DISSEMINATED INTRAVASCULAR COAGULATION POST ENDOVASCULAR AORTIC REPAIR

NIKOLAOS SCHIZAS, GEORGIA NAZOU, CONSTANTINE ANTONOPOULOS, DIMITRIOS C. ANGOURAS

Introduction: Disseminated Intravascular Coagulation (DIC) after Endo-Vascular Aneurysm Repair (EVAR) is a highly un- common clinical entity. With only a few case-reports available, its management strategy still remains enigmatic.

Objectives: The purpose of this study was to retrieve, synthesize, and appraise all existing data for DIC after EVAR.

Materials and methods: All published articles regarding DIC post-EVAR were identified from 3 major databases and analyzed. Clinical parameters, predisposing factors, along with mortality and morbidly were assessed.

Results: The total number of publications included in the review was 15 describing 17 cases. DIC presented with a broad spectrum of clinical manifestations, while the time of diagnosis varied significantly. **Endoleak was the main causative factor, with an incidence reaching 71%. The mortality of DIC after EVAR reached 29%, regardless of the therapeutic approach chosen. DIC was treated effectively in 47% of the patients (8/17), with better outcomes among patients who received conservative therapy or among those who were submitted to endovascular interventions.**

Conclusions: DIC after EVAR, although rare, is a potentially lethal clinical condition which requires prompt diagnosis and urgent medical consideration. Treatment of endoleak may help in quick restoration of normal parameters

