

Extracorporeal Life Support as a Rescue Measure for Managing Life-Threatening Arrhythmia and Brugada Syndrome

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Abstract: We describe the use of extracorporeal cardiopulmonary resuscitation (E-CPR) to transiently stabilize a 3-month-old patient who presented with ventricular tachyarrhythmias leading to spontaneous cardiac arrest. The patient required 4 days of extracorporeal life support (ECLS) where he was diagnosed with probable Brugada syndrome (BS). The patient was discharged home in stable condition after implantable cardioverter defibrillator placement. This case highlights the importance of early transfer to extracorporeal membrane oxygenation (ECMO) center in the setting of unexplained cardiac arrhythmia in a pediatric patient. BS is an

autosomal dominant genetic disorder with variable expression characterized by abnormal findings on electrocardiogram (ECG) in conjunction with an increased risk of ventricular tachyarrhythmias and sudden cardiac arrest (SCA). Early management is critical and early consideration to transfer to an institution where extracorporeal life support (ECLS/ECMO) is present to support the patient while further diagnostic work up is in progress is lifesaving. **Keywords:** Brugada syndrome, extracorporeal membrane oxygenation (ECMO), extracorporeal cardiopulmonary resuscitation (E-CPR). *J Extra Corpor Technol. 2017;49:312–316*

Brugada syndrome (BS) is a genetic disorder transmitted in an autosomal dominant pattern. It is characterized by specific electrocardiogram (ECG) findings and carries an increased risk for ventricular tachyarrhythmias, spontaneous cardiac arrest, and sudden death. The characteristic ECG findings are right bundle branch block and two distinct types of ST-segment patterns found in leads V1-V3 (1–4). The prevalence of the typical ECG changes of BS ranges from 0.01 to .1% of the general population, but higher in Southeast Asian population, and more common in males (5,6). BS usually presents in adult patients (average age 41 years) (7), and it is rarely diagnosed in children but has been reported in as young as 9 days old (8,9). A variety of factors may play a role in the clinical presentation of BS (4,10). Genetic testing has identified two gene mutations in cardiac sodium channel (SCN) genes; SCN5A and SCN10A with the former being more common (11). When

BS presents with ventricular tachyarrhythmia and or spontaneous cardiac arrest, it is important to stabilize the patient and provide adequate cardiopulmonary support. Early deployment of extracorporeal membrane oxygenation (ECMO) during active chest compressions in patients who failed to respond to conventional cardiopulmonary resuscitation (CPR) was 1st reported in 1992 by del Nido and colleagues (12). Since then, extracorporeal cardiopulmonary resuscitation (E-CPR) has been increasingly used in cases where conventional resuscitation has failed to restore adequate circulation (13–16). The current American Heart Association (AHA) pediatric advance life support guidelines recommend considering E-CPR in cases of cardiac arrest if the conditions leading to the arrest are considered reversible or amenable to heart transplantation (13). We report a case of a 3-month-old boy who presented with ventricular tachyarrhythmia and spontaneous cardiac arrest who was resuscitated with E-CPR as he failed to respond to conventional CPR and who later was diagnosed with BS.

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CASE REPORT

The patient was a full term 3-month-old Caucasian boy (6.48 kg), with a past medical history significant only for

severe gastroesophageal reflux disease. After a bath at home, the patient's mother noted that the patient felt stiff and was having labored breathing. When the patient's father picked him up, he went limp, continued to have struggled breaths, and became cyanotic. The patient's parents immediately called 911 and began rescue breath maneuvers with chest compressions. When the paramedics arrived, the patient was pulseless; he was transferred to the local medical center while receiving CPR and one defibrillation attempt en-route.

