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## Case report

# Deep brain stimulation failure due to external cardioversion in a patient with Parkinson's disease



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## ABSTRACT

We report a case of deep brain stimulation (DBS) hardware failure due to emergently performed subcutaneous coronary angioplasties complicated by cardioversion for rapid worsening of angina pectoris and some trouble shooting problems emerged after invasive cardiovascular procedures. The patient with prior implantation of permanent pacemaker due to vasovagal syndrome underwent successful left-sided unilateral electrode implantation into the subthalamic nucleus. During 21 months follow-up period the patient experienced 2 times episodes of aggravation of unstable angina pectoris 15 and 21 months respectively, which necessities emergent coronary angioplasties. After the first emergently performed coronary angioplasty with cardioversion the interrogation of DBS system revealed the depletion of an internal pulse generator (IPG). The secondly performed coronary angioplasty complicated by ventricular tachyarrhythmia with DBS system switched on during emergent cardioversion resulted in partial dysfunction of DBS electrode. Patients harboring cardiovascular implantable electronic devices (CIEDs) and DBS systems require special attention and good cooperation of neurosurgeons, interventional cardiologist, and neurologist. Some emergently performed invasive cardiovascular procedures which necessities cardioversion may cause DBS hardware failure with subsequent worsening of movement disorder symptoms.

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## 1. Introduction

Cardiovascular implantable electronic devices (CIEDs), such as permanent pacemaker (PPM) or implantable cardioverter

defibrillator (ICD) play a major role in treating cardiac arrhythmias and dysrhythmias. Deep brain stimulation (DBS) remains an effective and safe treatment modality for movement disorders such as Parkinson's disease (PD), dystonia, and essential tremor. The number of patients with both systems implanted simultaneously will undoubtedly grow in

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the future. Interestingly, the worldwide experience in urgently performed cardiovascular ischemic episodes in patients with both CIEDs and a DBS system is very limited [1-5].

Few reports can be found in the world literature in relation to invasive emergently performed life-saving cardiovascular procedures including, in particular, cardioversion or implantation of ICD in DBS patient population [4-6,8]. We would like to present a case of a patient with vasovagal syndrome and PD implanted with both PPM and DBS systems who experienced 2 episodes of unstable angina pectoris requiring emergent coronary angioplasties over a period of 21 months after DBS surgery. Both emergent cardiovascular procedures resulted in DBS hardware failure.

## 2. Case presentation

A 62-year-old right-handed man was diagnosed with PD at the age of 51 years. Motor symptoms at onset were right hand rest tremor, bradykinesia, and rigidity of the right arm and leg. The patient met the clinical criteria of the United Kingdom Parkinson's Disease Society brain-bank for idiopathic PD [9] and fulfilled also the CAPSIT-PD criteria [10]. After 7 years of PD, he experienced syncope episodes and during an examination performed at the cardiology department he was diagnosed with a vasovagal syndrome. He was implanted with PPM. His PPM was programmed in the DDD bipolar sensing mode. For the following years, he was free of any cardiac arrhythmias. Although he increased his antiparkinsonian medication, PD symptoms worsened and handicapped him in the performance of professional as well as daily living activities. He was referred by his neurologist for consideration of unilateral left sided subthalamic DBS due to bradykinesia, rigidity and levodopa-induced dyskinesia affecting the right hemibody. The patient also received the permission from the cardiologist for the performance of magnetic resonance imaging of his head before a planned stereotactic procedure. An examination in the practically defined off state showed a Unified Parkinson's Disease Rating Scale UPDRS part III score of 23 and a score of 14 after the intake of levodopa. We took into consideration and explained to the patient the possibility of unilateral pallidotomy. The treating neurologist and the patient after obtaining information of ablative and deep brain stimulation procedures opted for STN DBS surgery. The reversibility and adjustability of DBS technique were main reasons to proceed with implantation of DBS system in this particular patient.

