Thrombosis and Haemostasis

Heterogeneity of vaccine-induced immune thrombotic thrombocytopenia after ChAdOx1 nCov-19 vaccination and safety of second vaccination with BNT162b2

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Abstract:
no abstract necessary because our manuscript is a letter to the editor.

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Heterogeneity of vaccine-induced immune thrombotic thrombocytopenia after ChAdOx1 nCov-19 vaccination and safety of second vaccination with BNT162b2

To the editor: Vaccine-induced immune thrombotic thrombocytopenia (VITT) is a rare side effect of two adenoviral vector vaccines, ChAdOx1 nCov-19 (AstraZeneca) and Ad26.COV2.S (Johnson&Johnson/Janssen); it is caused by platelet-activating immunoglobulin G (IgG) that recognizes platelet factor 4 (PF4), as shown by positive testing by PF4/heparin-enzyme-linked immunosorbent assay (PF4-H-ELISA) in combination with PF4-enhanced washed platelet activation assays (PF4-PAA). Clinical presentation is heterogeneous, with some patients presenting without overt thrombosis (VITT with isolated thrombocytopenia) or with severe headache. Few data exist regarding long-term decline in PF4-dependent antibodies; in addition, there is uncertainty about timing and safety of subsequent booster vaccination after an episode of VITT.

We report four cases of VITT (3 females, aged 38, 56, and 76 years; and 1 male, aged 22 years) that illustrate its diverse clinical spectrum (see figure 1 A-D for details). Two patients (patients 1 and 2) had thrombocytopenia associated with both arterial and venous thrombosis, while one (patient 3) had lower-limb venous thrombosis without thrombocytopenia. The most unusual case was patient 4, who had thrombocytopenia together with severe, persistent headache, and abdominal pain/transaminitis: however, imaging studies were negative for cerebral and abdominal thromboses, and symptoms resolved in association with early anticoagulation therapy.

Results of PF4-dependent antibodies
For detection of PF4-dependent antibodies a PF4/heparin enzyme-linked immunosorbent assay (PF4-H ELISA, in house assay of the Greifswald laboratory\textsuperscript{1,9}) and a chemiluminescent immunoassay for detection of HIT antibodies (CLIA, Werfen) were performed. In addition heparin-induced platelet activation assay (HIPA), and PF4-enhanced washed platelet activation assay (PF4-PAA) were analyzed in available blood samples \textsuperscript{9}. In all patients, PF4-dependent antibodies were detected. There was heterogeneity in reaction profiles: three patients presented with PF4-H-ELISA antibodies while two patients (including the ELISA-negative patient) had positive results in the PF4-PAA. The heparin-induced platelet activation assay (HIPA) and the chemiluminescent immunoassay for detection of HIT antibodies (CLIA-assay) remained negative in all patients. During follow-up, results of PF4-H-ELISA became negative in only one of these patients after 3 months while the PF4-H-ELISA antibodies persisted for more than 5 months in the other two patients. PF4-PAA became negative (at 1- and 3-month follow-up) in both patients with initially positive results.

**Results of thrombophilia screening**

Inherited and acquired thrombophilia including factor V Leiden mutation, prothrombin mutation, protein C-, protein S- and antithrombin-deficiency, antiphospholipid-antibodies and heparin-induced thrombocytopenia was excluded in all patients with thrombosis.

**Clinical course and treatment of patients**

**Patient 1** (see figure 1A) presented with severe headache and elevated D-dimer on day 13 after vaccination. Cerebral CT angiography on admission showed no vascular occlusions, thrombosis, or fresh ischemia. Immediately following CT, there was visual disturbance in the
left eye, nausea, and vomiting. Lysis therapy was initiated. One day later, after starting anticoagulation with low molecular weight heparin (LMWH), the platelet count dropped to 40x 10⁹/l and the patient developed right hemisymptomatics with motor aphasia. Subsequent CT angiography revealed a new occlusion of the middle cerebral artery and cerebral vein thrombosis. Arterial thrombectomy was performed successfully and neurological clinical symptoms improved. LMWH was stopped, intravenous immunoglobulins were given twice (day 17 and day 18) and aspirin was initiated, followed by additional fondaparinux (5mg once daily) after an increase in platelet count. On day 17 CT thorax revealed asymptomatic central pulmonary artery embolism as incidental finding. After initiation of fondaparinux therapy, there was a further increase in platelet count, aspirin was stopped and the patient was switched to long term oral anticoagulation with therapeutic dose apixaban 5mg twice daily.