Upon arrival at the local medical center, the patient was orotracheally intubated and admitted to the pediatric intensive care unit (PICU). In PICU, he required four defibrillations and four rounds of code dose epinephrine secondary to continued unstable wide complex ventricular tachycardia (VT). He was adequately sedated, and received a total of 35 mg of amiodarone (5 mg/kg), and started on an esmolol drip at 50 mcg/kg/min. In addition, the patient was volume resuscitated with 90 mL (15 mL/kg) of intravenous (IV) normal saline. Once stabilized, a venous blood gas (VBG) was taken which revealed a pH of 7.29 and bicarbonate level of 38. A head computerized tomography (CT) scan and echocardiogram were performed at the local hospital, both were unremarkable. The patient was transferred to our hospital for further management of his VT. There were no additional arrhythmia episodes throughout the transport.

After admission to the PICU, the patient reverted into Torsades de pointes and had multiple premature ventricular contractions. CPR, IV magnesium sulfate, and cardioversion were initially successful; however, the patient continued to revert to pulseless VT and ventricular fibrillation (VF). The patient was defibrillated more than 12 times in conjunction with the administration of several drugs, including magnesium sulfate, amiodarone, esmolol, lidocaine, and epinephrine. Epinephrine was the only drug observed to provide transient rhythm stabilization.

Given the patient's continued instability, the decision was made to rescue resuscitation with ECMO (E-CPR).

The right neck was prepared and the patient's right internal jugular vein (RIJ) and right carotid artery (RCA) were identified and isolated. To achieve an activated clotting time of >200 seconds, 100 units/kg of IV systemic heparin was administered. The distal RCA was ligated and an incision was made for cannulation. The vessel was cannulated with a 10 French (Fr.) Bio-Medicus (Medtronic Inc., Minneapolis, MN) cannula and advanced to the transverse aortic arch. The RIJ was then cannulated with a 14 Fr. Bio-Medicus cannula and advanced to the level of the right atrium. Throughout the entirety of the cannulation procedure, the patient was in a VT arrest state with no pulse and CPR continued. Quality of CPR was monitored using diastolic blood pressure (DBP) via the patient's arterial line, and end tidal carbon dioxide (ETCO₂) that were displayed on the monitor. DBP was constantly above 30 mmHg, and ETCO₂ was above 20 mmHg. Both cannulas were then de-aired and connected to the ECMO circuit. Veno-arterial ECMO was initiated with a Centrimag (Thoratec Co., Pleasanton, CA) blood pump and pediatric Quadrox (Maquet Getinge Group, Rastatt, Germany) oxygenator. The patient was stabilized on ECMO with a blood flow of 650 mL/min (100 mL/kg/min).

His ECG and telemetry were reviewed and showed evidence of right bundle branch block in leads V1 and V2 as well as ST-segment elevation in leads V1–V4. These findings were suspicious for BS (Figure 1). Given the baseline ECG pattern and clinical suspicion, a procainamide challenge was performed and showed typical QRS complex and ST-segment changes (Figures 2 and 3). The diagnosis of BS was suspected and the patient was started on quinidine per the recommendation of the pediatric cardiology electrophysiology team. On the 3rd day of ECMO support, the patient had transient hypertension accompanied with right pupil dilation and rhythmic right arm movement. A stat head ultrasound and cranial CT scan were both performed and were negative for intracranial hemorrhage. Despite the negative head imaging, pediatric neurology recommended initiation of Keppra for the