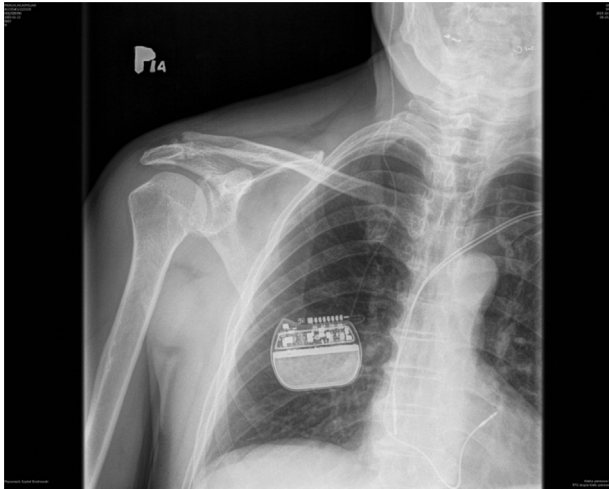
The surgery was performed in local anesthesia in the medication off condition. The target coordinates of the left subthalamic nucleus were calculated according to the mid-commissural point derived from merging of contrast-enhanced CT images with fusion of T2 and T1 weighted MR images using the software frame link 5 (Stealth station Medtronic, Minneapolis). After stereotactic implantation of 4 contact macroelectrodes (ANS cat 6149) (Fig. 1), he was brought into general anesthesia and IPG (Libra St Jude) was placed in the subcutaneous pocket under the clavicle on the right side contralateral to the previously implanted PPM on the left (Fig. 2). The stimulation was originally started with the parameters of 1.75 mA, 65 us, and 130 Hz with excellent



**Fig. 1 – The plain X-ray of the patient's skull showing the DBS electrode implanted in the left hemisphere, the extracranial part of deep brain stimulation lead is tunneled to the right parietal region in order to implant the neuronal internal pulse generator in the right subclavicular area.**

control of PD symptoms on the right side. The stimulation was set in the monopolar mode contact 1 (-), IPG (+).

For over 15 months of the postoperative follow-up period, he was independent with excellent control of PD symptoms. The rapid worsening of unstable angina pectoris with cardiac arrhythmia resulted in an emergently performed coronary angioplasty with cardioversion at 120J intensity. The DBS system was not switched off before coronary angioplasty. The cardiovascular intervention with placement of drug eluting stent in the left main coronary artery resulted in a good clinical outcome. After cardiovascular procedure, PD symptoms reappeared and the interrogation of the DBS system revealed no communication with the St Jude external programmer. He was scheduled for the IPG replacement in local anesthesia and sedation. The replacement of IPG was uneventful and setting the previous chosen stimulation parameters and stimulation mode provided a good control of PD symptoms on the right side. Unfortunately, after 6 months, he experienced another episode of unstable angina pectoris, which made it necessary to perform a rapid catheterization of coronary arteries with the placement of 2 drug eluting stents (1 stent placed in the circumflex branch of the left coronary artery and the other in the right coronary artery) in another cardiology department. The DBS system was not switched off. During the coronary angioplasty, the patient developed unexpectedly a cardiac arrhythmia with a subsequent cardioversion performed 2 times at the intensity of 120J and 200J. The cardioversion provided a normal cardiac rhythm and coronary angioplasty resulted in a good clinical outcome. During the hospitalization the patient experienced rapid worsening of PD symptoms. The interrogation of DBS system revealed the impedance factor over 31 indicating the hardware failure. The DBS system before



**Fig. 2 – The X-ray of the patient's chest showing the location of the internal pulse generator implanted in the subcutaneous pocket in the right subclavicular area at least 6 inches from a permanent pacemaker to avoid potential electrical interactions.**

cardioversion was set in the monopolar stimulation mode utilizing contact 1 as a cathode and IPG case as an anode. The cardioversion resulted in damaging of contact 1 of implanted DBS lead. Changing the active contacts of the stimulation provided a normal range of impedance. The monopolar mode of stimulation set as a cathode – contact 2 and IPG case as an anode provided again a good control of PD symptoms at 2.25 mA, 65  $\mu$ s and 130 Hz. The following 10 months have been uneventful of any cardiac and neurological problem in this patient. At 12 months follow-up the monopolar mode of stimulation had been changed to bipolar. A cathode – contact 2, anode contact 3, the amplitude was increased to 2.8 mA. The remaining stimulation settings were unchanged.

### 3. Discussion

The existence and the potential electrical interaction of 2 electronic devices implanted in the same patient evoke concerns of a probability of complications and interference between them obstructing proper setting of the stimulation parameters for both devices. The cardiovascular procedures are considered to be life-saving and have prevailed over the DBS procedures in the same patient. Furthermore, some CIEDs preclude the performance of the magnetic resonance imaging. Patients with CIEDs are usually on antiplatelet medication, which increases the risk of bleeding in the stereotactic trajectory even if antiplatelet medication is withdrawn before the planned neurosurgical procedures. In addition, patients with CIEDs often suffer from arterial hypertension, which also contributes to an increased risk of intraoperative bleeding during the electrode placement.

