Case Report

Cesarean section complicated with presumed massive pulmonary embolism and cardiac arrest treated with rescue thrombolytic therapy—two case reports

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Background: Massive pulmonary embolus (PE), resulting in cardiac arrest during pregnancy and postpartum, is a rare but potentially catastrophic event. The most severe manifestation of massive PE is cardiovascular instability, including cardiogenic shock and cardiac arrest requiring intensive care unit (ICU) admissions. Up to 23% of high-risk PE pregnant and postpartum patients experience cardiac arrest.

Case Description: Case 1, a 34-year-old obese patient, with a twin pregnancy, had cesarean sections in the 24th week of pregnancy due to premature abruption of the placenta. Immediately after the birth, she experienced a sudden cardiac arrest. Treatment was initiated in line with antimicrobial lock solutions (ALS), heparine and alteplase was administered due to suspected massive pulmonary embolism. After 20 minutes from return of spontaneous circulation (ROSC), the uterine atony and severe hemorrhage occurred, and a postpartum hysterectomy was performed. The mother and two daughters are alive in 2021. Case 2, a 24-year-old obese patient had a cesarean section due to abruption of the placenta in the 28th week of pregnancy. Twelve hours after cesarean delivery, the patient's condition suddenly deteriorated. The patient reported dyspnea, chest pain, and presented cyanosis. The blood pressure was 66/30 mmHg, heart rate 130/min, tachypnea with a respiratory rate of 30/min, saturation 80% on air. High flow oxygen via face mask with reservoir (FiO_2 0.85) and ephedrine 2×10 mg i.v. were administered. Due to suspected pulmonary embolism, a bolus of 5,000 IU of heparin was administered iv. Despite the implemented measures, cardiac arrest was confirmed with the initial rhythm of pulseless electrical activity (PEA) (sinus tachycardia 120/min). Treatment consistent with ALS was initiated. Due to the high probability of pulmonary embolism, a bolus of alteplase was administrated. ROSC was obtained 7 minutes later. Because of obstetric hemorrhage hysterectomy was performed. The mother and the baby are alive in 2022.

Conclusions: In light of current evidence, presented data suggest that early and aggressive recombinant thrombolytic use in case of cardiac arrest and suspected PE in obstetric patients may be life-saving, effective treatment with a good neurological outcome. Major bleeding complications should be anticipated when administering this therapy.

Keywords: Thrombolytics; pulmonary embolism; cardiac arrest; cesarean section; case report

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Introduction

Massive pulmonary embolus (PE), resulting in cardiac arrest during pregnancy and postpartum, is a rare but potentially catastrophic event. It is a leading direct cause of maternal mortality in middle and high resource countries. PE complicates from 1 per 1,000–3,000 to 1–1.5 per 10,000 pregnancies, with massive PE manifestations comprising about 5% of all PE and resulting in 3.5% fatality (1-3).

The rate of postpartum pulmonary embolism without an antecedent thrombotic event was 0.45 per 1,000 births (4). The mortality rate due to PE in high resource countries ranges between 0.7–1.56 per 100,000 maternities (5-7). The most severe manifestation of massive PE is cardiovascular instability, including cardiogenic shock and cardiac arrest, requiring intensive care unit (ICU) admissions (8). Up to 23% of high-risk PE pregnant and postpartum patients experience cardiac arrest (9).

Perioperative life-saving treatment of PE cardiac arrest obstetric patients with a thrombolytic agent is associated with the risk of numerous complications, including major bleeding, need for re-laparotomy, hysterectomy, coagulopathy, and fetal death. Cardiac arrest, either perioperatively or in the operating room, is a significant challenge for a multidisciplinary team taking care of the patient. The decision of systemic thrombolysis peri cesarean delivery brings a lot of controversy for clinicians facing this challenge; however, it may be the only effective treatment available when access to surgical embolectomy, catheter-directed treatment, or extracorporeal life support (ECLS) is limited. We present two in-hospital maternal cardiac arrest cases during and after cesarean section with successful systemic thrombolysis and good patient neurological outcomes. We present the following cases in accordance with the CARE reporting checklist (available at https://apm.amegroups.com/article/view/10.21037/apm-22-435/rc).