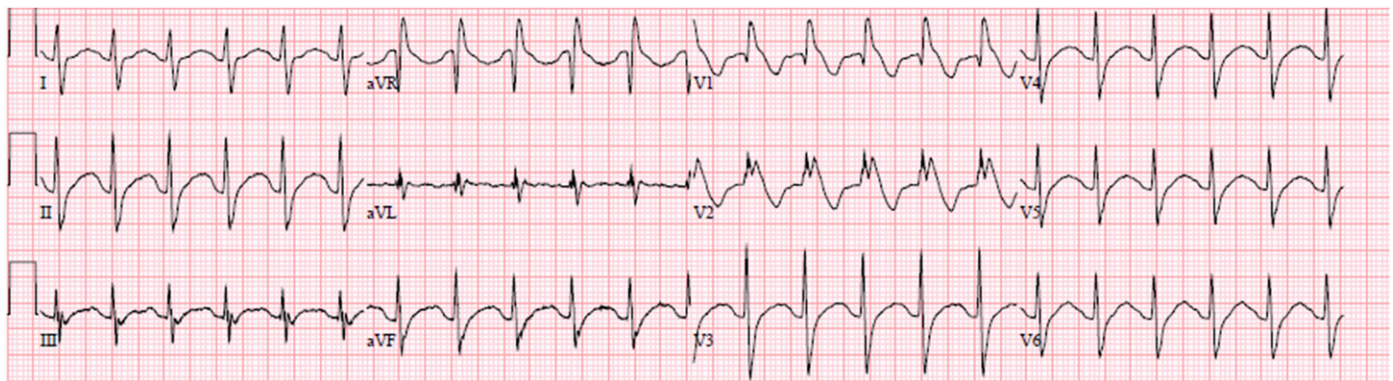


Figure 1. ECG on arrival to the pediatric intensive care unit (PICU).

possible seizure that was witnessed. Given his improved hemodynamics, absence of continued VT, and the presumed diagnosis of BS, he was weaned from ECMO support and decannulated (in addition to repair of the RCA and ligation of the RIJ) on the 4th day of ECMO support. He was extubated the next day. On post-ECMO day 5, the patient was discharged from the ICU and transferred to the pediatric cardiology general care floor, where he was monitored on telemetry. On post-ECMO day 14, the patient was taken to the cardiac catheterization lab, where he underwent the implantation of a trans-venous cardiac defibrillator. In the cardiac catheterization lab, the patient was noted to be stable in sinus rhythm. The defibrillator was turned on the next day. On post-ECMO day 21, the patient was discharged to home in stable condition.

He continues to follow up in the pediatric cardiology electrophysiology clinic to date. Genetic testing was performed and he was found to have SCN5A mutation that is consistent with BS. Two weeks after discharge, he had two ventricular high-rate episodes. Device interrogation showed non-sustained VT/VF that spontaneously converted and required no implantable cardioverter-defibrillator (ICD) shock therapy. A couple of days later, he received an appropriate shock for VT/VF. He has not had any further episodes of VT/VF or shocks from his defibrillator since that time. He also has not had any seizure activity and has successfully been weaned off Keppra. He continues to grow and develop normally.

DISCUSSION

ECMO therapy has been successfully used for circulatory support in patients with refractory ventricular

arrhythmias resulting from intrinsic cardiac disease, drug overdose, acute myocarditis, coronary artery spasm, or hypoxemia (4,5). This case report is the 1st to describe the initiation of ECMO and E-CPR to provide cardiovascular and hemodynamic support during an electrical storm of wide complex VT and VF in a patient who was later diagnosed with BS. However, Pagel et al. (10) reported supporting a 24-year-old pregnant female with known BS before delivery.

The majority of causes of sudden cardiac arrest (SCA) and sudden cardiac death (SCD) are because of VF and are typically associated with structural heart disease and more specifically coronary artery disease (10). Only about 5–10% of SCA cases occur in structurally normal hearts. BS, congenital long QT syndrome (LQTS), Short QT syndrome, catecholaminergic polymorphic VT (CPVT), idiopathic VT, and commotio cordis are some of the causes of SCA in structurally normal hearts (17).

ECMO has been used for years to provide circulatory support during active chest compressions in both adults and children (13,18). In 1992, del Nido et al. (12) was the first to report the use of E-CPR–enhanced survival among children with cardiac disease who had cardiopulmonary arrest and failed to respond to conventional CPR. Since then, E-CPR has been increasingly used to resuscitate patients with both cardiac and non-cardiac disease receiving CPR when conventional resuscitative measures have failed. The current AHA pediatric advance life support guidelines recommend consideration of E-CPR for in-hospital cardiac arrest if the conditions leading to arrest are reversible or amenable to heart transplantation (13).