The aforementioned circumstances explain the relatively limited experience related to the simultaneous use of CIEDs and the DBS system [1–8]. Most patients reported in the literature with 2 devices underwent the first implantation of a

DBS system with subsequent placement of a CIED, due to a cardiac disease [3–5,7]. Even a smaller number of case reports exist on the implantation of a DBS system in a patient with a previously implanted CIED [1,2] like the presented case. This can be explained by the fact that patients with cardiac PPM or ICD are usually refused DBS procedure. Another drawback of the simultaneous use of a CIED and a DBS system is the risk of emergently performed cardiovascular procedures including cardioversion, which may result in hardware failure or neurological deficit, due to brain glial tissue damage [6,8].

The first case like that was presented by Yamamoto et al. in 2000 [6]. Cardioversion performed two times at the intensity of 100 and 200 J for paroxysmal atrial fibrillation resulted in brain tissue damage around the electrode located in the left thalamus with the subsequent development of central dysesthetic pain. The patient described by us had a fully implantable DBS system. The cardioversion performed emergently also two times resulted in no tissue damage. We have chosen a monopolar stimulation mode in this patient because it was very effective even at a lower amplitude in alleviating PD symptoms. To reduce interactions between the implanted systems, the PPM was programmed for bipolar sensing mode. Theoretically, setting bipolar neurostimulation mode in our patient could even reduce the damage of implanted DBS hardware. Bipolar stimulation mode limits the path of electrical current that flows around DBS electrode, as opposed to unipolar neurostimulation mode that relies on the patient's tissue to complete the electrical circuit back to the internal pulse generator. We can draw a preliminary conclusion that the bipolar stimulation mode should be advised in patients with unstable angina pectoris to avoid possible current flow from external cardioversion to DBS electrode if needed. In the recently published paper by Sharma et al. [8] three patients with interaction between cardiac pacemakers and DBS pulse generators presenting with cardiac and neurological manifestations have been reported. In this report a 71 year-old man with bilateral DBS pulse generators underwent an external defibrillator for cardiac arrest and suffered defibrillator injury to the right lead and IPG which required revision. Interestingly, in this patient a neurological state deteriorated even after PPM failure. The revision of PPM leads with the replacement of cardiac pacemaker to abdominal wall corrected the cardiac and neurological manifestations.

Moreover, we have identified few reports describing patients with ICDs and DBS systems presenting contradictory findings of possible interference between 2 devices. Rosenow et al. reported a patient with bilateral subthalamic stimulators who underwent successful placement of ICD [4]. Multiple episodes of cardioversion caused by dislodged ICD lead had no effects on the functioning of implanted bilateral DBS electrodes. Even external cardioversion at the intensity of 300 J did not result in DBS hardware failure. Testing both devices over a wide range of settings revealed no interaction. These authors used fully implantable DBS Medtronic system in contrast to DBS system described by Yamamoto et al. [6] In other two case reports the implantation of an ICD in a patient with preexisting bilateral neurostimulators for PD and preexisting unilateral thalamic stimulation for essential tremor revealed no interaction between 2 types of implanted electrical devices [3,7]. On the other hand, Tavarnier et al. [5] reported a patient with a

**Table 1 – The reported cases of external cardioversion or implantation of implantable cardioverter defibrillator in DBS patients presented in chronological order with possible interference between DBS hardware and external or internal cardioversion. Abbreviations: ICD – implantable cardioverter defibrillator, PPM – permanent pacemaker, DBS – deep brain stimulation, IPG – internal pulse generator, Vim – nucleus ventralis intermedius of the thalamus, STN – subthalamic nucleus, B – bilopar, M – monopolar, Bil – bilateral, Sub – subclavicular, PD – Parkinson's disease, ET – essential tremor.**

Author and year of publication	Cardioversion external or implantable cardioverter defibrillator (ICD)	Indication for DBS	Target chosen for DBS	Mode of DBS	Implant side if DBS	Indication for cardioversion or implantation of ICD	Mean follow-up in months	Implant side of ICD or PPM	Complications after cardioversion or between 2 electric devices
Yamamoto et al., 2000 [6]	External cardioversion	Action/kinetic left hand tremor due to thalamic hemorrhage	Right Vim	NR		Paroxysmal atrial fibrillation. External cardioversion performed 2 times at intensity of 100 and 200 J	Approximately 5 years	NA	Thalamotomy like effect, persistent dysesthetic pain due to brain damage around DBS electrode
Tavernier et al., 2000 [5]	ICD tachyarrhythmia	PD 4 months	Bil STN Abdominal	B Reset of DBS settings, and reset to the output Off state	Sub on both sides	Ventricular			
Obwegeser et al., 2001 [3]	ICD	ET	Left Vim	B	Left sub	Heart failure	4 months	Right sub	None interference
Rosenow et al., 2003 [4]	External cardioversion ICD	PD	Bil STN	Right B Left M	Sub on both sides	Ventricular tachycardia with syncope External cardioversion at 300 J Ischemic	NR	Abdominal	None interference
Karimi et al., 2012 [7]	ICD cardiomiopathy	PD NR	Bil STN Abdominal	Right B Left M None interference	Sub on both sides				

