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Pediatric Heparin-Induced Thrombocytopenia: prevalence, thrombotic risk, and application of the 4Ts scoring system

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Abstract

Objective—To characterize heparin-induced thrombocytopenia (HIT) at a single pediatric center including the prevalence and the accuracy of the 4Ts scoring system as a predictor of HIT.

Study design—In this retrospective cohort study, we identified 155 consecutive patients < 21 years old with sufficient data for 4Ts scoring. The 4Ts scoring system is a validated pretest tool in adults that predicts the likelihood of HIT using clinical features. Hospital-wide exposure to unfractionated (UFH) and low molecular weight heparin (LMWH) was determined by querying the hospital pharmacy database.

Results—The majority of patients with suspected HIT (61.2%) were on surgical services. Initial 4Ts scoring predicted the risk of HIT as 3 (2%) had high risk 4Ts scores, 114 (73%) had intermediate risk 4Ts scores, and the remaining 38 (25%) had low risk 4Ts scores. HIT was confirmed in 0/38 patients with low risk 4Ts scores, 2/114 patients with intermediate-risk 4Ts scores and all three patients with high-risk 4Ts scores presented with HIT with thrombosis. Of 12 positive HIT screening tests, results were falsely positive in 66.6% of patients with intermediate risk 4Ts scores and 100% of patients with low risk 4Ts scores. The prevalence of HIT was 0.058% and HIT with thrombosis was 0.046% in pediatric patients on UFH.

Conclusions—The incidence of HIT appears significantly lower in pediatric patients compared with adults. Application of the 4Ts system as a pretest tool may reduce laboratory evaluation for HIT in heparin-exposed children with low risk 4Ts scores, decreasing unnecessary further testing, intervention and cost.

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Keywords

HIT; Thrombosis; Children; 4Ts score

Heparin-Induced Thrombocytopenia (HIT) is a pro-thrombotic, immune-mediated complication of unfractionated and low molecular weight heparin therapy. HIT is characterized by moderate thrombocytopenia 5–10 days after initial heparin exposure, detection of platelet-activating anti-platelet factor 4(PF4)/heparin antibodies, and an increased risk of venous and arterial thrombosis.^{1, 2,3} The diagnosis of HIT is complicated, and the management of patients with suspected HIT includes immediate discontinuation of all sources of heparin and the initiation of an alternative anticoagulant.

The term HIT has been used to describe three groups of patients: those for whom laboratory testing for HIT was sent due to clinical suspicion (“suspected HIT”), patients with expert clinician opinion HIT and positive laboratory testing (HIT), and HIT with thrombosis (HITT).⁴

In adult patients receiving heparin, the prevalence of HIT is reported to be 0.5 – 5%.^{5,6} Studies of adults have noted thrombotic complications at the time of the diagnosis of HIT in 30 – 60% of patients.^{2, 7} The risk of thrombosis continues for several days after heparin withdrawal with 50% of the remaining patients diagnosed with HIT subsequently developing a thrombotic event.^{7, 8} Prospective data on the prevalence of HIT and HITT in pediatric patients are lacking, however published case series/reviews of HIT in children suggest that the prevalence of HIT may be lower than in adults (1.5% – 3.7%) and as low as 0.33% in non-neonates receiving cardiopulmonary bypass.^{9–13}

Laboratory testing for suspected HIT includes immunoassays for anti-PF4/heparin antibodies and functional assays for platelet aggregation or activation. Immunoassays detect anti-PF4/heparin antibodies via enzyme-linked immunosorbent assay (ELISA). Immunoassays are available in most medical centers.^{14, 15} Unfortunately, immunoassays have a poor specificity (74 – 86%) and anti-PF4/heparin antibodies can be detected in patients without HIT.^{4, 5, 8} Functional assays, including the gold standard ¹⁴C-serotonin release assay (SRA), measure platelet-activating effects of anti-PF4/heparin antibodies with > 95% sensitivity and specificity for HIT.^{8, 16} However, they are technically complex to perform and are not routinely available at most medical centers.