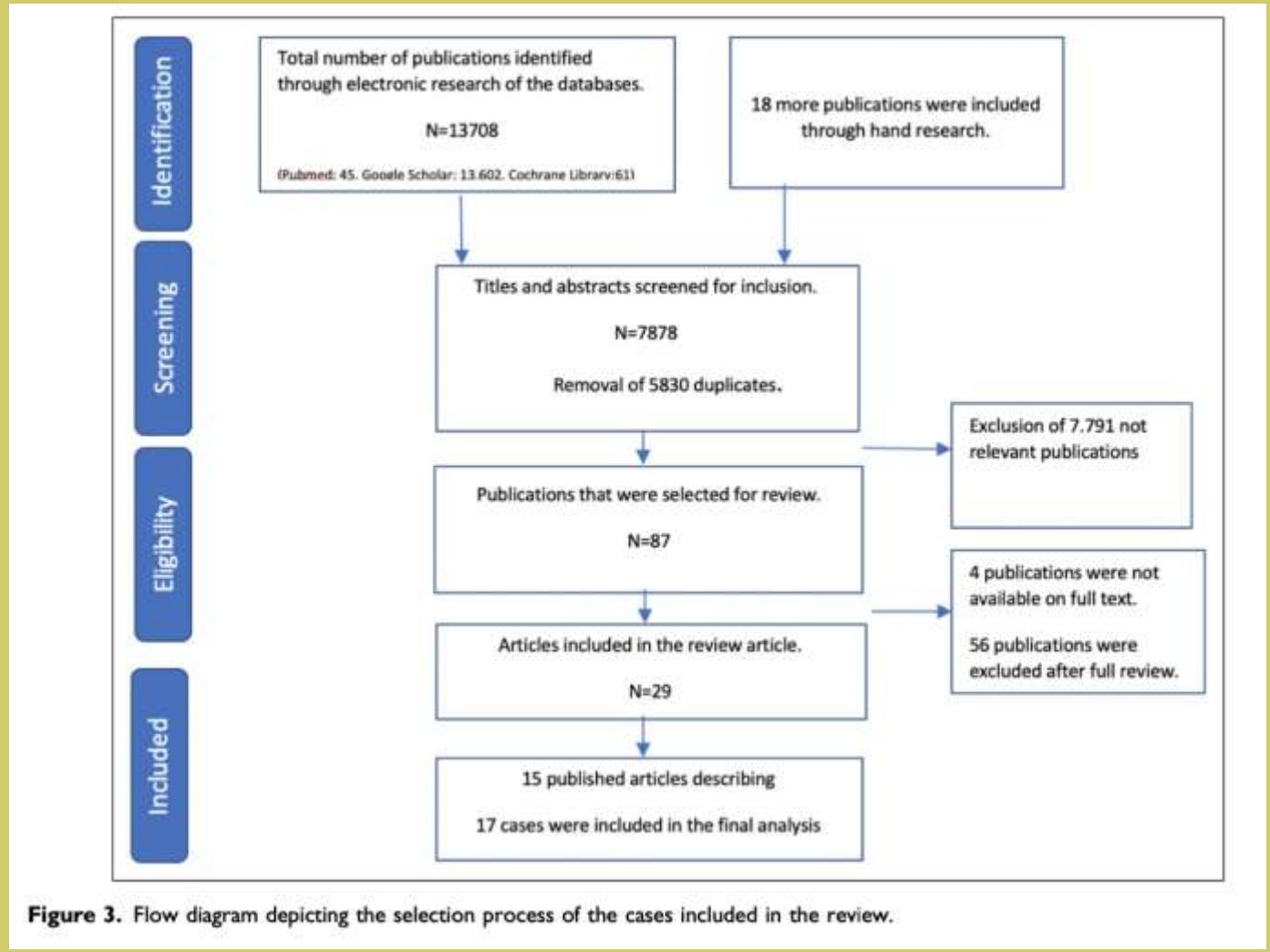

Figure 3. Flow diagram depicting the selection process of the cases included in the review.

