Propofol for electrical storm; a case report of cardioversion and suppression of ventricular tachycardia by propofol

[Le propofol et la tempête électrique; l'observation d'un cas de cardioversion et de suppression de la tachycardie ventriculaire par le propofol]

Jessica E. Burjorjee MD, Brian Milne FRCP(C)

Purpose: To present a case report where propofol abolished recurrent ventricular tachycardia (VT) and to suggest a mechanism by which this may have occurred.

Clinical features: A 65-yr-old male was admitted to the intensive care unit (ICU) with electrical storm. Recurrent episodes of VT persisted despite maximal anti-arrhythmic therapy and resulted in a prolonged ICU course and the need for intra-aortic balloon pump support. This was complicated by an ischemic limb, necessitating an anesthetic for femoral thrombectomy. On several occasions while in the ICU, episodes of VT had resolved with boluses of propofol prior to planned cardioversion. In the operating room, episodes of non-sustained VT resolved after a bolus of propofol and remained suppressed for the duration of the case with the use of a propofol infusion.

Conclusion: The effects of propofol on cardiac conduction and on the autonomic nervous system have been studied but its effects on arrhythmias are not well documented. In this case report, propofol was associated with the resolution and suppression of VT. Recent evidence suggests that sympathetic blockade may be an effective treatment for electrical storm. This may be the mechanism by which propofol can abolish this arrhythmia intraoperatively.

Objectif : *Présenter un cas où le propofol a aboli une tachycardie ventriculaire récurrente (TV) et tenter d'expliquer le mécanisme qui a produit cet effet.*

Éléments cliniques : *Un homme de 65 ans a été hospitalisé à l'unité des soins intensifs (USI), victime d'une tempête électrique. Des épisodes récurrents de TV ont persisté malgré un traitement antiarythmique maximal et ont entraîné un traitement prolongé à l'USI et le besoin d'un ballon intra-aortique. La situation s'est compliquée par une ischémie d'un membre, ce qui a nécessité une anesthésie pour thrombectomie fémorale. À quelques reprises, à l'USI, des épisodes de TV ont été traités avec des bolus de propofol avant la cardioversion planifiée. Dans la salle d'opération, des épisodes non soutenus de TV ont été supprimés après un bolus de propofol et sont demeurés ainsi pendant toute la durée de l'intervention avec l'utilisation d'une perfusion de propofol.*

Conclusion : *Les effets du propofol sur la conduction cardiaque et sur le système nerveux autonome ont été étudiés, mais ses effets sur les arythmies ne sont pas encore bien connus. Dans le cas présent, le propofol est associé à la résolution et à la suppression de TV. Des observations récentes portent à croire que le blocage sympathique pourrait traiter efficacement la tempête électrique. C'est peut-être le mécanisme par lequel le propofol peut abolir l'arythmie pendant l'opération.*

ELECTRICAL storm is a syndrome of recurrent ventricular tachycardia (VT) or fibrillation traditionally treated with anti-arrhythmics, implantable cardio-defibrillators and ablation techniques. New evidence has shown that sympathetic blockade may also have a beneficial effect.[1] Many studies have examined the effects of propofol on cardiac conduction and on the autonomic nervous system, yet few describe its effects on arrhythmias. Several case reports have described propofol converting supra-ventricular arrhythmias.[2–4] However, this report describes a case where propofol had an effect on a ventricular arrhythmia and discusses the mechanism by which this may have occurred.

From the Department of Anaesthesiology, Queen's University, Kingston, Ontario, Canada.
Address correspondence to: Dr. Brian Milne, Department of Anaesthesiology, Victory 2, Kingston General Hospital, 76 Stuart Street, Kingston, Ontario K7L 2V7, Canada. Phone: 613-548-3232 ext. 7827; E-mail: milneb@post.queensu.ca
Funding: not applicable.
Accepted for publication April 9, 2002.
Revision accepted August 9, 2002.

Case report

A 65-yr-old male with a recent history of electrical storm presented to the operating room (OR) with an ischemic left leg following intra-aortic balloon pump (IABP) removal for femoral embolectomy and vein patch angioplasty.