Case presentation

Case 1

A 34-year-old pregnant woman, gravida III, para II, was admitted to the obstetrics and perinatology department of the tertiary care center at 21 weeks and six days of gestation in dichorionic twin pregnancy due to the risk of miscarriage. Her medical history included pregnancy-induced hypertension and WHO class III obesity [body mass index (BMI) 44 kg/m^2] without venous thromboembolism. On admission, the patient's vital signs and laboratory tests were normal (see Table S1). No abnormalities were found in physical examination except obesity. The patient complained of minor vaginal bleeding. A speculum examination revealed a cervix shortened by 20%, directed to the sacrum, and external os opened at 1 cm, internal os closed, a small amount of dark red blood, and no signs of the premature rupture of membranes. Ultrasound revealed a subchorionic hematoma—5 cm in diameter. Abdominal palpation and uterine basal tone were normal, without contractions. Due to subchorionic hematoma patient received a reduced dose of nadroparin 5,700 IU subcutaneously q24 h.

At 24 weeks and four days, the patient presented contractions and vaginal bleeding. Preterm labor was diagnosed. Because of suspicion of placental abruption, the decision was made to perform emergency, category one, cesarean section under general anesthesia. After induction of anesthesia, the patient was successfully intubated using rapid sequence induction. The proper position of the endotracheal tube was confirmed with auscultation, and obtaining the reliable value of end-tidal carbon dioxide ($ETCO_2$) of 33–35 mmHg. During cesarean section, before delivery, the patient required an increased fraction of inspired oxygen (FiO_2) up to 0.8. The delivery was uneventful, and two premature female babies were born. The weight of the babies was 690 and 680 g, and the Apgar score was 4/5/6 and 2/5/6 for the first and the second baby, respectively. Placental abruption was confirmed.

After delivery, the patient manifested an episode of sinus tachycardia (160 bpm) with a blood pressure drop to 90/50 mmHg. Concurrently, $ETCO_2$ suddenly dropped from 35 mmHg to undetectable, coupled with a decreasing pulse oximetry value (90–85–70%) despite an increase of FiO_2 up to 1.0. Equal breath sounds were confirmed during auscultation, and there were no signs of bleeding. It was followed by bradycardia 30/min and further blood pressure drop. Massive pulmonary embolism was suspected. Differential diagnoses of hypovolaemia due to hemorrhage or amniotic fluid embolus (AFE) were considered. The patient received atropine 2×0.5 mg i.v., followed by ephedrine 2×12.5 mg i.v. and a bolus of crystalloid 500 mL. Subsequently, a bolus of adrenaline was administered two times 0.5 mg iv due to lack of improvement of heart rhythm and hypotension. Because of suspicion of pulmonary embolism, a bolus of 5,000 IU of heparin i.v. was administered. Despite the implemented treatment, cardiac arrest was confirmed 10 minutes after the delivery. CPR was started immediately. The initial cardiac arrest rhythm was pulseless electrical activity (PEA)—sinus tachycardia

130/min), and 1 mg of adrenaline was administered intravenously and repeated every 3–5 minutes. Except for cardiopulmonary resuscitation (CPR) and involved cardiac arrest treatment, a bolus of 20 mg of alteplase was given intravenously, followed by 60 mg of alteplase 10 minutes infusion. Return of spontaneous circulation (ROSC) was achieved 5 minutes after alteplase administration.

Due to persistent hemodynamic instability, the infusion of catecholamines (noradrenaline and dobutamine followed by adrenaline) was implemented. The perioperative focused cardiac ultrasound was performed, demonstrating right ventricle dilation, hypokinesia, and enlarged and stiff inferior vena cava during assisted ventilation consistent with massive PE, with no signs of pericardial effusion or aortic abnormalities. After 20 minutes from ROSC, the uterine atony and severe hemorrhage occurred, and a postpartum hysterectomy was performed. During surgery, the patient received ten units of red blood cells (RBC), four units of fresh frozen plasma (FFP), and 2 g of fibrinogen concentrate, according to the results of multiple laboratory assessments of FBC, clotting, and fibrinogen level. Point of care arterial blood assessment revealed severe acidosis (pH 7.04), hypocalcemia (0.74 mmol/L), and increased lactate level (8 mmol/L). The disturbances were gradually corrected with sodium bicarbonate, calcium administration, and hemodynamic stabilization. After surgery, the intubated patient was transferred to the ICU for further treatment. In the ICU, sedation and mechanical ventilation were maintained, the infusion of catecholamines was continued, and unfractionated heparin infusion was administered, aiming at the therapeutic APTT index. In ICU, the patient received 14 units of RBC, ten units of FFP, and 1 unit of platelets. The patient was extubated on the third day of ICU stay with a good neurological outcome (cerebral performance category—CPC 1). After stabilization, CT pulmonary angiography was done—no filling defect suggesting pulmonary embolism was found. The patient was transferred to the obstetrics and perinatology department the next day without signs of circulatory or respiratory insufficiency. After the next three days in the obstetric department, the patient was discharged home. The follow-up treatment included oral rivaroxaban. Thrombophilia was excluded. The mother and two daughters are alive in 2021 (5 years after the episode).