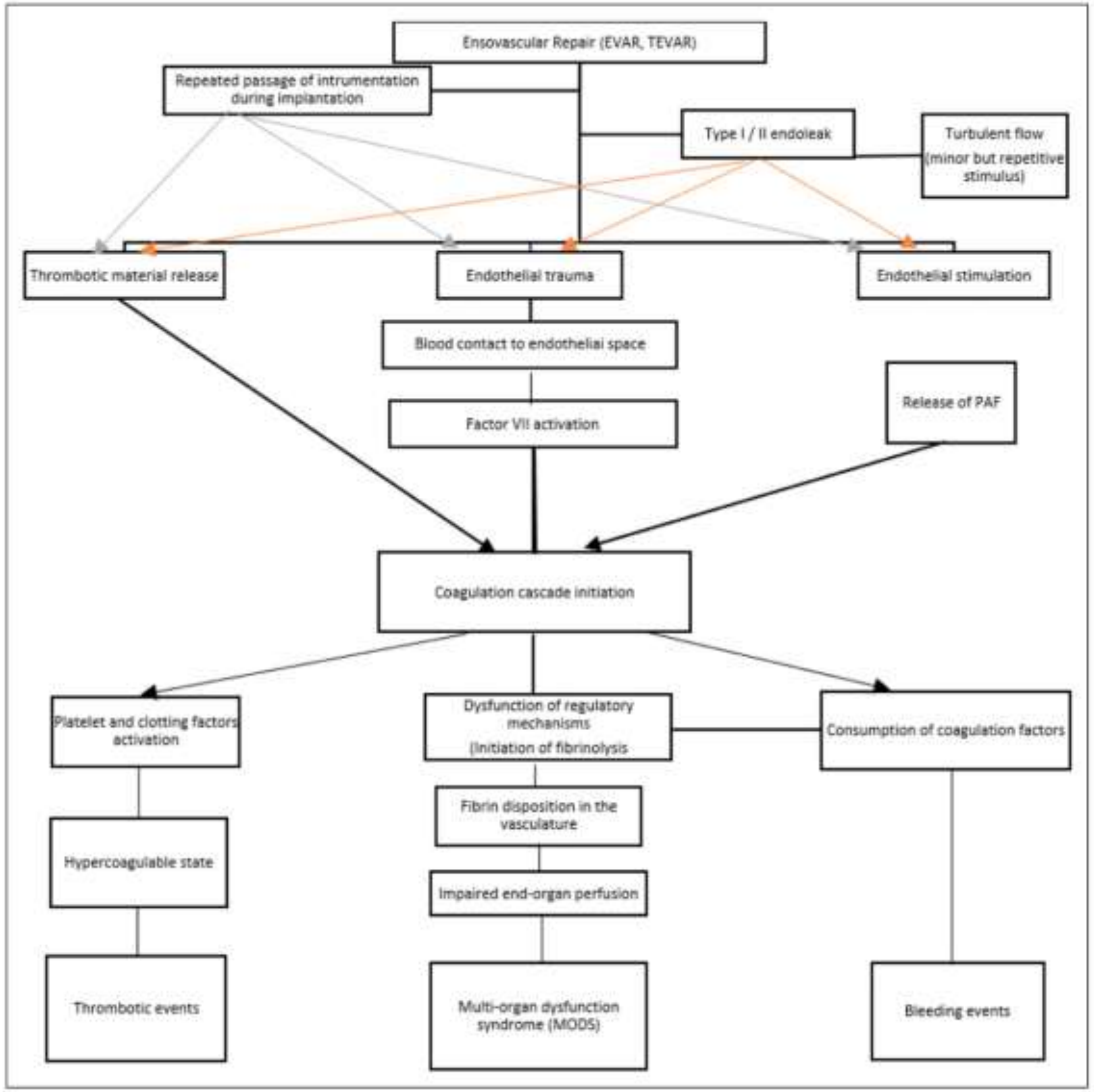

Figure 1. Basic pathophysiological steps for the development of post-EVAR DIC. DIC, disseminated intravascular coagulation. EVAR, endovascular aortic repair. PAF, platelet-activating factor. TEVAR, thoracic endovascular aortic repair.

Table 3. Summary of Patients' Demographics, Comorbidities, Primary Disease and Initial Intervention, Time of Diagnosis and Clinical Manifestations of DIC, Laboratory and Imaging Findings, Treatment Including Transfusions/Medications, Duration of Hospitalization, Complications, and Outcome. All Cases are Cited by Chronological Order of Publication.