His past medical history was significant for ischemic cardiomyopathy secondary to three prior myocardial infarcts, an implantable cardiac defibrillator (ICD) insertion for VT and an unsuccessful VT ablation procedure two years prior.

The current admission was for initially hemodynamically stable VT, which was not terminated by seven anti-tachycardia pacing sequences or by six ICD shocks. His condition deteriorated rapidly and he required multiple external cardioversions, mechanical ventilation, inotropic and IABP support. A transthoracic echocardiogram showed severe dilatation of the left ventricle (LV), severe regional wall motion abnormalities and a LV ejection fraction of 15%. The right ventricle was normal, the left atrium was moderately dilated and mild mitral regurgitation was present.

Over the following ten days in the intensive care unit, he had over 40 episodes of VT and received over 55 shocks despite anti-arrhythmic therapy with amiodarone and procainamide. During this time, it was noted that the patient would have arrhythmias whenever his sedation medications, including combinations of fentanyl, lorazepam, midazolam or propofol, were decreased. In addition, many of these arrhythmias occurred with suctioning, turning and repositioning. Providing propofol boluses of 20–30 mg *iv* prior to nursing care appeared to prevent this from occurring. It was also documented that, on three separate occasions, his VT resolved after propofol 30 mg *iv* was given, prior to the planned cardioversion.

The left limb was noted to be ischemic following IABP removal and he was taken to the OR five hours later. He remained intubated, ventilated, with a central venous line, arterial line and a urinary catheter. External cardioversion pads remained *in situ* as his ICD was inactivated and the pacer set for AAI pacing. His medications included infusions of amiodarone at 120 $mg \cdot hr^{-1}$ and fentanyl at 300 $\mu g \cdot hr^{-1}$ as well as procainamide, lorazepam, cefazolin, ASA, ranitidine, metoclopramide, while heparin and phenylephrine had been held for the preceding nine hours. He had received 180 mg of propofol in six doses for nursing care over the preceding 12 hr with the most recent dose administered 40 min prior to incision.

On arrival to the OR, his vital signs were: blood pressure (BP) 105/45 mmHg, mean arterial pressure 60 mmHg, central venous pressure 12 mmHg, heart rate (HR) 59 $beats \cdot min^{-1}$, temperature 37.7°C, and an O_2 saturation of 97%. His eyelids would flicker in response to his name and stimulation but there were no spontaneous movements. His laboratory investigations were unremarkable. Arterial blood gases showed a pH of 7.40, pO_2 of 106 mmHg, pCO_2 of 34 and HCO_3 of 21. Cardiac enzymes showed elevated creatine kinase with a peak of 4115 $U \cdot L^{-1}$, occurring one week prior to the OR and a borderline troponin T value of 0.071 $ng \cdot mL^{-1}$.

General anesthesia was induced with isoflurane at an end-tidal concentration of 0.47% in 100% oxygen. Prior to incision he received 100 µg of fentanyl and 2 mg of midazolam, while his fentanyl and amiodarone infusions where continued at the prior rates. Muscle relaxants were not utilized and the patient did not respond to surgical stimulus. Approximately ten minutes after skin incision multiple runs of non-sustained VT, ranging from ~5–20 beats in length were observed. Due to his prior history of resolving arrythmias with propofol, 40 mg of propofol *iv* was administered followed by an infusion at 40–50 $ug \cdot kg^{-1} \cdot min^{-1}$. Subsequently, and for the remaining 60 min, there were no further ectopic beats or runs of VT. Throughout the case, BP was stable between 95/60–120/65 mmHg, with a HR between 50–60 $beats \cdot min^{-1}$, SpO_2 99–100%, $ETCO_2$ 32 mmHg and temperature of 36.9°C. The thrombus was removed and blood flow was restored to the ischemic limb.