**Patient 2** (see figure 1B) developed diarrhea from day 8 after vaccination. From day 13 extensive hematomas developed in both legs. In addition, walking distance was acutely reduced to 10 meters and a drop of platelet count to 20x10⁹/l was diagnosed by the family doctor. After admission to hospital popliteal vein thrombosis and arterial occlusions in both legs were diagnosed on day 21. Initially low dose fondaparinux 2.5mg once daily was started due to the hematomas and low platelet count. After increase of platelet count the patient was switched to apixaban 5mg twice daily (day 27). In the further course arterial thrombectomy and stenting was performed in both legs followed by additional platelet aggregation inhibition.

**Patient 3** (see figure 1C) presented with low D-dimer elevation and venous thrombosis of the right leg on day 5 after vaccination. Apart from vaccination no other risk factors for
venous thrombosis were identified. Rivaroxaban 15mg twice daily was started followed by rivaroxaban 20mg once daily 3 weeks after initiation of oral anticoagulation.

**Patient 4** (see figure 1D) presented with severe headache, a drop in platelet count and elevated D-dimer on day 12 after vaccination. Within one day after first presentation D-dimer increased to 10.5mg/L and therapeutic oral anticoagulation with apixaban 5mg twice daily was immediately started because a “pre-VITT” syndrome was suspected by the treating physician. Platelet count increased and cerebral vein thrombosis was successfully excluded twice. On day 23 abdominal pain and transaminase elevation was observed but splanchnic vein thrombosis was excluded by abdominal magnetic resonance venography.

**Second vaccination with BNT162b2**

Second vaccination with the messenger RNA (mRNA) vaccine, BNT162b2 (Pfizer-BioNTech) was performed in three of the patients, without thrombocytopenia or other adverse sequelae (the fourth patient declined repeat vaccination); for the patient (patient 3) whose PF-H-ELISA remained positive at time of booster vaccination, no increase in subsequent ELISA reactivity was seen. After the second vaccination with the mRNA-vaccine SARS-CoV2 IgG Spike antibodies increased in the three secondly vaccinated patients while SARS-CoV2 antibodies against IgM/IgG nucleocapsid antibodies remained negative (for details see figure 1 B-D).

**Limitations**

Patient 1 presented with clinical symptoms of VITT in March 2021. At that time the syndrome was relatively unknown and specific laboratory assays for diagnosis of PF4-induced antibodies were not yet available. High dose immunoglobulins were applied and the
PF4-PAA assay was first measured 3 months after VITT. This assay was negative while the PF4-H ELISA was persistently positive. The application of immunoglobulins might have caused the negative test-result in the PF4-PAA assay. In addition it is known that PF4-PAA assay results decline earlier than PF4-ELISA-assay results.

Patient 3 presented with venous thrombosis without thrombocytopenia. PF4 H-ELISA-assays remained positive while the PF4-PAA assay was negative. Although up to 6.8% of patients vaccinated with ChAdOx1 nCov-19 or BNT162b2 may develop low titer PF4-H-ELISA antibodies without clinical relevance, patient 3 developed high-titer PF4-H-ELISA antibodies in combination with venous thromboses. Since PF4-PAA antibodies remained negative this might have been the reason for not developing thrombocytopenia.

Recent guidelines and recommendations to diagnose and treat VITT

Following the recognition of VITT multiple guidelines have been published to risk stratify patients presenting with possible symptoms after ChAdOx1nCoV-19 vaccinations.