Given the limitations of laboratory testing for suspected HIT, clinical scoring systems such as the 4Ts^{17–19} and HIT Expert Probability (HEP) Scores²⁰ have been developed to assess the pretest probability of HIT. The utility of the 4Ts clinical scoring system has been prospectively evaluated in adult studies, and has proven useful in identifying patients at low risk for HIT,^{18, 21–23} with a negative predictive value of 98–100%.¹⁸ To date, the 4Ts scoring system has not been validated in pediatric patients. The main objective this study was to evaluate the 4Ts clinical scoring system as a predictor of HIT in children. Our secondary objective was to assess the prevalence of HIT among all heparin-exposed patients at our institution during the study period.

Methods

This retrospective study was approved by the Boston Children's Hospital Institutional Review Board, which waived the need for informed consent. Patients with suspected HIT were identified from a database when clinical evaluation for HIT (ELISA testing) was sent at the discretion of their treating physician. 176 consecutive patients with anti-PF4/heparin antibody testing were identified between October 1, 2007 and December 31, 2011. Sufficient clinical data for retrospective 4Ts scoring were available for 155 subjects. As several patients had repeat testing, a total of 191 samples were sent during this time period. Clinical information was collected by chart review.

To understand whether a procedure or underlying diagnosis contributes to risk of HIT, we categorized patients as medical or surgical, and cardiac or non-cardiac. Cardiac medical patients were admitted for scheduled cardiac catheterization or medical management of fluid overload or systemic illness. Cardiac surgical patients were admitted for surgical repair. Patients included in the "other surgical" category underwent a variety of procedures including orthopedic surgery, lung or renal transplantation, and multi-visceral organ transplantation. The group of "other medical" patients comprised a heterogeneous group of patients receiving critical care management of conditions associated with thrombocytopenia including vascular anomalies, sepsis physiology and systemic chemotherapy for malignancy.

Definition of HIT/HITT

Patients were determined to have a diagnosis of possible HIT if they developed thrombocytopenia (platelet count fall $> 50\%$ or platelet nadir $\geq 20,000$ cells/ μL) with recent or concurrent heparin exposure and the absence of other causes for thrombocytopenia, were positive PF4/heparin ELISA, and met expert consensus. Patients were determined to have possible HITT if they developed a thrombus in addition to meeting the above criteria. All patients with positive ELISAs were evaluated by six pediatric hematologists for expert consensus diagnosis.

Determination of Heparin Exposure

A Boston Children's Hospital Pharmacy database was queried for all orders of either unfractionated heparin (UFH) or low molecular weight heparin (LMWH) during the study period. Systemic therapy orders, including subcutaneous UFH and LMWH prophylaxis orders, were counted. Non-systemic doses (locks, flushes, continuous flushes, Port-a-caths, intra-arterial and other line maintenance orders) were excluded. Remaining orders were re-categorized by number of orders, number of admissions, and number of patients. The number of admissions including exposure to treatment or prophylactic doses of heparin was used as the denominator for prevalence calculations. Separate calculations were performed for UFH and LMWH exposures. No episodes of thrombosis with thrombocytopenia were identified in our database of all new thrombotic events requiring anticoagulation, aside from those with positive ELISA testing captured in this study.

4Ts Score

The Warkentin 4Ts scoring system¹⁹ assigns scores based on the degree of Thrombocytopenia, the Timing of the fall in the platelet count, the presence of Thrombosis, and the absence of oTher explanations for the thrombocytopenia. Patients receive scores of 0 – 2 points for each of these categories before sending laboratory testing for HIT. In adults, the probability of HIT is predicted to be high in patients with scores greater than or equal to 6 points, intermediate in patients scoring 4–5 points and low in patients scoring 3 or fewer points. In our study, a 4Ts score was retrospectively assigned based on the clinical and laboratory findings at the time ELISA testing was sent. All patients in the ELISA database were scored by one reviewer who was blinded to the ELISA result at the time of scoring. Cases in question were reviewed with a senior hematologist and 4Ts scores for the 12 patients with positive ELISA results were also reviewed by a group of six pediatric hematologists at Boston Children's Hospital.

Laboratory Testing

During the study period, anti-PF4/heparin antibody testing was performed at a local reference laboratory (Massachusetts General Hospital, Boston MA) using a commercial poly-immunoglobulin specific immunoassay (Asserachrom HPIA ELISA, Diagnostica Stago, Asnières, France). According to the manufacturer's instructions, an in-house control was run with every sample run and results were reported as positive if above the positive cut-off value, negative if below the negative cut-off value, and "negative but borderline, recommend repeat" if the values fell between the positive and negative cut-offs for that run. Quantitative ELISA optical density (OD) values were collected to assess if higher titer antibodies were more predictive of HIT, as described in adult HIT studies.^{24–26}

During the period of this retrospective study, all laboratory studies were sent at the discretion of the treating clinician. Few confirmatory functional tests (SRA) were sent to our reference laboratory at the University of Pennsylvania and performed as described previously.^{27, 28} Given the absence of gold-standard SRA testing in most patients, positive SRA results were not required for the diagnosis of possible HIT/HITT in this study (see our definition above).