Pediatric E-CPR survival rates ranges from 35% to 56% with 50–80% have favorable neurological outcomes (12–16,18–21). Early identification and patient selection as well

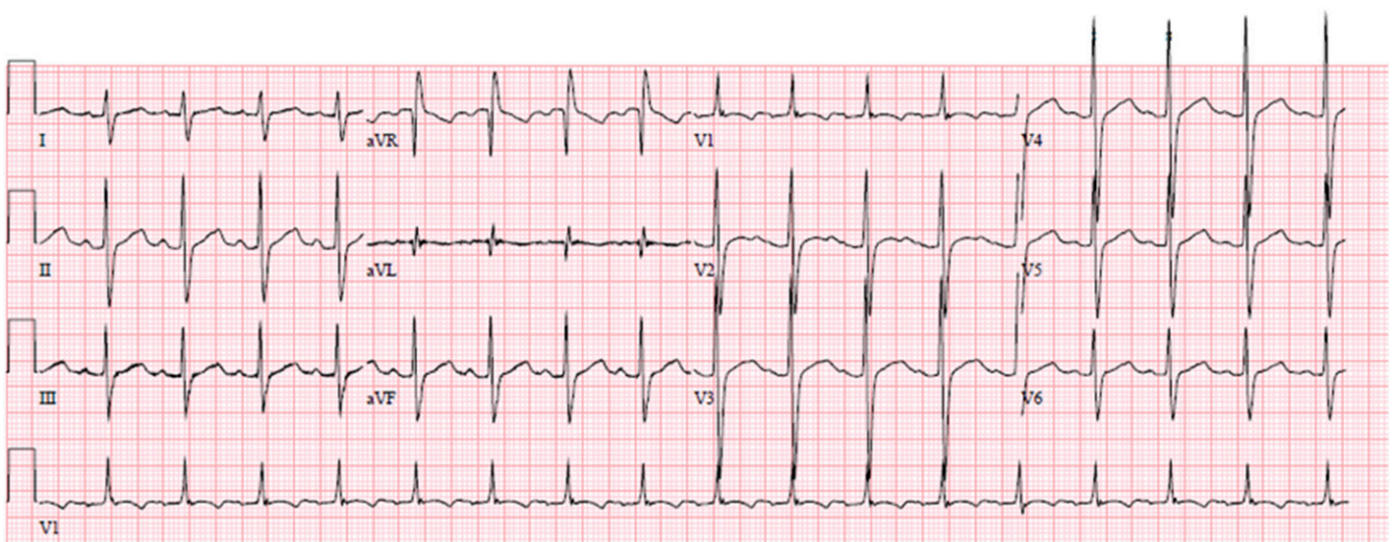


Figure 2. Baseline ECG while on ECMO and before the procainamide challenge.