During his postoperative course, he underwent two electrophysiological studies (EPS) with radiofrequency ablation procedures with transient success in preventing further VT. The final procedure was an EPS guided local alcohol injection ablation procedure to a branch of the posterior descending artery supplying the involved territory. Unfortunately, although the recurrent VT was prevented he went into irreversible cardiogenic shock and died.

Discussion

In this case, the use of propofol was associated with both the conversion and suppression of VT in a patient with electrical storm. Although there have been many studies on the effects of propofol on cardiac conduction, there have only been a few case reports of its clinical effects on arrythmias.

Propofol is a substituted isopropylphenol, short acting general anesthetic agent that acts through its interactions with the gamma-aminobutyric acid receptor. The effects of propofol on the cardiac conduction system have been demonstrated in various animal studies. In guinea pigs, propofol slows the atrial rate and depresses atrioventricular (AV) nodal conduction

predominantly through an M_2-muscarinic receptor mechanism.[5] In pigs, the sinus node and His-Purkinje system functions were depressed but there was no effect on AV node function, or on the conduction of atrial or ventricular tissue.[6] However, in dogs there was no direct effect on the conduction system if complete autonomic blockade was implemented with atropine and propranolol prior to propofol.[7]

In human electrophysiological studies, propofol has been shown to have no direct effect on sinoatrial node activity, intra-atrial or AV conduction.[8,9] Following induction with propofol, the QT interval is prolonged in both children[10] and in adults[11] although this may be due to a reduction in sympathetic stimulation rather than to a direct effect on conduction. Conflicting evidence reveals a shortened QT interval with propofol anesthesia with an unchanged HR adjusted QT interval.[12] A case report also shows elevated defibrillation thresholds associated with the use of propofol during ICD testing.[13]

Although propofol has been shown to have little direct effect on the normal AV conduction system in humans, it has many cardiovascular effects due to its effects on the autonomic nervous system. The increase in heart rate and mean arterial pressure seen with propofol are believed to be due to central vagotonic effects, resetting of baroreflexes[14] and also due to inhibition of sympathetic activity. This has been shown in rats, where propofol decreased BP and HR through its actions on brain stem vasomotor centres leading to decreased sympathetic nerve discharge.[15] In humans, propofol has been shown to decrease peripheral vascular resistance through inhibition of sympathetic vasoconstrictor nerve activity, with similar effect to sympathetic denervation via stellate ganglion blockade.[16] The bradyarrythmias and heart blocks that have been reported in association with propofol are likely explained by an increased sensitivity to parasympathetic stimulus due to the reduction in sympathetic tone.[17,18]

There have also been case reports of utilizing the anti-arrhythmic effects of propofol on patients with supraventricular tachycardia,[2–4] specifically for atrial fibrillation, supraventricular tachycardia and multiple premature atrial beats to produce sinus rhythm. In contrast, case reports describe supraventricular tachycardia deteriorating into VT in a patient receiving propofol,[19] and acceleration of VT following propofol in a patient with a heterotopic cardiac transplant.[20]

The patient in this case report had over 40 episodes of VT during his ten day admission, and meets the accepted definition for electrical storm of two or more episodes of VT or ventricular fibrillation (VF) within a 24-hr period.[21] Although there are many other syndromes which may lead to this state, the most prevalent is due to ischemic heart disease. The abnormal reentrant circuit is initiated and maintained due to the abnormal conduction present in the scarred myocardium. New ischemia, electrolyte abnormalities, metabolic profile, cardiac decompensation and autonomic nervous system input alter the conduction properties of the myocardium and may thus be involved in initiating the arrhythmia.[22] Low HR variability, a marker for a relative increase in sympathetic tone, has been identified as a risk factor for a higher rate of sudden death in these patients. In this particular case, VT occurred more frequently with activities such as repositioning and suctioning that may have increased his endogenous stress, as well as with surgical stimulus.