Results

The clinical characteristics for the 155 patients with suspected HIT are summarized in Table I. All received UFH at the time suspected HIT testing was sent. One received LMWH immediately prior to admission and one patient received both LMWH and UFH during hospitalization. Similar to studies performed in adults,^{5, 29} the majority (61.3%) of patients with suspected HIT were on surgical services (Table II).

4Ts scores corresponding to the 155 initial ELISA tests and the reason for hospitalization are shown in Table II. Three (2%) had high risk 4Ts scores, 114 (73%) had intermediate risk 4Ts scores, and the remaining 38 (25%) had low risk 4Ts scores. Low risk scores were most common in non-surgical, non-cardiac medical patients, representing 22 of 38 (58%) of low risk scores. The prevalence of HIT/HITT in patients by 4Ts score was 0% (0 of 38 patients)

with low risk, 1.8% (2 of 114 patients) with intermediate risk and 100% (3 of 3 patients) with high risk 4Ts scores. High risk 4Ts scores (6–8) had 100% specificity and positive predictive value. Intermediate risk 4Ts scores (4–5) had 40% sensitivity, 25.3% specificity, 1.8% positive predictive value and 92.7% negative predictive value. Low risk 4Ts scores (1–3) had 100% sensitivity and negative predictive value (Table III; available at www.jpeds.com).

Repeat HIT testing was sent on 36 patients due to persistent clinical concern or initial “negative but borderline” results. All of these patients’ initial 4Ts scores were intermediate risk and their repeat 4Ts scores remained unchanged, though one repeat ELISA result was newly falsely positive (Case 3; Table IV).

Table IV shows the clinical characteristics for the 12 patients with a positive anti-PF4/heparin ELISA. We identified five cases of HIT: four HITT cases and a cardiac surgical patient with HIT (Case 6). Six (50%) positive ELISAs occurred in cardiac surgical patients. However, other causes of thrombocytopenia were evident in all but one case (Case 6) and the remaining 5 cases were considered false positive tests with subclinical seroconversion. All three of the patients with low risk 4Ts scores also had other explanations for thrombocytopenia; these ELISA results were also considered false positives. Of note, all three patients with high-risk 4Ts scores presented with HITT and were patients from non-cardiac surgical disciplines. The rate of thrombosis was 33% for patients with positive ELISA testing and 100% for patients with high-risk 4Ts scores. Nine of twelve patients with positive ELISAs, including one with HIT (Case 6) and one with HITT (Case 1), were re-exposed to heparin without HIT recurrence. These patients were re-exposed to UFH 2 to 6 weeks after their ELISAs were positive. Repeat ELISA testing was not sent in either case, likely due to the fact that these patients were not subsequently thrombocytopenic.

SRAs were only sent in half of the patients with positive ELISAs and were negative except in Case 11. This was a 5-year-old patient who developed HITT while on UFH after brachial artery repair after a supracondylar humerus fracture. He presented with extensive venous and arterial thromboses that resulted in hand amputation. The ELISA and SRA were sent concurrently in this case.

We plotted the OD data from the 191 anti-PF4/heparin ELISAs and compared them with the adult cutoffs for positive (>0.4) and high titer positive (>1.0)^{24–26} tests (Figure). No cases of HIT or HITT occurred in patients with ELISA OD less than the adult positive cut off of 0.4. Two of the three positive ELISAs with OD >1.0 were false positives. HITT was seen in pediatric patients with ODs ranging from 0.522 – 2.068 (Table IV). Case 11 had profound thrombosis and HITT with an OD of 0.925.