Authors	Year	Age	Comorbidities	Primary Disease	Initial Intervention	Time of DIC Diagnosis	Clinical Manifestations	Laboratory Findings	Imaging Findings	Interventional Treatment	Medical Treatment	Hospital Stay	Complications	Outcome
Cross et al	2000	78	Not reported	Infrarenal AAA, rapidly increased in size (35 to 42 mm)	EVAR (Bifurcated Endograft)	Post-op period	Bilateral hemorrhagic pulmonary effusions, pericardial hemorrhage, hemorrhage from skin, gastric and vaginal mucosa	PLT 128 $\times 10^9$/L, PT 25", Fib degradation products >400 mg/dL	Well positioned stent-graft (postmortem examination)	Not reported	12 RBCs, 6 FFPs, 10 PLTs	1 day	Prolonged procedural duration, placement of second stent graft due to leakage	Death after 12 hours
Kim et al	2006	84	Myelodysplastic syndrome, chronic stable thrombocytopenia	Infrarenal AAA (70 mm)	EVAR	4 months later	Ecchymosis and petechia in lower limbs, and mucosal bleeding	PLT 63 $\times 10^9$/L, Fib 4 mg/dL, D-dimers 40.17 ng/mL, INR 1.3	Endoleak type Ia	EVAR (extension of stent graft, Talent AAA, medtronic AVE, USA)	5 RBC, 13 FFP, 6 PLT	10 days	None	Resolved after the 8th postoperative day
Higashiura et al	2007	72	Liver cirrhosis, hepatitis C	Infrarenal AAA (80 mm)	EVAR (modular bifurcated endograft consisted of a spiral Z-stent handmade)	1 month later and 52 months later	1st: Psoas muscle hematoma, 2nd: Repetitive intramuscular hematoma	1st: PLT 62 $\times 10^9$/L, Fib 32 mg/dL, INR 1.25, 2nd: PLT 84 $\times 10^9$/L, Fib 22 mg/dL, INR 1.44, D-dimers 74000 ng/ml	1st: Endoleak type III, 2nd: Endoleak type I	1st: Endovascular coil placement, 2nd: Open surgery (femorofemoral bypass, 8 mm thin-walled polytetrafluoroethylene (PTFE) graft (W. L. Gore and associates, Flagstaff, AZ, USA)	1st: FFP, 2nd: FFP	1st: 18 days, 2nd: 47 days	Multiorgan failure	Death
[illegible] et al	2007	79	Silicosis	TAAA	EVAR (Talent, Medtronic Inc, USA)	Post-op period	Oral mucosal bleeding, Femoral access bleeding, hemoptysis	Not defined thrombocytopenia, PT prolongation	Endoleak type III	Additional EVAR	18 RBCs, 16 FFPs, 1 PLT, 7 units of fibrinogen concentrate	More than 25 days	Diffused bleeding disorders, endoleak type III	Death after 25 days
Patel et al	2009	73	CAD, HTN, hyperlipidemia, and CABG 5 years before	AAA	EVAR (Talent, Medtronic Inc, USA)	Post-op period	Femoral access bleeding	PLT 56 $\times 10^9$/L, clauss Fib 1.32, INR 1.05, D-dimers 4400 ng/mL	Endoleak type I	Additional EVAR (palmaz stents cordis, miami lakes, FL)	4 RBCs, 2 PLTs	Not reported	None	Resolved in few weeks
Nienaber et al	2014 (3 cases)	89	Not reported	AAA (58 mm)	EVAR (Talent Device (Medtronic Inc, Santa Rosa, California)	5 years later	Recurrent wound hematomas after pacemaker placement	PLT count 96 $\times 10^9$/L, Fib 128 mg/dL, ISTH score 6, D-dimers 14800 ng/mL	Endoleak type Ia	None	Not reported	Not reported	None	Stable DIC for 3 years (death due to pneumonia)
		88	Probable idiopathic thrombocytopenic purpura	Descending thoracic aortic aneurysm (63 mm)	TEVAR + subsequent surgery for thoracoabdominal IV aneurysm restoration	8 years later	Not reported	PLT 77 $\times 10^9$/L, Fib 126 mg/dL, D-dimers >20000 ng/mL, ISTH score 4	Endoleak type Ia	TEVAR and cervical debranching	Preoperative dalteparin (2000 units subcutaneously daily) and postoperatively 20 units of cryoprecipitate and 3 PLTs. Discharged on dalteparin	4 days	None	Persistent thrombocytopenia (death related to cardiac disease after 6 months)
		74	Not reported	AAA (58 mm)	EVAR (AneuRx Device (Medtronic Inc)	8 years later	Clinical signs (bruising, epistaxis, hematuria)	PLT 86 $\times 10^9$/L, Fib 74 mg/dL, D-dimers >20000 ng/mL, ISTH score 5	Endoleak type Ia	Open surgery	Preoperatively 60 units of cryoprecipitate, 6 RBCs, 6 FFPs, 5 PLTs	Not reported	Persistent low fever, laboratory clotting disorders related to liver function	Died from unknown cause 2 months later
Kanaya et al	2015	74	Not reported	TBAD	TEVAR + LC-LSB (zenith TX2 TAA endovascular graft (Cook Medical, Bloomington, Ind)	1st post-op day	Cervical hematoma	PLT 41 $\times 10^9$/L, Fib 116 mg/dL, D-dimers 35200 ng/mL, INR 1.4	Extended false lumen, no endoleak	Conservative	RBCs, FFPs, PLTs (undefined number)	31 days	None	DIC resolved