Many studies have demonstrated that sympathetic blockade by using beta blockers is beneficial in the post myocardial infarction patient. In particular, they have shown a decrease in the incidence of post infarct ventricular arrhythmias.[23] Recent studies (CAST - Cardiac Arrythmia Suppression Trials, SWORD - Survival With Oral D- Sotalol) have shown that the use of prophylactic anti-arrhythmics for asymptomatic ventricular arrhythmias is not indicated and may be harmful. Acute treatment for the patient with ischemic cardiomyopathy and ventricular arrhythmias includes maximal therapy for congestive heart failure and ischemia with beta blockers and angiotensin converting enzyme inhibitors, whereas long term treatment for patients with inducible VT should include an ICD (MADIT - Multicenter Automatic Defibrillator Implantation Trial, MUSST - Multicenter Unsustained Tachycardia Trial). Optimal anti-arrhythmic treatment of patients receiving multiple shocks from an ICD for electrical storm has not been as clearly defined, although adrenergic blockade is suggested.[24]

Increased sympathetic activation has been implicated in the generation of electrical storm whereas sympathetic blockade has been shown to prevent VF and sudden death. Thus a recent study compared sympathetic blockade for the treatment of ventricular storm to standard advanced cardiac life support (ACLS) guided therapy.[1] Sympathetic blockade with left stellate ganglion blockade, esmolol or propranolol significantly reduced both the number of VT/VF episodes and the mortality rate, when compared to those receiving ACLS anti-arrhythmics (lidocaine, procainamide or bretylium, amiodarone). In this study, sympathetic blockade, either at adrenergic receptors or by sympathectomy effectively suppressed ventricular arrythmias. Other sympatholytic treatments, such as the alpha (2) agonist clonidine[25] and thoracic epidural anesthesia,[26,27] have been shown to have similar anti- arrhythmic effects in animal models and in humans.

In our patient propofol was associated with both conversion of VT and suppression of further ventricular arrythmias. Although propofol has been shown to have few direct effects on the human cardiac conduction system it has been previously shown to abolish sympathetically mediated tone. Sympathetic activation has been implicated in the pathogenesis of ventricular arrhythmias, while sympathetic blockade has been shown to be effective in the treatment of electrical storm. It is possible then that the anti-arrhythmic effects of propofol, as seen in this case were due to the reduction in sympathetic tone.

References

1 *Nademanee K, Taylor R, Bailey WE, Rieders DE, Kosar EM.* Treating electrical storm. Sympathetic blockade versus advanced cardiac life support–guided therapy. Circulation 2000; 102: 742–7.

2 *Miro O, de la Red G, Fontanals J.* Cessation of paroxysmal atrial fibrillation during acute intravenous propofol administration (Letter). Anesthesiology 2000; 92: 910.

3 *Hermann R, Vettermann J.* Change of ectopic supraventricular tachycardia to sinus rhythm during administration of propofol. Anesth Analg 1992; 75: 1030–2.

4 *dos Santos JET.* Propofol suppresses premature atrial contractions during anesthesia (Letter). Pediatr Cardiol 1998; 19: 272.

5 *Alphin RS, Martens JR, Dennis DM.* Frequency-dependent effects of propofol on atrioventricular nodal conduction in guinea pig isolated heart. Mechanism and potential antidysrhythmic properties. Anesthesiology 1995; 83: 382–94.

6 *Pires LA, Huang SKS, Wagshal AB, Kulkarni RS.* Electrophysiological effects of propofol on the normal cardiac conduction system. Cardiology 1996; 87: 319–24.

7 *Ikeno S, Akazawa S, Shimizu R, et al.* Propofol does not affect the canine cardiac conduction system under autonomic blockade. Can J Anesth 1999; 46: 148–53.

8 *Sharpe MD, Dobkowski WB, Murkin JM, Klein G, Yee R.* Propofol has no direct effect on sinoatrial node function or on normal atrioventricular and accessory pathway conduction in Wolff-Parkinson-White Syndrome during alfentanil/midazolam anesthesia. Anesthesiology 1995; 82: 888–95.

9 *Lavoie J, Walsh EP, Burrows FA, Laussen P, Lulu JA, Hansen DD.* Effects of propofol or isoflurane anesthesia on cardiac conduction in children undergoing radiofrequency catheter ablation for tachydysrhythmias. Anesthesiology 1995; 82: 884–7.

