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# Total Intravenous Anesthesia for a Child with Congenital Long QT Interval Syndrome

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**Abstract**

We managed a male infant (1 year 9 months old, 87 cm, 13.2 kg) who was diagnosed with congenital long QT interval syndrome just after birth. Markedly long QT (QTc interval, 700 msec) was shown in electrocardiogram findings, and frequent torsades de pointes-type ventricular arrhythmia and non-sustained ventricular tachycardia were observed from birth. He was administered a combination of mexiletine and propranolol, after which arrhythmia disappeared and the QTc interval became stable at 420-450 msec. For ophthalmic surgery, we conducted total intravenous general anesthesia with remifentanil and propofol using laryngeal mask airway management. During the operation, HR was 100-110 bpm and non-invasive blood pressure was 80-100/35-40 mmHg, while the QTc interval was 460 msec without further QT lengthening.

**Key words;** congenital long QT interval syndrome, torsades de pointes type ventricular arrhythmia, total intravenous anesthesia, propofol, remifentanil

## Introduction

Congenital long QT syndrome (CLQTS) is an electrocardiographic entity that causes predisposed individuals to develop harmful and life-threatening ventricular arrhythmias, such as nonsustained ventricular tachycardia (NSVT), torsade de pointes (TdP)[1] and cardiac arrest[2]. Additionally, prolongation of the QT interval is strongly associated with sudden infant death syndrome[3].

Herein, we report perioperative anesthetic management for an infant diagnosed with severe CLQTS (QTc interval 700 msec) and TdP immediately after birth.

## Case presentation

The subject was a male infant aged 1 year 9 months (87 cm, 13.2 kg). Arrhythmia was noted in an electrocardiographic examination at the gestational age of 38 weeks. His mother was hospitalized at the gestational age of 39 weeks and she gave birth by vaginal delivery on the next day (infant body weight was 3,670 g; Apgar scores, 9 after 1 minute and 9 after 5 minutes). Electrocardiography findings just after birth revealed that the neonate had a prolonged QTc interval.

Following admission to the heart center, the infant had a heart rate (HR) of 160 bpm and regular sinus rhythm. The QTc interval was prolonged markedly at 700 msec. It was speculated that long QT interval syndrome (LQTS) was present and a genetic diagnosis confirmed type 3 LQT. Immediately after diagnosis, the patient was given 2 mg/kg of mexiletine intravenously, after which the QTc interval was shortened to 571 msec. Subsequently, a continuous intravenous infusion of 0.7 mg/kg/hour of mexiletine was started. Although PVC occurred sporadically even after the start of medication, life-threatening arrhythmia such as TdP did not appear. However, TdP was suddenly observed for 3 seconds at 14 days

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after birth when the infant cried strongly. Since mexiletine was increased to 1.2 mg/kg/hour and oral administration of propanolol (1 mg/kg/day) was added, TdP and disappeared and the QTc interval became stabilized at 420–450 msec. As a result, the patient was discharged from the hospital at 3 months of age.

Surgery was considered necessary for a hyperkinetic oblique of the right eye and a retrodisplacement procedure under general anesthesia was planned. Preoperative ultrasonography revealed no abnormal findings. In the 24-hour Holter ECG findings (**Fig. 1**), total HR was 208,342/day, with maximum HR at 234/minute, minimum HR at 111/minute, and mean HR at 150/minute. PVC originated at 2 focuses and occurred 8 times/day. There were no abnormalities found in a preoperative blood biochemical and electrolyte examination, and no arrhythmia in electrocardiography findings. The QTc interval was 450 msec. He continued to receive mexiletine at 25 mg/kg/day and propranolol at 1.3 mg/kg/day orally and blood levels of those drugs were controlled favorably within therapeutic ranges.