Case 2

A 24-year-old patient gravida 2, para 2, without any comorbidities except for WHO class II obesity (BMI 36.7 kg/m^2), was admitted to the obstetrics and perinatology department of the tertiary care center in the 28th week of pregnancy due to left hydronephrosis of the fetus for placing vesicoamniotic intrauterine shunt. On admission, vital signs and laboratory tests were normal (see Table S2). The patient had a history of cesarean section in the previous pregnancy, without any history of venous thromboembolism. According to local guidelines, no routine thromboprophylaxis was given during pregnancy (10). Due to symptoms of premature abruption of the placenta the next day after the fetal surgery, the emergency cesarean section was performed without complication under spinal anesthesia. A premature female baby with 1,350 g birth weight was born. The Apgar score was 4/6/6 points in the 1st, 3rd, and 5th minutes. Routine thromboprophylaxis with LMWH was introduced after surgery—enoxaparin 40 mg every 12 hours. Twelve hours after cesarean delivery, the patient's condition suddenly deteriorated after leaving bed in the morning. The patient reported dyspnea, chest pain, and presented cyanosis. The blood pressure was 66/30 mmHg, heart rate 130/min, tachypnea with a respiratory rate of 30/min, saturation 80% on air. High flow oxygen via face mask with reservoir (FiO_2 0.85) and ephedrine 2×10 mg i.v. were administered. The patient had decreased level of consciousness, GCS 11 (E3V4M4). The infusion of dobutamine and norepinephrine was initiated. Due to suspected pulmonary embolism, a bolus of 5,000 IU of heparin was administered iv. Despite the implemented measures, cardiac arrest was confirmed with the initial rhythm of PEA (sinus tachycardia 120/min). Chest compressions and ventilation were started immediately, and adrenaline 1 mg was administered and repeated every 4 minutes. The patient was intubated with confirmed tube placement. During assisted ventilation, the bedside focused cardiac ultrasound demonstrated right ventricle dilation with hypokinesis, enlarged and stiff inferior vena cava. There were numerous PE risk factors: puerperium, recent cesarean section, immobilization, and obesity. Due to the high probability of pulmonary embolism, a bolus of 40 mg of i.v. actilyse was administered and followed with 60 mg in 10 minutes infusion. There was temporary ROSC for 1 minute during CPR, followed by PEA (bradycardia <60/min). ROSC was obtained 7 minutes later with HR 130/min (sinus tachycardia), blood pressure of 107/62, and SpO_2 62% with 0.85 FiO_2. Lung auscultation and bedside-focused lung ultrasound did not reveal any abnormalities. The abdomen was soft on palpation, with no signs of

bleeding on abdominal ultrasound examination. Due to the decrease in blood pressure and persistent bradycardia, adrenaline and norepinephrine infusion were administered.

The repeated bedside echocardiography image did not reveal right ventricle enlargement, and an improvement in right ventricle contractility was observed. About 15 minutes later, symptoms of genital tract bleeding occurred. Despite i.v. administration of 100 micrograms of carbetocin, there was no improvement, and the decision to perform re-laparotomy was taken. The decision to perform a supracervical hysterectomy without ovarian ducts was made. During surgery, the patient required transfusion of 10 units of RBC, eight units of fresh frozen plasma, two units of platelets, and 3 g of fibrinogen concentrate. After surgery, the patient required admission to ICU, CT pulmonary angiography was done—no filling defect suggesting pulmonary embolism was found. Furthermore, in the postoperative period, the patient received four units of RBC and four units of FFP. The patient was extubated on the second day of the ICU stay and transferred back to the obstetrics and perinatology department. The patient was discharged home after 23 days. The follow-up treatment included oral warfarin and diagnostics for thrombophilia as a PE risk factor. The mother and the baby are alive in 2022 (1 year after the episode).