Review of all orders of UFH during the study period identified 333,000 orders. Orders were further sorted into nontherapeutic (e.g. line flushes), prophylactic and therapeutic UFH orders. We identified 15,427 therapeutic orders placed during 8,547 admissions for 4,668 patients. Of 8,547 admissions, there were 12 positive ELISAs in 191 evaluations of 155 patients with suspected HIT. HIT was suspected in 155 (3.3%) of 4,668 UFH-exposed pediatric patients. Five patients (Table IV) had HIT with or without thrombosis, which

occurred at a prevalence of 0.058% of admissions during the study period of 4.25 years. Of 1,958 encounters with LMWH exposure, there were no occurrences of suspected or confirmed HIT.

Discussion

We suggest that children with low-risk 4Ts scores have low risk (0/38) of HIT and high risk (3/3) of false positive testing. Avoidance of false positive testing may reduce patient care costs and reduce complications from heparin avoidance and from transition to less familiar anticoagulants (e.g. argatroban, fondaparinux). Consistent with adult literature, low risk 4Ts scores have a 100% sensitivity and negative predictive value in our study. Children with low risk 4Ts scores should not undergo SRA testing or alterations in anticoagulation management. False positives may be particularly problematic in a subset of pediatric patients with complex congenital heart disease, congenital malformations, or other challenging conditions, whose usual care would call for future heparin use. Re-exposure to heparin was not problematic in any of nine patients with positive ELISAs, including one with HIT and one with HITT; this is consistent with adult literature^{4, 30}.

This study and the adult HIT literature suggest that false positive HIT testing in children can be reduced in (at least) three ways. Utilization of a pretest risk stratification system can increase the prior probability of positive testing. We found the simplicity of the 4Ts system appealing for education of house staff and ease of use. The HEP score may hold promise in pediatrics as well, but was too complex for this retrospective study and will require prospective evaluation in children. Application of 4Ts scoring to determine the utility of testing would have eliminated 38 of 191 evaluations (20%) during our study period. At our center, this study resulted in the recommendation to mandate 4Ts scoring before ordering laboratory evaluation for suspected HIT, and a greater appreciation of the potential harm of false positive HIT ELISAs. Initial testing with an IgG-specific anti- PF4/heparin antibody will improve specificity of testing. This was not available at our reference laboratory during this study, though is now our standard initial testing. Concurrent serotonin release or other functional testing, especially if available with real-time turnaround, will improve specificity further. Whereas adult studies evaluating the utility of the 4Ts score as a pretest tool to predict HIT were able to confirm each diagnosis with a positive SRA,^{8, 21, 31, 32} we observed inconsistent SRA evaluation and few positive SRA tests. We relied on expert consensus to confirm the diagnosis of HIT/HITT. We recognize that many studies require positive functional (SRA) testing to confirm the diagnosis of HIT/HITT. We suspect some of our SRA results were false negative due to delay in processing and shipment after phlebotomy or delays in SRA testing (up to one month later; patient 10) after positive ELISA result (Table III). Although adult data demonstrate that high titer ELISA OD results (>1.0) are associated with an increased likelihood of a positive SRA and HITT,^{24, 25} our study was unable to assess this relationship due to inconsistent confirmatory SRA testing and the small numbers of patients with positive screening ELISA testing.

Pediatric HIT is rare, with only 5 cases at our institution in 4.25 years. Despite 155 evaluations for HIT, these 5 cases from 8,547 UFH-exposed encounters yield a prevalence of HIT at 0.058% and of HITT (4 cases) at 0.047% of children with UFH exposure. Overall,

this estimate of prevalence is much lower than published rates in adults.^{5, 33} The high rate of thrombosis seen at the time of HIT diagnosis is consistent with several case reports note that thromboembolic complications may be the first presenting symptom of HIT in pediatric patients.^{10, 34–36}

It is unclear why children should have a significantly lower risk than adults of developing HIT after UFH exposure. The etiology of anti-PF4/heparin antibodies is poorly understood and may include immunologic priming and/or antigen exposure, which may be less common in children. Consistent with data from adults showing a lower risk of HIT with LMWH,³⁷ we did not identify any cases of suspected HIT in 1,958 patient encounters with LMWH exposure.