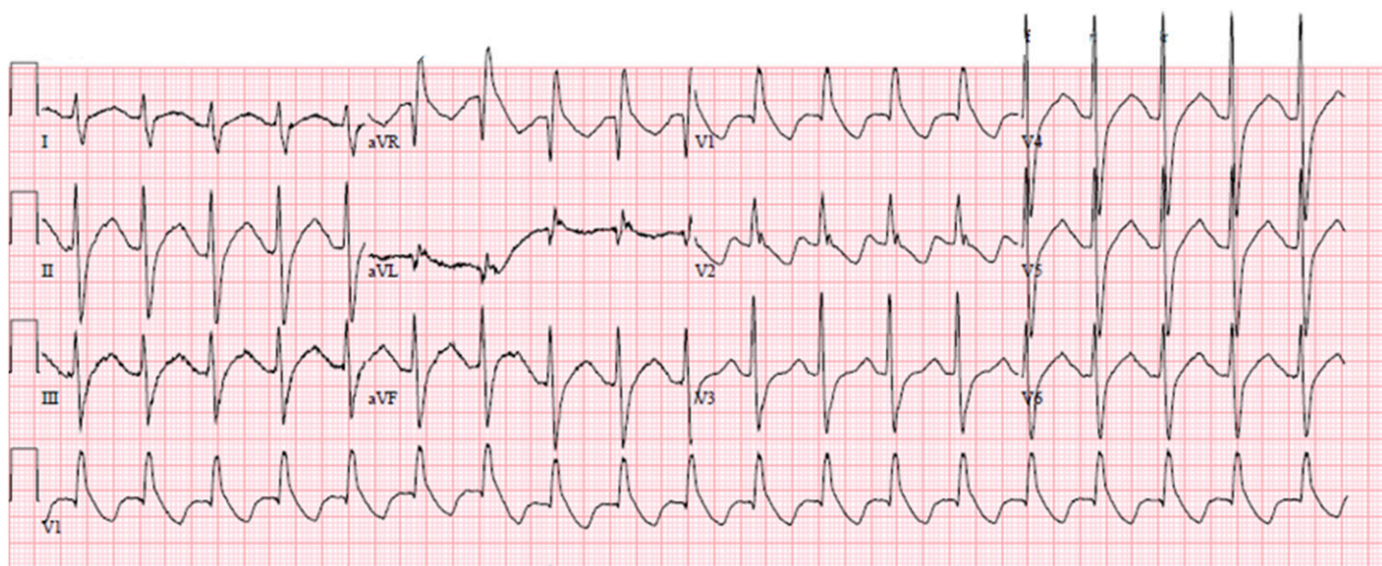


Figure 3. ECG after procainamide challenge showing evidence of right bundle branch block and ST-segment changes in lead V1 consistent with BS.

as early deployment of E-CPR are essential. In our patient, despite CPR being performed, we were unable to obtain return of spontaneous circulation, so we decided to activate E-CPR for circulatory support as the underlying dysrhythmia and what was considered probable BS is something we can further work up and manage medically to save his life.

BS is transmitted in an autosomal dominant fashion with variable expression and low penetrance (4). Mutation in the SCN gene is one of the known factors that play a role in the clinical presentation of BS. The defective myocardial sodium channels reduce sodium inflow currents, thereby reducing the duration of normal action potentials. Genetic testing has identified two gene mutation in SCN gene; SCN5A, and SCN10A (11). Mutation in the SNC5A gene is located on chromosome 3 (21–24). It is present in 18–30% of BS families (4). Genetic testing revealed that our patient had the specific Brugada SCN5A gene mutation. SNC5A mutation are “loss of function” mutations and results in a variety of abnormalities in sodium channel activity including failure of expression, alterations in the voltage and time dependence of activation, and accelerated or prolonged recovery from inactivation (2). The SCN mutations may explain the ability of Na channel blockers to expose the ECG changes in some patients with this disorder using procainamide and ajmaline (2,13,18). A procainamide challenge was done on our patient and supported our diagnosis of BS. Isoproterenol was used to wean off ECMO and bridge him to oral antiarrhythmic therapy with quinidine. Both isoproterenol and quinidine are two major drugs used for pharmacological suppression of BS electrical storm by restoring action potential morphology and normalizing ST-segment elevation (10).

The primary focus for treating patients with BS is the termination of any ventricular arrhythmias with an ICD.

Initial pharmacologic therapy for arrhythmia prevention has been tried in BS with relatively little success, so ICD implantation should be the 1st line therapy for nearly all patients. ICDs are safe and effective for terminating a life-threatening arrhythmia in patients with BS but their role in patients with genetically or ECG diagnosed BS and no symptomatology is less clear. Because most patients with BS who require ICD therapy are relatively young, consideration regarding long-term risk of ICD-related complications such as inappropriate firing, lead displacement, and infection should be weighted carefully. Based on all the available data, recommendations were made by The 2013 Heart Rhythm Society/European Heart Rhythm Association/Asia Pacific Heart Rhythm Society (HRS/EHRA/APHRS) for ICD placement (25).

CONCLUSION

BS is an autosomal dominant genetic disorder with variable expression characterized by abnormal findings on ECG in conjunction with an increased risk of ventricular tachyarrhythmias and SCA. Early management is critical, and early consideration to transfer to an institution where extracorporeal life support (ECLS/ECMO) is present to support the patient while further diagnostic work up is in progress is lifesaving.

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