The patient was given midazolam syrup orally (6 mg) as premedication and the patient was admitted to the operating room in a drowsy state. At that time, percutaneous oxygen saturation ($SpO_2$) was 99%, HR was 110 bpm, and QTc interval was 460 msec in lead II findings. A peripheral infusion route was secured under oxygen-nitrous oxide (67%) inhalation, then remifentanil at 0.5 μg/kg/minute was started under a 100% oxygen mask. Two minutes later, propofol at 2 mg/kg was administered intravenously and then continuous infusion of propofol at 5 mg/kg/hour was started. Since HR was 100 bpm and no QT interval lengthening was observed, a laryngeal mask airway (LMA) ProSeal™ #2 (PLMA; LMA North America, San Diego, CA, USA) was inserted without using a muscular relaxant, at which time there were no changes in HR or QT interval. During surgery, total intravenous anesthesia (TIVA) was maintained using oxygen at 1 L/minute, air at 2 L/minute, remifentanil at 0.25 μg/kg/minute, and propofol at 5 mg/kg/hour. Just before the end of surgery, 20 μg of fentanyl was administered intravenously.

The surgery was completed in 25 minutes, with 65 minutes of anesthesia. There was no occurrence of arrhythmia associated with sympathetic nerve stimulation caused by LMA insertion and removal, nor bra-

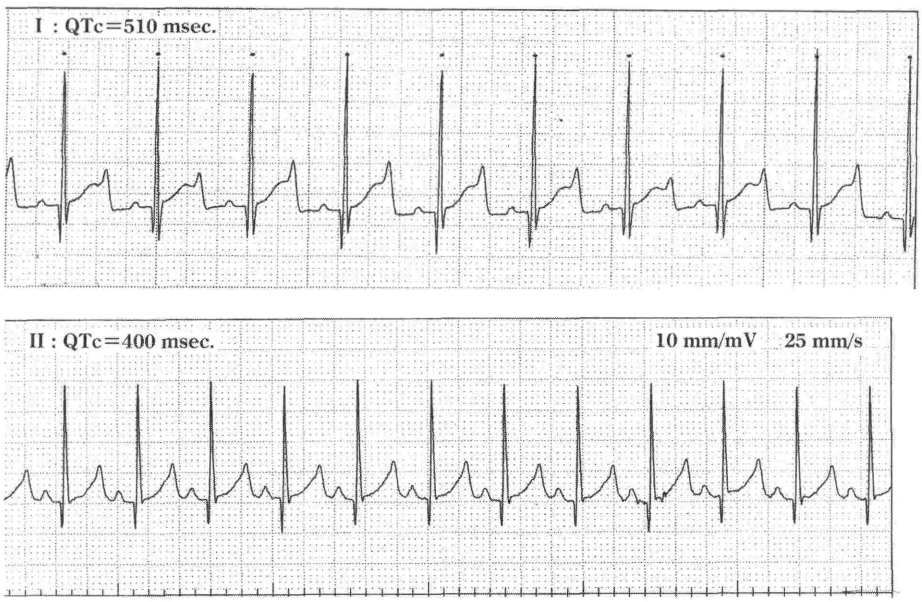


**Figure 1 ECG findings.**
I : 30 days after birth (oral administration of mexiletine plus propranolol).
II : 2 days before operation.

dycardia due to the use of intravenous anesthetics or oculocardiac reflex.

## Discussion

CQTLS is an autosomal dominant type genetic disorder that develops from a mutation of the ion channel (sodium, potassium and calcium channel) and is responsible for repolarization of the ventricular muscle[4], as well as genes of the membrane and receptor protein. Thus far, 10 genotypes have been reported[5], of which LQT1, LQT2, and LQT3 have been found in more than 90% of cases. The present patient was classified as LQT3 type. As for clinical findings, patients with LQT1 and LQT2 tend to frequently show cardiac events, such as syncopal attack and cardiac arrest, at the time of sympathetic nerve stimulation[6], whereas LQT3 patients frequently suffer from seizures during sleeping and resting. Moreover, the lifelong rate of incidence is low in LQT3 patients, though the fatality rate is high. Accordingly, pharmacotherapy is indispensable, with mexiletine (class Ib antiarrhythmic) the first choice and a $\beta$-blocker (class IV antiarrhythmic) added when the effect is not sufficient. A pacemaker with defibrillator is sometimes surgically implanted as a treatment for patients with ventricular arrhythmias or bradycardia[7,8].