**Table 1 (Continued)**

Author and year of publication	Cardioversion external or implantable cardioverter defibrillator (ICD)	Indication for DBS	Target chosen for DBS	Mode of DBS	Implant side if DBS	Indication for cardioversion or implantation of ICD	Mean follow-up in months	Implant side of ICD or PPM	Complications after cardioversion or between 2 electric devices
Sharma et al., 2016 [8]	External cardioversion	PD	Bil STN	NR	Sub on both sides	Cardiac arrest	Approximately 9 years	Repositioning of PPM to abdominal wall	Right DBS lead malfunction and right IPG injury post cardioversion
Presented case	External cardioversion	PD	Left STN	M	Right sub	Cardiac arrhythmia during coronary angioplasty 2 external cardioversions performed 3 times at intensity of 120 (2 times) and 200 J	15 and 21 months	Left sub	IPG failure (first cardioversion) and partial failure of DBS lead (second cardioversion)

life-threatening ventricular tachyarrhythmia with preexisting neurostimulators placed in the anterior chest walls who had an abdominal ICD implanted. Testing both devices revealed that IPGs did not affect bipolar sensing of ICD. Unfortunately, the ICD shock affected both IPGs resetting polarities and the output to the off state. We cannot compare the observations related to ICDs and DBS systems because our patient received PPM for the treatment of a vasovagal syndrome. We have followed the proposed surgical precautions for the simultaneous use of DBS systems and CIEDs. The IPG was implanted on the right side more than 6 inches away from the PPM previously implanted on the left side. Extensive testing of both devices performed by us revealed no interactions as described in the previous case report or the case series. The reported cases of external cardioversion or implantation of implantable cardioverter defibrillator in DBS patients presented in chronological order with a possible interference between DBS hardware and external or internal cardioversion are shown in [Table 1](#).

We would also like to stress that patients with an implanted PPM usually have a coronary artery disease that can rapidly worsen over time resulting in a delayed diagnosis of a myocardial infarction due to DBS, especially when the monopolar stimulation is applied. Monopolar DBS stimulation may strongly interfere with a routine electrocardiogram (ECG) tracings and monitors, which can cause significant problems if the stimulation cannot be turned off in time. Mindermann and Maurer [11] presented a patient that was diagnosed with a myocardial infarction with a delay due to ECG artifacts coming from the monopolar stimulation. According to these authors, bipolar DBS mode interferes less with ECG recordings and enables faster diagnosis of a myocardial infarction in patients with unstable angina pectoris. In our patient, the myocardial infarctions' episodes were diagnosed with ECG recordings that were not disturbed by DBS and measurement of elevated cardiac troponin levels in the blood and a typical chest pain. Choosing bipolar DBS mode in a patient with the diagnosis of unstable angina pectoris may be more appropriate to use in case of a faster recording of ECG tracings characteristic for the myocardial infarction.

#### 4. Conclusion

This case illustrates the feasibility of implanting a DBS system in a patient with previously implanted PPM for vasovagal syndrome. Certain precautions must be taken into account to reduce possible interference between the two devices. Moreover, extensive testing of both devices performed by us revealed no interactions with proper functioning for both of them. We would like to stress that patients with any cardiac disease may unexpectedly deteriorate due to unstable angina pectoris resulting in a heart attack. This situation may require emergent cardiovascular interventions that can cause damage to the implanted DBS hardware. The DBS hardware should be switched off before any emergently performed cardiovascular intervention including cardioversion thus minimizing the risk of damage to the brain glial tissue. Proper management of such patients by an interventional cardiologist and neurosurgeons may reduce some complications when life-saving invasive cardiovascular procedures are needed.

#### Conflict of interest

None declared.

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None declared.

#### Ethics

The work described in this article has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans; Uniform Requirements for manuscripts submitted to Biomedical journals.

#### Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at [doi:10.1016/j.pjnns.2017.05.005](https://doi.org/10.1016/j.pjnns.2017.05.005).

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