Anaesthesia for left thoracoscopic sympathectomy for refractory long QT syndrome: three case reports

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Introduction

Long QT syndrome (LQTS) is caused by malfunction of cardiac ion channels impairing ventricular repolarisation. This can be congenital or acquired. Age of presentation can be anywhere from in utero to adulthood. The stress of anaesthesia and surgery can predispose to the development of the polymorphic ventricular tachycardia torsade de points and some drugs used during anaesthesia can prolong the QT interval. This may either revert spontaneously back to sinus rhythm causing syncope or degenerate to ventricular fibrillation causing sudden death. There is evidence that the left stellate ganglion is dominant, and therefore it has been the focus of attention. About 30% of the affected population fail to respond to medical treatment and remain symptomatic. Hence thoracoscopic denervation techniques have been tried.

Therapeutic options for patients with LQTS include β-blockade calcium channel blockers, implantable cardioverter defibrillators (ICDs) and left cardiac sympathetic denervation (LCSD). For patients who continue to have cardiac events while taking β-blockers, receiving frequent shocks from ICDs or are unable to tolerate pharmacotherapy, LCSD is another therapeutic option.

Left cardiac sympathetic denervation (LCSD), a modification of the left stellactomy, is a proven alternative for high-risk patients. The procedure involves an inferior stellate ganglionectomy and ganglionectomy of the upper 4 or 5 thoracic ganglia as shown in Figure 1. Newer techniques include using thoracoscopic sympathectomy while leaving the upper stellate ganglion intact to minimise the risk of causing Horner syndrome. In a retrospective study, Schwartz et al. showed a dramatic > 90% decrease in the yearly number of cardiac events per patient following LCSD. Collura et al. published the Mayo Clinic experience with videoscopic LCSD in 20 paediatric and adult patients. Appropriate ICD shocks have been completely eliminated so far in 8 of 11 patients who presented with a history of ICD shocks or aborted cardiac arrest. One patient, who received 15 ICD shocks in the year prior to surgery, has had only one shock in the 36 months since her procedure. The two remaining patients have had less successful results with a minimal reduction in the frequency of cardiac events/ICD shocks postoperatively. The mean follow-up time was 16.6 ± 9.5 months. In their study found no major perioperative complications. Longer-term follow-up was available in 22 of 24 patients at a median follow-up of 28 months (range, 4–131 months). Sixteen (73%) of the 22 patients experienced a marked reduction in their arrhythmia burden, with 12 (55%) becoming completely arrhythmia free after sympathectomy. Six (27%) of the patients were nonresponsive to treatment; each had persistent symptoms at follow-up and concluded that video-assisted thoracoscopic left cardiac sympathetic denervation can be safely and effectively performed in most patients with life-threatening ventricular arrhythmias. This minimally invasive procedure is a promising adjunctive therapeutic option that achieves a beneficial response in most symptomatic patients. These results support the inclusion of thoracoscopic cardiac sympathetic denervation within the treatment armamentarium in all patients with ventricular arrhythmias refractive to conventional medical therapy.

In the present article, we report our experience and review the literature to summarise outcomes of thoracoscopic sympathectomy in two children and a young adult. Videothoracoscopic surgery has become increasingly popular for cervical sympathectomy. This procedure is performed under general anaesthesia, with the use of double lumen tube (DLT) orotracheal intubation or endobronchial intubation with the patient in the right lateral decubitus position.

Case report

History and presentation

Three patients, two of whom were children — a male aged 14 years and a female aged 4 years — and an adult female aged 24 years were diagnosed with LQTS. The 14-year-old male and the 24-year-old female were siblings with autosomal dominant inheritance, dental abnormalities, clinodactyly, and bidirectional VT with long QT. The 4-year-old female child was a sporadic case who was diagnosed after the child repeatedly clenched her chest

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while crying or under stressful conditions and had history of seizures and sensorineural deafness. Several different genetic mutations have been implicated in causing LQTS, and most are inherited in an autosomal dominant pattern. Rarely, patients present with a prolonged QT interval in association with congenital deafness, also known as Jervell and Lange-Nielsen syndrome (JLNS). JLNS is inherited in an autosomal recessive pattern.

Table 1 gives a brief summary of the symptoms and outcome of the patients after thoracoscopic sympathectomy.

### Anaesthetic management
Evaluation of patients was done, which included a detailed history, routine laboratory investigations and a complete cardiac and neurological workup. The patients were deemed fit for surgery by a combined team of specialists that included the cardiologist, cardiothoracic surgeon, paediatrician, anaesthetist and general surgeon who were involved in the management and workup of these patients. The procedure was explained to all patients and written informed consent was taken from the patient or, in the case of children, the patient’s parents. Preoperative fasting guidelines were followed as per the age of the patient and medications were continued following the cardiologist’s advice.