These guidelines have been developed based upon the laboratory results and clinical symptoms observed in the initial cases of VITT. Definite cases typically present with a combination of the following symptoms:

1. Occurrence within 5-28 days after a first vaccination with ChAdOx1 nCov-19
2. Decrease in platelet count
3. Raised D-dimer
4. Low Fibrinogen
5. Positive PF4-induced antibodies (either measured by a PF4-ELISA-assay and/or a platelet factor 4 enhanced platelet activation assay)
6. Rapid HIT-assays like chemiluminescence assays or lateral flow technologies remain negative
7. Acute venous and/or arterial thrombosis

However it is becoming increasingly clear that VITT may encompass a broader range of clinic-pathological presentations as observed in the patients presented in this letter to the editor.

Recommended treatment options are the avoidance of all types of heparins, the use of intravenous direct thrombin inhibitors, subcutaneous fondaparinux or oral anticoagulation with direct oral anticoagulants and the immediate application of intravenous immunoglobulins in severe cases to reduce the high mortality rates. In live-threatening situations additional plasma exchange might be considered.

Conclusions
Our findings have implications for clinical practice: one should be aware that patients can present with diverse clinical symptoms ranging from isolated thrombocytopenia or single-site thrombosis to the full-blown picture of VITT with multiple arterial and/or venous thrombosis and thrombocytopenia. The possibility that early detection and therapeutic-dose anticoagulation could prevent thrombosis (as seen in patient 4) should be considered; moreover – based on this case series - mRNA vaccines may be safe for use in VITT patients.

Conflicts of interest

Edelgard Lindhoff-Last has received lecture honoraria and advisory fees from Bayer AG, Boehringer Ingelheim, Bristol-Myers Squibb/Pfizer, Daiichi-Sankyo, Portola, CSL Behring and
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**Figure 1 A-D:** Clinical Course of four patients with heterogenous presentations of vaccine-induced immune thrombotic thrombocytopenia (VITT). „Day 0“ indicates the date of first vaccination with ChAdOx1nCoV-19 (Astra Zeneca).

The inset shows results of D-dimer (d-D; normal range < 0.5mg/L), fibrinogen (Fib; normal range < 1.5mg/dL) and testing for VITT-antibodies. In all patients, four assays for VITT/HIT-antibodies were performed: a PF4/heparin enzyme-linked immunosorbent assay (PF4-H ELISA), a chemiluminescent immunoassay for detection of HIT antibodies (CLIA, Werfen), a heparin-induced platelet activation assay (HIPA), and a PF4-enhanced washed platelet
activation assay (PF4-PAA). Since none of the patients developed positive results in the HIPA-assay and the CLIA-assay, these negative results are not shown in the figure.

(A) Patient 1 (female, 38 years) presented with thrombocytopenia associated with arterial and venous thrombosis and the platelet count increased rapidly after two doses of IVIG. Persistent PF4-H ELISA positivity was observed. The patient declined repeat vaccination.

(B) Patient 2 (female, 76 years) had severe thrombocytopenia and arterial and venous thrombosis. Clinical symptoms improved during anticoagulation, without IVIG application. PF4-H ELISA and PF4-PAA declined over time. Second vaccination with BNT162b2 (day 125, Pfizer-BioNTech) was successfully applied under oral anticoagulation after VITT antibodies had become negative and vaccination was well tolerated.

C) Patient 3 (male, 22 years) presented with isolated venous thrombosis without thrombocytopenia. PF4-H ELISA-antibodies persisted and successful vaccination with BNT162b2 (day 72, Pfizer-BioNTech) was performed without side effects under oral anticoagulation.

D) Patient 4 (female, 56 years) had thrombocytopenia with high D-dimer levels but venous thromboses were excluded despite severe headache and abdominal pain. She received early oral anticoagulation until day 51 after vaccination. The PF4-PAA was once positive and became quickly negative. Second vaccination with BNT162b2 (day 95, Pfizer-BioNTech) was successfully applied after stop of anticoagulation.