The article received approval from the Ethics Committee of Jagiellonian University, Cracow, Poland (Approval No. 1072.6120.275.2021).

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Helsinki Declaration (as revised in 2013). Written informed consent were obtained from the patients for publication of this case report and accompanying images. A copy of the written consent is available for review by the editorial office of this journal.

Discussion

Sudden deterioration of obstetric patient peri cesarean delivery may have a different origin. PE diagnosis is difficult to exclude without lung scintigraphy or CT pulmonary angiography. The diagnostics tools are often not available when, after a short time of deterioration, patients experience sudden cardiac arrest. The following risk factors and symptoms suggest a diagnosis of pulmonary embolism: hypercoagulability due to pregnancy and puerperium, recent surgery, bed immobilization, obesity, sudden onset of symptoms with cardiovascular collapse, chest pain, and dyspnea or decreased $ETCO_2$ signal if monitored. However, the differential diagnosis should include hemorrhage, amniotic fluid embolism (AFE), sepsis, concomitant cardiac disease (myocardial infarction, peripartum cardiomyopathy), anaphylaxis, or venous air embolism.

A recent comparison of international guidelines for diagnosing suspected pulmonary embolism during pregnancy indicated numerous diagnostic tools and measures. However, these are not feasible for cardiac arrest patients. The authors suggested the empirical treatment in high-risk patients based on clinical suspicion before diagnostic imaging (11). Echocardiography in PE may be helpful in diagnostics, showing right ventricular overload and enlargement, hypokinesia, tricuspid valve regurgitation, right atrium enlargement, and the presence of thrombi in the right atrium and ventricle. However, the point of care diagnostic approach has been questioned in the recent update to resuscitation guidelines 2021, as right ventricular dilation in isolation during cardiac arrest should not be used to diagnose massive pulmonary embolism (12). It should be combined with relevant evidence from patient history and the course of treatment available when facing sudden deterioration and cardiac arrest. Both patients we presented had echocardiographic findings suggesting, with clinical context, massive PE.

Similar symptoms of sustained hypotension, respiratory deterioration, or otherwise unexplained cardiac arrest may be present in AFE. Against AFE in both cases was lack of disseminated intravascular coagulation (DIC); the bleeding began about 20 minutes after administration of alteplase. Additionally, the second patient experienced deterioration and cardiac arrest 12 hours after CS. Furthermore, patients had no neurological symptoms before deterioration. One of the possibilities for quick confirmation of AFE could be thromboelastometric detection of hemostatic failure, supporting a diagnosis of AFE (13). However, there was no access to this assessment in any of the cases. It is worth underlining that both patients responded quickly with ROSC for alteplase administration. The diagnosis of pulmonary embolism is made on CT pulmonary angiography, ventilation/perfusion lung scintigraphy, objectively diagnosed proximal DVT with a clinical PE, echocardiography with RV dilation, and clinical signs of PE. In both patients, the diagnosis of presumed PE was based on physical examination, the clinical context of the patient history, and echocardiographic heart and lung ultrasound findings without assessment of DVT in the acute phase.

Sudden deterioration resulting in a cardiac arrest made it impossible to perform CT pulmonary angiography in the acute phase. CT pulmonary angiography examinations were performed after achieving cardiovascular stability and did not reveal main pulmonary arteries occlusion. We conducted the relevant literature review and did not find data presenting evidence of the effectiveness of systemic fibrinolysis assessed with CT pulmonary angiography. In our opinion, lack of main pulmonary arteries occlusion results from effective fibrinolysis resulting in quick recovery from cardiac arrest and cardiovascular stability after alteplase administration. D-dimer levels were not assessed before the patients' deterioration.

The treatment choice in confirmed PE relates to the symptoms severity and mortality risk (14). Massive PE during pregnancy and postpartum may be complicated with cardiac arrest in up to 23% of cases (9).

Pregnancy, puerperium, and recent surgery are relative or absolute contraindications for fibrinolytic use. However, rescue thrombolytic therapy may be the only effective treatment in PE cardiac arrest if alternatives like surgical embolectomy or catheter-directed treatment are not immediately available. In both cases, there was no immediate access to these facilities. A recent review reported a lower survival rate for surgical embolectomy (84% survival; with a cardiac arrest ratio of 33%) when compared with systemic thrombolysis (92% survival; with a cardiac arrest ratio of 19.3%) in pregnant or postpartum patients with massive PE (9).