Problems with anesthetic management for LQTS include evaluation of the effects of preoperative pharmacotherapy using antiarrhythmic agents, and avoidance of invasive anesthetic procedures[6] and agents that facilitate QT prolongation[8]. In the present patient, arrhythmia had been noted since the prenatal period and a markedly long QTc interval of 700 msec was seen in ECG findings immediately after birth. Moreover, he was classified as severe type LQTS, as he had multiform PVC, NSVT, and frequent TdP. By electrolyte management and pharmacotherapy with mexiletine and a propranolol for 3 months, LQT was improved and arrhythmia disappeared. However, even in CLQTS cases favorably controlled before surgery, such as the present patient, anesthetic procedure and surgical stimulation, especially tracheal intubation/extubation, can potentially induce fatal ventricular arrhythmia, TdP[1], and cardiac arrest[2]. The present operation was a minor surgery and the airway management was able to be maintained by a LMA, which can be easily inserted without using a muscle relaxant and this procedure causes much less sympathetic nerve stimulation, which induces arrhythmia.

Management of TdP is very important. Related episodes may be short-lived and lead to life-threatening ventricular arrhythmia, while long bursts may cause severe hemodynamic compromise and can degenerate into ventricular fibrillation. Short-term control of recurrence can be achieved with magnesium sulphate[9], even if the serum level is normal, or temporary pacing, which is effective for controlling TdP if intravenous administration of magnesium is ineffective.

Among nitrous oxide and inhalation anesthetics[10~14], such as halothane, enflurane, isoflurane, and sevoflurane, have been recognized to influence the duration of the QT interval. Recent studies have also demonstrated that anesthesia with isoflurane prolongs the QT interval in contrast to halothane, which shortens that interval. Ventricular arrhythmia occurring after inhalation of sevoflurane decreases when the effect of sevoflurane diminishes in case of TdP[14]. All 4 of these volatile agents have been used uneventful, in known LQTS patients who were taking $\beta$-blocker drugs[15~17], though sevoflurane further prolongs QTc. On the other hand, enflurane and isoflurane have also been shown to cause TdP in LQTS patients receiving $\beta$-blockers whose anesthetics were complicated by TdP.

Intravenous anesthetics have less effects on QT interval[18]. Propofol appears to be potentially beneficial with respect to QTc interval in individuals at high risk of developing TdP, based on its use in 3 patients with LQTS undergoing insertion of an implantable cardioverter defibrillator after midazolam premedication[8,19], which suggests that it is worthy of further study. Propofol may prolong QT interval in healthy, premedicated adults and children, though some inves-

tigators found no effect on QTc interval[18,19]. Very limited clinical experience suggests that propofol may be useful in patients with LQTS, as it can be used for maintenance of anesthesia, while electrophysiological evidence of a beneficial effect on transmural dispersion of repolarization would be very helpful in confirming its suitability and antiarrhythmic effect. Also, midazolam alone has no effect on QTc in healthy adults[20]. Remifentanil has strong analgesic properties with a short effect duration, and is considered to be a narcotic agent with no or an extremely low effect on QT interval, such as fentanyl[21,22].

Among the neuromuscular blockage in common use, only succinylcholine[23] consistently prolongs QTc interval. Vecuronium has also been used in several LQTS patients, with the rationale being its lack of autonomic effects. Anticholinesterases and anticholinergic agents have major serious side-effects, and atropine and glycopyrrolate prolong QT interval in healthy individuals[24]. Administration of atropine was reported to precipitate TdP in a patient with LQTS. In contrast, there are no known reports of neostigmine given in isolation to reverse neuromuscular block, thus its true effect is unknown, though it seems that the inevitable resultant bradycardia would be undesirable, given the pause dependency of some forms of LQTS. Overall, until additional information is available, reversal of neuromuscular block in known LQTS patients is probably best avoided whenever possible.

In conclusion, we experienced an extremely rare case of anesthetic management for a child with CLQT. The important points are preoperative treatment for arrhythmia and evaluation of its efficacy using 24-hour Holter ECG, and minimal use of invasive anesthetic procedures and drugs that induce QT prolongation.

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