10 *Saarnivaara L, Hiller A, Oikkonen M.* QT interval, heart rate and arterial pressures using propofol, thiopentone or methohexitone for induction of anaesthesia in children. Acta Anaesthesiol Scand 1993; 37: 419–23.

11 *Lischke V, Wilke HJ, Probst S, Behne M, Kessler P.* Prolongation of the QT-interval during induction of anesthesia in patients with coronary artery disease. Acta Anaesthesiol Scand 1994; 38: 144–8.

12 *Kleinsasser A, Kuenszberg E, Loeckinger A, et al.* Sevoflurane, but not propofol, significantly prolongs the Q-T interval. Anesth Analg 2000; 90: 25–7.

13 *Cohen TJ, Chengot T, Quan C, Peller AP.* Elevation of defibrillation thresholds with propofol during implantable cardioverter-defibrillator testing. J Invasive Cardiol 2000; 12: 121–3.

14 *Ebert TJ, Muzi M.* Propofol and autonomic reflex function in humans. Anesth Analg 1994; 78: 369–75.

15 *Krassioukov AV, Gelb AW, Weaver LC.* Action of propofol on central sympathetic mechanisms controlling blood pressure. Can J Anaesth 1993; 40: 761–9.

16 *Robinson BJ, Ebert TJ, O'Brien TJ, Colinco MD, Muzi M.* Mechanisms whereby propofol mediates peripheral vasodilation in humans. Sympathoinhibition or direct vascular relaxation? Anesthesiology 1997; 86: 64–72.

17 *Deutschman CS, Harris AP, Fleisher LA.* Changes in heart rate variability under propofol anesthesia: a possible explanation for propofol-induced bradycardia. Anesth Analg 1994; 79: 373–7.

18 *Sochala C, Van Deenen D, De Ville A, Govaerts MJM.* Heart block following propofol in a child. Paediatr Anaesth 1999; 9: 349–51.

19 *Munoz R, Goldberg ME, Cantillo J, Subramoni J, Nemiroff MS.* Perioperative arrhythmias with a propofol- based anesthetic. J Clin Anesth 1991; 3: 149–52.

20 *Jayamaha JEL, Dowdle JR.* Acceleration of ventricular tachycardia following propofol in a patient with heterotopic cardiac transplant. Cardioversion of ventricular tachycardia in the native heart. Anaesthesia 1993; 48: 889–91.

21 *Dorian P, Cass D.* An overview of the management of electrical storm. Can J Cardiol 1997; 13(Suppl A): 13A–7A.

22 *Saliba WI, Natale A.* Ventricular tachycardia syndromes. Med Clin N Am 2001; 85: 267–304.

23 *Gottlieb SS, McCarter RJ, Vogel RA.* Effect of beta-blockade on mortality among high-risk and low-risk patients after myocardial infarction. N Engl J Med 1988; 339: 489–97.

24 *Credner SC, Klingenheben T, Mauss O, Sticherling C, Hohnloser SH.* Electrical storm in patients with transvenous implantable cardioverter-defibrillators. Incidence, management and prognostic implications. J Am Col Cardiol 1998; 32: 1909–15.

25 *Arnar DO, Xing D, Lee H, Martins JB.* Prevention of ischemic ventricular tachycardia of Purkinje origin: role

for alpha(2)-adrenoceptors in Purkinje? Am J Physiol Heart Circ Physiol 2001; 280: H1182–90.

26 *Meissner A, Eckardt L, Kirchhof P, et al.* Effects of thoracic epidural anesthesia with and without autonomic nervous system blockade on cardiac monophasic action potentials and effective refractoriness in awake dogs. Anesthesiology 2001; 95: 132–8.

27 *Scott NB, Turfrey DJ, Ray DAA, et al.* A prospective randomized study of the potential benefits of thoracic epidural anesthesia and analgesia in patients undergoing coronary artery bypass grafting. Anesth Analg 2001; 93: 528–35.