Heparin-induced thrombocytopenia (HIT) is an adverse drug reaction caused by platelet-activating IgG antibodies that recognize multimolecular PF4/heparin complexes. Therapeutic plasma exchange (TPE) has been recommended as a way to remove HIT antibodies quickly, as might be required to permit administration of heparin for urgent cardiac surgery. However, HIT antibodies (IgG) are not as effectively removed by TPE as IgM. Using serial pre-/post-TPE sera obtained from a patient with subacute HIT who underwent repeated TPE before heparin reexposure indicates that patients with subacute HIT undergoing repeated TPE before heparin reexposure should be tested by serial platelet activation assays even when their EIAs remain strongly positive. (Blood. 2015;125(1):195-198)

**Case report**

A 76-year-old female with renal carcinoma invading the inferior vena cava (IVC)/right atrium developed HIT without thrombosis (4Ts score, 6 points), with strong-positive SRA and EIA, and with uneventful platelet count recovery during fondaparinux 7.5 mg therapy once daily subcutaneously. Cardiac surgery was scheduled 3 months post-HIT for coronary artery bypass grafting (CABG) and removal of IVC/intracardiac tumor thrombus. However, because her SRA and EIA remained strongly positive (99% serotonin release at 0.3 IU/mL unfractionated heparin [UFH]; IgG-specific EIA, 2.58 optical density [OD] units), TPE was performed on 4 consecutive days (3-L exchanges with 5% albumin replacement), yielding a persistently negative SRA postsecond TPE, despite the EIA-IgG remaining strongly positive (1.85 OD units postsecond apheresis vs 2.30 OD units on serum obtained immediately before). Two days postfourth TPE, she received UFH (30 000 units intraoperatively) for cardiopulmonary bypass, undergoing: quadruple CABG, IVC/intracardiac tumor thrombectomy, and radical nephrectomy. Unfortunately, tumor removal was incomplete, and intraoperative splenic injury resulted in major blood loss, requiring splenectomy in massive transfusion setting (16 U red blood cells, 10 frozen plasma, 10 cryoprecipitate, 3 U platelets). The preoperative platelet count was 141 × 10^9/L, with an intraoperative nadir of 48 × 10^9/L. Postoperatively, daily fondaparinux 2.5 mg and aspirin 81 mg were given. Complications included complex-partial seizures (computed tomography brain scan was negative for thrombotic or hemorrhagic stroke) and ileus/aspiration pneumonitis on postoperative day 6. She was discharged on postoperative day 34.
Methods

Testing for HIT antibodies was performed using the SRA and an in-house anti-PF4/heparin IgG-specific EIA (McMaster Platelet Immunology Laboratory), as described previously.5,6 Serial serum samples were drawn for HIT antibody testing immediately before and after each TPE session. SRA-positive control sera obtained from 15 different patients previously diagnosed with HIT (each serum yielding >50% serotonin release at 0.3 U/mL UFH) were tested in fourfold serial dilutions (1/5 to 1/5120). The SRAs were performed over 2 days, and the EIA-IgG in 1 day using 3 plates, with internal HIT-positive and -negative control sera producing expected results.

For comparison, sera are usually diluted 1 in 5 (final) in our SRA and 1 in 50 (final) in our EIA-IgG. Statistical analysis was performed by Student t test, paired 2-sample for means (Microsoft Excel 1997-2003). The patient provided written consent to report her case, and permission was obtained from the Hamilton Integrated Research Ethics Board to perform the studies using HIT-positive sera.

Results and discussion

Figure 1 shows the percent serotonin release (at 0.3 IU/mL UFH) induced by the patient’s sera obtained at different time points precardiac surgery (cardiac surgery, day 0; HIT diagnosis, day −87), as well as immediately before/after each of 4 TPE sessions (days −5 through −2). We found that the EIA-IgG reactivity—expressed in OD units—abruptly fell after each TPE session (by a mean of 0.94 U; P < .001), but by the following day, EIA-IgG reactivity had risen significantly once again (by mean of 0.69 U; P = .0025). These observations are consistent with the partial removal of IgG antibodies by TPE, with subsequent redistribution of IgG from the extravascular/interstitial spaces into the intravascular compartment.3 Nevertheless, TPE was sufficient in our patient to remove IgG antibodies to a meaningful extent, as indicated by the negative SRA.