When using thrombolysis in pregnancy and puerperium, the primary concern is the risk of fatal hemorrhage, complicating the treatment. The highest risk relates to its perioperative use. In the obstetric population with massive PE requiring administration of a thrombolytic drug, major bleeding reported antepartum was present in 18% of patients, whereas postpartum it was three times more frequent (58%) (9). In the non-pregnant population, only 10% of patients with thrombolytic administration due to PE are at risk of bleeding (15). Recombinant thrombolytics, theoretically, may be preferable to urokinase or streptokinase because they do not cross the placenta. Alteplase appears to be the best option for systemic thrombolysis in pregnancy due to its availability, properties, and pharmacokinetic profile (16-18).

There are no guidelines defining doses and duration of thrombolytic agent administration in case of cardiac arrest due to PE in obstetric patients. Cardiac arrest during or early after a cesarean section generates additional challenges.

The European Resuscitation Guidelines recommend administering rescue thrombolytic therapy in rapidly deteriorating patients (19). Additionally, the European Society of Cardiology (ESC) indicates that the decision to treat acute PE must be taken early when a good outcome is still possible (14). The decision to start the treatment is much more complex when sudden cardiac arrest occurs without a confirmed diagnosis, and alternatives to rescue thrombolytic therapy like surgical embolectomy or catheter-directed treatment are not immediately available.

In a recent literature review, the rt-PA thrombolytic intravenous dosage ranged from 25 to 100 mg (20). Another study presented the administration time of the thrombolytic drug in massive PE in pregnancy ranging from 5 to 120 minutes with rt-PA and doses of 40–100 mg. This review reported 39% of bleeding complications of different severity (16). However, those reviews did not specifically focus on cardiac arrest patients.

Reports from UK and Turkey showed that massive PE related to cesarean section accounted for 78% of early severe postpartum PE and resulted in high mortality between 50–82%. Most massive PE cases occurred postpartum and were unexpected (21,22).

A recently published case report describes a patient with massive PE in pregnancy with pre-hospital cardiac arrest who re-arrested in hospital and received two i.v. 50 mg bolus doses of alteplase in 15 minutes intervals. The thrombolytic treatment of PE was administered after 1 hour from the first episode of cardiac arrest and 20 minutes after the patient hospital admission. Despite the negative outcome, the authors suggest that systemic rescue thrombolysis and hysterotomy represent a reasonable treatment option for maternal cardiac arrest from PE (23). In a recent review presenting postpartum administration of rt-PA, hemorrhagic complications requiring hysterectomy were present in 3 of 13 patients. Two more patients required subsequent laparotomy, and all of these deliveries were cesarean sections. The rt-PA doses reported in this review ranged between 3–100 mg, and most of the 13 cases included required transfusion of blood products (24).

The reported cases in which the perinatal hysterectomy was not required were treated with embolectomy or had vaginal delivery (25,26). Picetti *et al.* analyzed the literature on the application of tranexamid acid (TXA) to inhibit fibrinolysis. Most of the analysis concerned *in vitro* research. They estimated that a TXA concentration of 5–10 mg /L already partially inhibited rtPA activity, and a concentration

of 10–15 mg/L caused a complete inhibition (27). Strong evidence supports the use of TXA in obstetric hemorrhage, reducing mortality due to hemorrhage. However, it did not reduce the risk of death from other causes or the risk of hysterectomy (28). Shakur *et al.* in a systematic review analyzed the use of antifibrinolytic drugs in postpartum hemorrhage—so far, the risk assessment of perinatal hysterectomy has only been analyzed in the WOMEN trial (29). The TRACES trial has been registered in 2016, it plans to determine superiority of either 1 g of TXA or 0.5 g of TXA, in comparison to placebo (30).