As a retrospective study, our estimate of prevalence may be inaccurate. First, undetected (unsuspected) cases of HIT are not captured retrospectively; we suspect these would be rare. Limitations of our pharmacy database allowed accurate assessment of ordered doses, but not confirmation of dispensing or administration to patients. Although we suspect a small minority of ordered doses may not have been administered, this may cause our data to overestimate the prevalence of HIT. Lastly, two patients in Table III with positive ELISA tests only had non-systemic UFH exposure. We chose to not include *all* UFH orders in the denominator as many clinicians would not consider HIT with non-systemic heparin exposure and inclusion would further reduce prevalence ~20 fold. The lack of consistent evaluation with confirmatory functional (SRA) testing possibly led to overestimation of HIT/HITT prevalence in this study. Additionally, we may have over-estimated our HIT/HITT prevalence by using expert consensus rather than SRA or ELISA O.D. >1 to define cases.

There are several limitations to our study. We applied a pre-test scoring system retrospectively, possibly arriving at different scores than the intended prospective application. In addition, 4Ts scoring in this study was performed by hematologists, and initial suspicion of HIT occurs across many disciplines. Our data is from a single pediatric institution with a large cardiology referral center, which limits the number of evaluations and applicability to other centers, especially smaller centers with fewer cardiology patients. Our reference laboratory used the poly-immunoglobulin ELISA screening test and few confirmatory functional tests were sent during our study, as discussed above. The 4Ts score itself is limited by a large number of intermediate scores (Table II), which are rarely predictive of HIT. We found one patient with a 4Ts score of 4 who developed HITT (Table III). The HEP scoring system measures more components of HIT risk and may better delineate patients with intermediate-risk 4Ts scores. Although quantitative ELISA OD >1 is more predictive of HIT in adults, our study was unable to assess this relationship due to inconsistent confirmatory SRA testing and the small number of patients with positive screening ELISA testing.

High risk 4Ts scores were only assigned to 3 patients in our retrospective study, though this was 100% predictive of HITT (Table III). Of the three patients receiving a retrospective high-risk 4Ts score, each patient had heparin discontinued but only one was switched to argatroban, then fondaparinux. Across all patients with suspected HIT in this study, heparin

avoidance and/or change to alternative anticoagulation was uncommon. This “real world” observation may reflect the low degree of concern for HIT appreciated by pediatric clinicians. Adult data suggest that any patient with intermediate- or high-risk scoring should have heparin stopped and alternative anticoagulation implemented.

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Abbreviations

DVT	deep venous thrombosis
ECMO	extracorporeal membrane oxygenation
ELISA	enzyme-linked immunosorbent assay
HIT	heparin-induced thrombocytopenia
HITT	heparin-induced thrombocytopenia with thrombosis
LMWH	low molecular weight heparin
OD	optical density
PF4	platelet factor 4
SRA	serotonin release assay
UFH	unfractionated heparin

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Figure. Optical Density (OD) Values from Patient ELISAs

ODs from 191 ELISAs are shown with HIT diagnoses as indicated in the legend. Adult positive cut-offs of 0.4 and 1.0 are indicated by the straight and dotted lines, respectively. The arrow indicates the only patient with a positive SRA.

Table 1

Patient Characteristics

Age	Neonatal (1 – 28 d)	Non-neonatal (29 d – 21y)	Total (%)
Number	20	135	155 (100)
Mean Age	13.4 days	6.6 years	5.9 years
Median Age	12.5 days	4 years	2.0 years
Standard Deviation	7.2 days	7 years	6.9 years
Sex	Number (%)	Number (%)	
Male	16 (10.3)	64 (41.3)	80 (51.6)
Female	4 (2.6)	71 (45.8)	75 (48.4)
Patient Type			
Cardiac Surgery	16 (10.3)	57 (36.8)	73 (47.1)
Cardiac Medical	1 (0.6)	24 (15.5)	25 (16.1)
Other Surgical	1 (0.6)	21 (13.5)	22 (14.2)
Other Medical	2 (1.3)	33 (21.3)	35 (22.6)

Table 2

Initial 4Ts Scores for Pediatric Patients Referred for HIT ELISA Testing

Patient Type	Low Risk	Intermediate Risk	High Risk	Total
Cardiac Surgical	8	65	0	73
Cardiac Medical	3	22	0	25
Other Surgical	5	14	3	22
Other Medical	22	13	0	35
Total	38	114	3	155

Table 3

Summary of 4Ts Score as a Pre-Test Tool for Prediction of Heparin Induced Thrombocytopenia in Children

