients with HIT and venous thrombosis given warfarin (with or without ancrod). Like
our patient 6, one patient with gangrene also developed classic central skin necrosis. Other case reports document warfarin-induced skin necrosis complicating HIT. The warfarin-induced skin necrosis with HIT seems clinically identical to the classically described syndrome in terms of onset in the first days of warfarin use and predilection for fatty areas of the body. As in patients with other thrombotic diatheses in whom frequently more than one hypercoagulable state coexists, it is not surprising that some of our patients had additional thrombolic risk factors (patients 5 and 6). Our series confirms the dangers of venous limb gangrene and skin necrosis when initiating warfarin therapy in patients with HIT.

Our patients illustrate a gamut of HIT clinical scenarios. In patients 1, 4, and 5, heparin was discontinued for acute HIT, then unopposed warfarin was initiated or continued. In patient 6, HIT was initially unrecognized. We emphasize that the emergence of warfarin-induced skin necrosis or worsening venous thrombosis should alert to the possibility of underlying HIT; patient 6 could have been spared further morbidity and life-threatening complications. In patients 2 and 3, there was some delayed-onset component to the HIT, and both had warfarin-related complications emerge during overlap with lepirudin therapy. To our knowledge, we are the first to report that in patients with HIT, the transition period from a direct thrombin inhibitor to warfarin can be potentially dangerous. Others have begun to recognize warfarin-induced worsening of venous thromboses in patients with HIT during the transition from the direct thrombin inhibitor lepirudin or argatroban. Argatroban has significant effects on prothrombin INR, which introduces challenges with warfarin overlap (as noted on the package insert), yet this is a double-edged sword, with risks not only of antiocoagulation overshoot with bleeding but also of warfarin-related prothrombotic effects if the argatroban is discontinued (or even held) prematurely. While lepirudin has less effect on the prothrombin INR, recent exhortations to reduce doses to minimally therapeutic levels during warfarin transition may raise similar dangers.

In the extreme prothrombotic milieu of HIT, alternative anticoagulants should be administered. Most patients will require transition to warfarin for the indication that first mandated anticoagulation, for thromboses that arose secondary to HIT, or for protection from the extreme risk of new thrombosis in isolated HIT. Several precautions could minimize the risks of warfarin initiation in patients with HIT, including (1) first waiting for the platelet count to increase to near normal as the HIT is “cooled”; (2) initiating modest doses, avoiding an overshoot of the target INR; and (3) shunning unopposed warfarin and assuring adequate levels of an alternative anticoagulant during transition. Wallis et al observed no increase in thrombotic events with warfarin treatment in 51 patients with HIT, 16 with HIT-related thromboses. Warfarin doses were modest (mean, 3.5 mg); therapy was started several days before HIT in half the patients, when the platelet count was generally 100 × 10^9/L. In all our patients, as in prior reports, thrombotic complications correlated with supratherapeutic prothrombin INRs.

Beyond implications toward the recognition and management of HIT, our observations bear generally on the optimal initiation of warfarin therapy. It is increasingly clear that protein C inhibition before effective paralysis of procoagulant pathways is more than a theoretic concern. In fact, early warfarin exacerbation of thrombotic diatheses has been reported with hereditary protein C deficiency, with cancer-related disseminated intravascular coagulation, and now confirmed with HIT. While there may be low-risk situations in which warfarin can be initiated unopposed, prudence dictates adequate systemic anticoagulation before warfarin use in any active thrombotic process. In a warfarin-naive patient, we endorse initial doses of 5 mg/d, sometimes lower in situations such as HIT.

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From the Section of Hematology-Oncology, Department of Medicine, Baylor College of Medicine, Houston, Tex (Drs Srinivasan, Rice, and Baker); the Section of Vascular Medicine, Department of Cardiovascular Medicine, The Cleveland Clinic Foundation, Cleveland, Ohio (Drs Bartholomew and La Perna); the Division of Cardiology, Department of Internal Medicine, University of Michigan Health System, Ann Arbor (Dr Kangaswamy); the Division of Hematology/Oncology, Department of Medicine, Hospital of the University of Pennsylvania, Philadelphia (Dr Thompson); and American Red Cross Blood Services and the Department of Medicine, University of Pennsylvania, Philadelphia (Dr Murphy).

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Corresponding author and reprints: Lawrence Rice, MD, Section of Hematology-Oncology, Department of Medicine, Baylor College of Medicine, 6365 Fannin, Mail Stop 902-Main, Houston, TX 77030 (e-mail: lrice@bcm.tmc.edu).

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