The rescue thrombolytic treatment during or after cesarean section resulted in atony and hemorrhage, followed by the decision to perform a life-saving hysterectomy. Postpartum hemorrhage is one of the common causes of morbidity as well as mortality among pregnant women. If conservative treatment options are exhausted, uterine artery embolization can also be performed if the woman is hemodynamically stable and there is a locally available embolization service. Embolization for PPH is highly effective, with clinical success rates ranging from 80% to near 90%. Bleeding control rates are higher, approaching 98%, with technical success rates of 100%. Proven clinical factors influencing the outcome include DIC, extravasation on angiogram, and hemodynamic instability (31,32). Although there are no extensive randomized studies, and the evidence level is limited, arterial embolization may be recognized as a safe and effective procedure (33). No studies known to the authors report treating obstetric hemorrhage involving embolization after systemic thrombolysis for PE cardiac arrest. The decision to perform a life-saving hysterectomy was performed due to cardiovascular instability and no access to the emergency embolization service.

Managing coagulopathy in obstetric hemorrhage with prothrombotic agents soon after induced thrombolysis is also controversial. Most reports describing the prothrombotic treatment of hemorrhage after thrombolysis convey administration of RBC, FFP, and platelets only to restore hemostasis. We have supplemented blood products (FFP, RBC, PLT) and fibrinogen concentrate according to the frequent assessment of standard coagulation tests (PT/INR, APPT), fibrinogen, platelets, and hemoglobin levels. No ROTEM/TEG assessment was available in the patient location. However, the role of ROTEM/TEG and treatment of obstetric hemorrhage after thrombolysis have not been defined yet. Despite evidence supporting the administration of tranexamic acid in obstetric hemorrhage, we decided to avoid antifibrinolytics use immediately after fibrinolysis due to PE cardiac arrest.

In both cases, we presented ROSC was achieved within 15 minutes, and there was no need for prolonged CPR attempts. Both cases were complicated with hemorrhage present in about 20 minutes from ROSC and required a hysterectomy. ESC guidelines identified gaps related to the clinical benefits *vs.* risks of reduced-dose thrombolysis in obstetric patients with intermediate- and high-risk PE. This issue should be evaluated in prospective randomized trials (14). A massive pregnancy-related PE is a rare event with the challenge of recruiting patients for prospective trials. Using The MAPP Registry for Thrombolysis and Invasive Treatments for Massive Pregnancy-related Pulmonary embolism may help collect data and gain widespread knowledge on this topic (3). Retrospective registries may allow for guiding and informing future clinical practice for these severe cases.

Limited data reports the neurological outcome of obstetric survivors from PE cardiac arrest. Both patients presented in this paper were discharged home neurologically intact (CPC1), without a long-term cardiac arrest sequel. Further investigation did not reveal hypercoagulability in the first case; the second patient was during diagnosis and lost in follow-up. All three neonates were preterm. The babies were delivered before administration of thrombolysis, and their birth status and follow-up were not related to the patients' PE episodes.

ECLS is one of the treatment options as rescue therapy for selected patients when conventional CPR fails. A recently published review showed that ECMO used for high-risk pregnancy-associated PE had grown recently. In both cases, we report, ROSC was achieved soon after administering rt-PA without the need for ECLS involvement (34).

Strength of study is showing the way of management in the facilities where is no possibility to perform emergency surgical embolectomy or interventional radiology. We presented two cases with successful outcome, without nuerological sequel for both patients.

Limitation of study is that the diagnosis is presumed based on hemodynamic instability, clinical presentation, echocardiography ultrasound examination. There was no time for a whole diagnostic approach before treatment.

In light of current evidence, presented data suggest that early and aggressive recombinant thrombolytic use in case of cardiac arrest and suspected PE in obstetric patients may be life-saving, effective treatment with a good neurological

outcome. Major bleeding complications should be anticipated when administering this therapy.

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Footnote

Reporting Checklist: The authors have completed the CARE reporting checklist. Available at https://apm.amegroups.com/article/view/10.21037/apm-22-435/rc

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://apm.amegroups.com/article/view/10.21037/apm-22-435/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The article received approval from the Ethics Committee of Jagiellonian University, Cracow, Poland (Approval No. 1072.6120.275.2021). All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Helsinki Declaration (as revised in 2013). Written informed consent were obtained from the patients for publication of this case report and accompanying images. A copy of the written consent is available for review by the editorial office of this journal.