4Ts Score	Sensitivity % (95% CI)	Specificity % (95% CI)	Positive Predictive Value % (95% CI)	Negative Predictive Value % (95% CI)
Low Risk (0–3)	100 (47.95–100)	25.33 (18.59–33.07)	4.27 (1.42–9.70)	100 (90.66–100)
Intermediate Risk (4–5)	40.0 (6.49–84.60)	25.33 (18.59–33.07)	1.75 (0.26–6.21)	92.68 (80.05–98.38)
High Risk (6–8)	60.0 (15.40–93.51)	100 (97.55–100)	100 (30.48–100)	98.68 (95.32–99.80)
Combined Intermediate and High Risk (4–8)	100 (47.95–100)	25.33 (18.59–33.07)	4.27 (1.42–9.70)	100 (90.66–100)

Table 4

Clinical Information for the 12 Patients with Positive ELISAs

Case	Age	Gender	Reason for Admission	Reason for UFH	4Ts Score	ELISA OD	SRA	Outcome	Diagnosis	Subsequent UFH
1	18y	F	Hepatocellular carcinoma resection	Post-op portal vein thrombus	6	2.068	Not Done	UFH used during subsequent surgeries and dialysis catheter placement.	HITT	Yes, 6 weeks later during same hospitalization
2	3y	F	Management of dilated cardiomyopathy	On Bypass	4	0.634	Not Done	Tolerated subsequent transplant on bypass.	False positive	Yes, with heart transplant
3	4y	F	Open heart surgery for congenital heart disease	On Bypass then ECMO	4	0.224 → 0.868	Not Done	Platelet count improved after off ECMO. Repeat HIT testing 1 year later negative.	False positive	Yes, subsequent cardiac catheterization
4	8y	M	New DVT. Worsening congenital heart disease.	Heparin drip to prevent clot extension.	4	0.575	False Negative	Two days later diagnosed with large thrombus in the left middle cerebral and left anterior cerebral arteries. Transitioned from heparin to argatroban the following day.	HITT	N/A; deceased
5	19y	M	Open heart surgery for congenital heart disease	On Bypass	4	0.497	Not Done	Thrombocytopenia resolved after repeat sternotomy to evacuate mediastinal hematoma and ligate a small bleeding vein.	False positive	Yes, with subsequent cardiac catheterization
6	4y	F	Open heart surgery for congenital heart disease	On Bypass	4	0.942	False Negative	Platelet count improved after all heparin briefly discontinued. Patient was not anticoagulated due to concurrent GI bleed.	HIT	Yes, 2 weeks later during same hospitalization; subsequent cardiac catheterizations
7	12y	M	Exploratory laparotomy for acute retroperitoneal hemorrhage	Line flushes	6	0.522	False Negative	No anticoagulation due to recent history of life threatening abdominal bleed and low von Willebrand factor levels. Continued to be exposed to UFH flushes.	HITT	No
8	4y	M	Open heart surgery for congenital heart disease	On Bypass	3	0.769	Not Done	Had significant post-op bleeding; resolved after transfused blood products. Platelet count steadily improved without further intervention.	False positive	Yes, duration of hospitalization
9	12y	F	Medical management of worsening cardiac dysfunction.	Heparin drip due to concern for intracardiac stasis	3	0.645	Negative	Testing sent prior to platelet count nadir. Subsequently on Bypass with heparin for 2 procedures without thrombotic complications.	False positive	Yes, duration of hospitalization
10	16y	F	Significant anemia in the setting of p-ANCA + vasculitis and acute renal insufficiency	Line Flushes	3	1.0929	Negative (sent 1 month later)	Improved with plasmapheresis and rituximab. Stopped all heparin.	False positive	Yes, plasmapheresis
11	5y	M	Vascular/orthopedic surgery	Heparin drip after vascular surgery	7	0.925	Positive	Developed thrombus in arterial bypass graft; hand amputated. Briefly on low molecular weight heparin before all heparin stopped then on argatroban and fondaparinux.	HITT	No

Case	Age	Gender	Reason for Admission	Reason for UFH	4Ts Score	ELISA OD	SRA	Outcome	Diagnosis	Subsequent UFH
12	4y	F	Medical management of worsening cardiac dysfunction.	On Bypass for ventricular assist device placement	5	0.614, 1.336	Not Done	Developed recurrent thrombi in ventricular assist device. Remained on low molecular weight heparin and unfractionated heparin before and after heart transplant.	False positive	Yes, duration of hospitalization including heart transplant