On arrival in the operating theatre, all three patients were secured with intravenous cannulae appropriate for their age. Intravenous fluid infusions were initiated. Monitors connected which included five-lead electrocardiography (ECG), noninvasive blood pressure (NIBP) monitoring and pulse oximetry for oxygen saturation monitoring. All patients were premedicated with 2 μg/kg fentanyl and 0.02 mg/kg midazolam. They were preoxygenated with 100% oxygen for five minutes. Induction was done with propofol 2 mg/kg and neuromuscular blockade was achieved with rocuronium 1 mg/kg. After complete muscle relaxation, the 24-year-old female patient and 14-year-old male patient were intubated with 32 Fr DLT and the 4-year-old female patient was intubated with a 4.5 uncuffed tube which was initially fixed at 14 cm but once single lung ventilation was required was repositioned and pushed to the right bronchus fixing at 18 cm at the angle of the mouth.

Once intubated, end tidal carbon dioxide (ETCO₂), temperature and urine output monitoring was done. Invasive arterial blood pressure was monitored after securing an age-appropriate adequate size arterial cannula for each patient. Central venous cannulation was also established for all three patients. External defibrillator pads were secured in all patients. Once this was done, the patient was put in the right lateral position. Anaesthesia was maintained with N₂O, O₂, isoflurane 1% and intermittent doses of vecuronium as per requirement.

Surgery was performed via a left-sided video-assisted thoracoscopic approach as seen in Figure 2.

The lung was collapsed so that the sympathetic chain could be viewed. Gas insufflation of the thoracic cavity was not done in any of the three cases. All three surgeries were uneventful and vitals were stable throughout the procedure. Figure 3 shows the intraoperative vitals of the 14-year-old male child.

All three patients were extubated at the end of the procedure after neuromuscular blockade reversal with neostigmine 0.05 mg/kg and 0.01 mg/kg glycopyrrolate. None of the patients needed to be defibrillated or cardioverted during surgery. All patients were shifted to the high-dependency unit postoperatively where adequate monitoring was carried out.

Postoperatively, analgesia was provided with i.v. opioids. The 4-year-old female patient had one run of ventricular tachycardia three hours following surgery for which a lignocaine infusion was started and stopped after two days, following which no similar episodes recurred. The other two patients had no further arrhythmias.

All three patients had relief of symptoms and remained asymptomatic even after nine months of follow-up.

Schwartz et al. report the largest data set available on LCSD, one of the three modalities of treatment for LQTS. The main findings were that LCSD significantly reduced the frequency and occurrence of both syncope and cardiac arrest; that among

### Table 1: Summary of cases of LQTS treated with video assisted thoracoscopic sympathectomy

| Age (years)/sex | Indications/ symptoms | Internal defibrillator in situ | Preoperative medications | Duration of symptoms | Syndrome | Complication |
|-----------------|-----------------------|-------------------------------|--------------------------|----------------------|----------|--------------|
| 24/F            | Palpitations, syncope, pseudo seizures, family history | No | Beta blocker | 2 years | Anderson–Tawil* | No |
| 14/M            | Palpitations, breathlessness, family history | No | Beta blocker | 3 months | Anderson–Tawil* | No |
| 4/F             | Recurrent VT, pseudo seizures | No | Beta blocker, Lignocaine infusion | 1 month | Jervell and Lange-Nielsen** | One run of VT 3 hours after surgery |

*Micrognathia, clinodactyly, ventricular arrhythmias, low-set ears.
**Prolonged QT, severe bilateral sensorineural deafness.
patients with only syncope before surgery, the five-year postoperative cumulative probability of aborted cardiac arrest (ACA) or sudden death (SD) was 11% and actual survival at five years was 97%. The five-year survival for the entire group, including preoperative ACA, was 95%. In addition, LCSD was associated with significant shortening of the QTc.

Discussion
Hughes\(^{14}\) reported the first endoscopic thoracic sympathectomy in 1942. In 1954, Kux\(^{15}\) reported his experience of more than 1400 procedures. However, it has become more popular since the introduction of video endoscopic techniques into surgery in the 1980s.

In the most recent article by Costello et al., following their retrospective review of paediatric patients with ion-channelopathies, the authors suggest that a prospective comparison needs to be done between surgical management and cardio-defibrillator use, which implies that we do not yet know enough to recommend LCSD as sole management strategy.\(^{24}\)

Preoperatively, these patients may be on \(\beta\)-blocker therapy, may have implantable cardioverter defibrillators (ICD)\(^{6}\) or have permanent pacemakers. Moss et al.\(^{11}\) found a significant reduction in the mean rate of cardiac events with \(\beta\)-blocker therapy. Although \(\beta\)-blockade helps reduce the incidence of cardiac events, it is not entirely effective in preventing torsade de pointes and sudden death in LQTS.