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Supplementary

Table S1 Laboratory data (case 1)

Variable	Reference range[†]	On admission	7:44 AM (before CS)	9:51 AM (after ROSC)	12:26 AM
Hematocrit (%)	37.00–47.00	32.6	34.6	21.7	23.5
Hemoglobin (g/dL)	11.00–15.00	11.1	11.2	6.8	7.4
White cell count (per mm^3)	$4*10^3$–$10*10^3$	$8.98*10^3$	$44.7*10^3$	$22.2*10^3$	$23.6*10^3$
Platelet count (per mm^3)	$125*10^3$–$340*10^3$	$249*10^3$	$245*10^3$	$115*10^3$	$94*10^3$
Red-cell count (per mm^3)	$3.5*10^6$–$5*10^6$	$3.83*10^6$	$3.80*10^6$	$2.47*10^6$	$2.64*10^6$
Mean corpuscular volume (fl)	82–92	85	91	88	89
Mean corpuscular hemoglobin concentration (g/dL)	32–36	34	32	31	32
Red-cell distribution width (%)	12.1–14.1	13.9	14.6	15.5	15
Prothrombin time (sec)		12.2	39.6	26.2	16.1
Prothrombin-time international normalized ratio	0.9–1.2	1.04	3.54	2.31	1.4
Partial-thromboplastin time (sec)	26–36	28.1	Does not clot	128.2	43.8
Fibrinogen (g/L)	1.8–3.5	3.2	Does not clot	0.4	1.2
Total protein (g/L)	66.0–87.0	58.4		35	
Albumin (g/L)	35.00–52.00			22	35
Urea/blood urea nitrogen (mmol/L)	2.76–8.07	2.3	3.1	3.6	4.5
Creatinine (umol/L)	44–80	36	64	59	74
C-reactive protein (mg/L)	<5.00	3.9	5.81		
Creatine kinase (U/L)	20–180				173
Creatine kinase-MB (U/L)	3–25				50
Troponin I hs (ng/L)	<19.0				6.9
D-Dimer (mg/L)	<0.55	8.85	>35		>35

[†], reference values are affected by many variables, including the patient population and the laboratory methods used. The ranges used at University Hospital in Cracow are for adults who are not pregnant and do not have medical conditions that could affect the results. They may therefore not be appropriate for all patients. CS, cesarean section; ROSC, return of spontaneous circulation.

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Table S2 Laboratory data (case 2)

Variable	Reference range[†]	On admission	7:26 AM (after CS, before cardiac arrest)	10:15 AM (after ROSC)	12:57 AM
Hematocrit (%)	37.00–47.00	37.2	31.5	24.6	26.5
Hemoglobin (g/dL)	11.00–15.00	12.7	10.9	7.8	9.1
White cell count (per mm^3)	$4*10^3$–$10*10^3$	$11.7*10^3$	$11.6*10^3$	$16.3*10^3$	$9.7*10^3$
Platelet count (per mm^3)	$125*10^3$–$340*10^3$	$269*10^3$	$166*10^3$	$99*10^3$	$115*10^3$
Red-cell count (per mm^3)	$3.50*10^6$–$5*10^6$	$4.18*10^6$	$3.53*10^6$	$2.50*10^6$	$3.08*10^6$
Mean corpuscular volume (fl)	82–92	89	89	98.4	86
Mean corpuscular hemoglobin concentration (g/dL)	32–36	34	35	32	34
Red-cell distribution width (%)	12.1–14.1	13.8	13.8	14	14.3
Prothrombin time (sec)		10.8		Does not clot	16.2
Prothrombin-time international normalized ratio	0.9–1.2	0.95		Does not clot	1.48
Partial-thromboplastin time (sec)	26–36	23.6		Does not clot	53.3
Fibrinogen (g/L)	1.8–3.5			Does not clot	1.11
D-dimer (mg/L FEU)	<0.55				>35.20
Total protein (g/L)	66.0–87.0				43.9
Albumin (g/L)	35.00–52.00				32.6
Urea/blood urea nitrogen (mmol/L)	2.76–8.07				2.56
Creatinine (umol/L)	44–80				86.7
Aspartate transaminase (U/L)	5–32				48
Alanine transaminase (U/L)	5–33				29
C-reactive protein (mg/L)	<5.00	1.58			12.6
Creatine kinase-MB (U/L)	3–25				13.39
Troponin I hs (ng/L)	<19.0				10,988
Procalcytonin (ng/L)	<0.50				0.37

[†], reference values are affected by many variables, including the patient population and the laboratory methods used. The ranges used at University Hospital in Cracow are for adults who are not pregnant and do not have medical conditions that could affect the results. They may therefore not be appropriate for all patients. CS, cesarean section; ROSC, return of spontaneous circulation.

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