Mendes et al	2015	55	HTN, hyperthyroidism	TBAD	TEVAR + LC-LSB (TX2 thoracic stent grafts (Cook Medical, Bloomington, IN, USA)	10 months later	Extensive ecchymoses in extremities and torso, spontaneous [illegible]	aPTT 44", PT 21.5", D-dimers >20,000 ng/mL, Fib 34 mg/dL	Endoleak type Ib and aneurysmatic sac 72 mm	TEVAR (extension c 28 × 130 mm TX2 stent-graft) + amplatzer II plugs (st Jude medical, st Paul, MN, USA)	Heparin infusion, cryoprecipitate	11 days	None	DIC resolved 7 days after the intervention
Ueda et al	2015	78	Parkinson's disease, cerebral stroke (left sided hemiplegia)	TAAA	TEVAR + LC-LSB + EVAR (Valiant, (Medtronic Vascular, Santa Rosa, CA, USA), EVAR (Zenith Flex, Cook, Inc, Bloomington, IN, USA)	2 years later	Clinically asymptomatic	Reduced (undefined) Fib, elevated FDP and D-dimers, ISTH score 5	Endoleak type III and aneurysmatic sac enlargement	None	TXA	Not reported	Recurrence - TXA not administered due to medical error	Aneurysmatic sac shrinkage when treatment administered
Yamauchi et al	2016	78	Systemic lupus syndrome, ischemic colitis (s/p stent placement in SMA)	TBAD	EVAR	3 months later	Repeated deep intramuscular bleeding in the right hip	PLT 44 $\times 10^9$/L, Fib 408 mg/dL, D-dimers 29800 ng/mL, ISTH score 7	Residual false lumen after aortic dissection	Hybrid approach - resection of thoracoabdominal dissected aorta + TEVAR + right to left axillo-axillary artery bypass	Heparin administration, RBCs, PLTs	Multiple hospitalizations	Life-threatening hemorrhage from the left kidney	Gradual resolution of DIC in 6 months
[illegible] et al	2017	72	HTN, severe aortic stenosis, AF	AAA (80 mm) and type I endoleak 1 year later	EVAR and extension for endoleak	5 years later	No symptoms related to DIC	PLT 74 $\times 10^9$/L, Fib 79.8 mg/dL, D-dimers 238000 ng/mL, ISTH score 7	Endoleak type II	Open aneurysm replacement (concomitant aortic valve replacement)	PLTs	90 days of observation and treatment (not reported if this period the patient was hospitalized)	Endocarditis	DIC resolved, death after 3 months due to endocarditis
Wang et al	2018	73	HTN, CAD s/p PCI, AF	TBAD	TEVAR	8 months later	Large hematoma within the right chest wall	PLT 91 $\times 10^9$/L, Fib 99 mg/dL, D-dimers 11,410 ng/ml	No endoleak but presence of contrast in the false lumen	TEVAR + stent grafts in both renal arteries + [illegible]	Not reported	Not reported (more than 7 days)	None	DIC resolved
Dobrzanska et al	2020	71	CAD (myocardial infarction 2 months before), chronic kidney disease, hyperlipidemia	AAA (77 mm)	EVAR	Immediately after surgery	Bleeding from the insertion femoral sites	PLT 68 $\times 10^9$/L, aPTT 131", D-dimers 172791 ng/ml, Fib 47 mg/dL	Impaired blood flow to the right kidney, preserved flow to the limbs (ultrasound)	None	RBCs, FFPs, cryoprecipitate, and PLTs (undefined number)	1 day	Persistent bleeding, multiorgan failure	Death
[illegible] et al	2020	78	HTN	TBAD	TEVAR	8 months later	Persistent hematuria, extended buccal bleeding, black stools	Hct 24.3%, Hb 6.5 mg/dL, PLT 46 $\times 10^9$/L, d-dimers 356700 ng/mL, INR [illegible]	Endoleak Ia and aneurysmatic sac 31 mm	Hybrid arch replacement type I	6 RBCs, 136 FFPs	41 days	Persistent bleeding postoperatively	Death due to persistent bleeding
[illegible] et al	2020	76	CAD - PCI, COPD	Endovascular repair of thoraco-abdominal and abdominal aneurysms and femoro-femoral bypass for thrombosed left iliac artery 18 years prior	TEVAR, EVAR, femoro-femoral bypass	10 years later	Large subcutaneous hematoma of the lateral chest wall	PLT 77 $\times 10^9$/L, PT 17", aPTT 53.6", Fib 113 mg/dL, D-dimers >20000 ng/mL, ISTH score 6	Enlarged aneurysmatic sacs and endoleak	Surgical repair (not described - removal of aneurysmatic sac and abdominal aorta restoration probably)	4 RBCs, PLTs, cryoprecipitate, TXA. Dual antiplatelet treatment discontinued	Not reported	Not reported	Not reported

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Nikolaos Schizas, MD, Msc, PhD(c), Georgia Nazou, MD, Msc, [...], and Dimitrios C Angouras, MD, PhD, Prof FECTS +1 View all authors and affiliations

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