Figure 2A shows SRA and EIA-IgG results for 15 serially diluted HIT sera. The data show that samples testing SRA-negative can still have strongly positive EIA-IgG reactivities. For example, at a 1 in 320 sample dilution, only 2 of 15 HIT sera tested SRA-positive, whereas all 15 corresponding EIAs tested positive (and most strongly positive), with a median OD (interquartile range) of 2.55 (1.77, 2.65). Further, when we compared the corresponding EIAs for the most dilute (but still SRA-positive) sera vs the corresponding fourfold more dilute (but now SRA-negative) sera, the mean OD values were similar (2.75 vs 2.60, respectively; P = .157) (Figure 2B). Interestingly, the maximum OD reactivity (at any dilution) was similar to the OD reactivity of the most diluted, but still SRA-positive sample.

Our observations have implications for managing patients with (sub)acute HIT using TPE before planned heparin reexposure. Previous American College of Chest Physicians (ACCP) consensus conference guidelines on HIT management published in 2008 recommended that patients with previous HIT can receive UFH provided that heparin-dependent, platelet-activating antibodies are no longer detectable by (washed) platelet activation assay, even if the EIA remains positive (a recommendation based on favorable outcomes among EIA-positive/washed platelet) activation assay–negative patients who were reexposed to heparin for urgent cardiac surgery.2,8,11,12 and we followed this approach to manage our patient. (Although the 2012 ACCP guidelines11 also recommend heparin use with “heparin antibodies ... absent,” the applicable assays are not specified.) Although SRA-negative status usually occurs within a few weeks post-HIT,12 when surgery is required urgently yet SRA-positive status persists, TPE becomes an important option.3,8,11 Our studies of serial pre-/post-TPE serum (Figure 1), as well as corroborative studies using serially-diluted HIT sera (Figure 2A-B), demonstrate that EIAs usually remain strongly positive, even when a patient is otherwise at acceptable risk for heparin reexposure (per negative washed-platelet activation assay). Although our findings might appear surprising—given the known predictivity for a positive SRA with increasing strength of EIA reactivity3,5—they point to the critical dependence of HIT serum–induced platelet activation to a crucial threshold level of platelet-activating antibodies (a phenomenon that helps to explain
the EIA-SRA interrelationship\textsuperscript{13-15}, and how quickly platelet-activating properties can be lost in an individual patient with declining antibody levels, either occurring naturally over time\textsuperscript{9,10,12} or by serum dilution performed experimentally or via TPE. Our observations also help to explain the serological profiles of 2 previously reported patients (patient 1/Figure 1A in reference 9, and patient 20/Figure 3 in reference 10) with recent HIT undergoing serosurveillance to assess readiness for heparin reexposure: consistent with our findings, these patients continued to have strong positive anti-PF4/heparin antibodies by EIA (with values similar to the highest ones obtained at HIT diagnosis), even when their sera had become negative by washed-platelet activation assay.\textsuperscript{9,10}

In summary, our observations indicate that diluted HIT serum—whether achieved clinically through serial TPE, or experimentally through serial sample dilutions—demonstrates loss of SRA reactivity well before a decrease in EIA reactivity. These findings point to the importance of performing platelet activation assays in parallel with the EIA, when testing pre- and post-TPE samples when judging patient suitability for a planned heparin reexposure.

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**Authorship**

Contribution: T.E.W. designed and supervised the experiments, analyzed the data, and interpreted the results; J.-A.I.S. designed and performed the experiments and interpreted the results; T.E.W., F.V.C., A.K., and A.G. helped to manage the patient using some of the data obtained in this report; M.A.C. provided the initial concept for the study; and all authors reviewed and approved the final version of the manuscript.
Conflict-of-interest disclosure: T.E.W. has received lecture honoraria from Pfizer Canada and Instrumentation Laboratory, has provided consulting services to and/or has received research funding from W.L. Gore, and has provided expert witness testimony relating to HIT. M.A.C. has sat on advisory boards for Janssen, Leo Pharma, Portola, and AKP America. He holds a Career Investigator award from the Heart and Stroke Foundation of Ontario, and the Leo Pharma Chair in Thromboembolism Research at McMaster University. His institution has received funding for research projects from Leo Pharma. M.A.C. has received lecture honoraria from Leo Pharma, Bayer, Celgene, Shire, and CSL Behring and has provided expert testimony (but not in cases involving HIT). The remaining authors declare no competing financial interests.

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References


Plasma exchange to remove HIT antibodies: dissociation between enzyme-immunoassay and platelet activation test reactivities

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