Anaesthesia in patients with untreated LQTS carries a very high risk of intraoperative malignant ventricular arrhythmias,\(^{17-19}\) which may prove refractory to treatment. The practical considerations of anaesthesia for patients with LQTS therefore include immediate management of torsade de pointes, and, in known cases, avoidance of factors that increase the risk of precipitating torsade de pointes. Inadequate or light plane of anaesthesia, hypertension, bradycardia, tachycardia, hypoxaemia and hypocapnia or hypercapnia must be avoided because they all potentially affect repolarisation of the cardiac myocyte and increase sympathetic tone, which can precipitate these arrhythmias. Patients should have adequate pain relief to avoid any stress response. Patients should be monitored throughout the perioperative period in a calm and quiet environment, and special attention should be paid to monitoring the QT interval.

There are various techniques of intubation for thoracoscopic sympathectomy. The commonly performed techniques are single-lumen endotracheal intubation with or without intrathoracic CO\(_2\) insufflation. The advantage of this technique is familiarity with the technique and avoidance of the hazards of tube misplacement. One disadvantage is lung deflation, and surgical access may be less successful than with lung isolation techniques. The other is double-lumen endobronchial intubation with or without intrathoracic CO\(_2\) insufflation. The advantage of this technique is good lung isolation if correctly positioned. The disadvantage is the risk of tube malposition.\(^{20}\)

While anaesthetising these patients consideration must be given to avoid drugs that prolong QT interval, in order to decrease the chances of precipitating malignant arrhythmias and torsade de pointes.

A review article published in the British Journal of Anaesthesia in 2014 by Staikou et al.\(^{25}\) discussed the effects of anaesthetic agents on the QT interval and torsadogenicity, particularly in patients with LQTS. All volatiles, especially isoflurane and desflurane, have been found to prolong QTc, while sevoflurane probably has no effect on TDR. Among the intravenous agents, propofol seems to be superior due to its minimal effects on QTc and TDR; in fact, a decrease in QTc has been demonstrated in many studies. Regarding opioids, fentanyl, alfentanil and remifentanil produced no effects on QTc, while sufentanil, at high doses, may induce QT prolongation. Succinylcholine, but not the non-depolarising neuromuscular blockers, produces QTc prolongation, which can be attenuated by opioids and beta blockers. Reversal of neuromuscular block with anticholinesterase–anticholinergic combinations has been associated with significant QTc prolongation, while such an
effect has not been demonstrated for sugammadex, even at high doses. Local anaesthetics probably have no intrinsic action on duration of repolarisation; nevertheless, an extensive subarachnoid sympathetic block may increase the duration of QTc. Conversely, thoracic epidural anaesthesia has been associated with a decrease in both QTc and TDR. Among adjuvants, midazolam seems to have no effect on QTc and TDR, while commonly used anetiemics, such as droperidol, domperidone and most 5-HT3 antagonists, produce significant QT prolongation. For patients with pre-existing repolarisation abnormalities, the effects of anaesthetic drugs and techniques on electrocardiographic conduction should be considered in the perioperative management.21

Conclusion
Long QT syndrome (LQTS) is being recognised with increasing frequency among the general population. It requires special attention and careful management in the perioperative period. The existing literature provides some insight into management of these patients. However, there are no definitive guidelines for anaesthetic management of LQTS. The results of this case report suggest that left thoracoscopic sympathectomy is a safe and effective approach for treating patients with LQTS.

References
1. Ackerman MJ. Cardiac channelopathies: it’s in the genes. Nat Med. 2004;10:463–4. http://dx.doi.org/10.1038/nm0504-463
2. Crampton RS. Preeminence of the left stellate ganglion in the long-QT syndrome. Circulation. 1979;59:769–78. http://dx.doi.org/10.1161/01.CIR.59.4.769
3. Schwartz PJ, Locati EH, Moss AJ, et al. Left cardiac sympathetic denervation in the therapy of congenital long QT syndrome. A worldwide report. Circulation. 1991;84:503–11.
4. Schwartz PJ, Snebold NG, Brown AM. Effects of unilateral cardiac sympathetic denervation on the ventricular fibrillation threshold. Am J Cardiol. 1976;37:1034–40. http://dx.doi.org/10.1006/jace.1996.0022-9149(76)90020-3
5. Epstein AE, Rosner MJ, Hageman GR, et al. Posterior left thoracic cardiac sympathectomy by surgical division of the sympathetic chain: an alternative approach to treatment of the long QT syndrome. Pacing Clin Electrophysiol. 1996;19:1095–104. http://dx.doi.org/10.1111/j.1540-8159.1996.tb05326.x
6. Groh WJ, Silka MJ, Oliver RP, et al. Use of implantable cardioverter-defibrillators in the congenital long QT syndrome. Am J Cardiol. 1996;78:703–6. http://dx.doi.org/10.1016/S0002-9149(96)00403-3
7. Li J, Liu Y, Yang F, et al. Video-assisted thoracoscopic left cardiac sympathetic denervation: a reliable minimally invasive approach for congenital long-QT syndrome. Ann Thorac Surg. 2008;86:655–8. http://dx.doi.org/10.1016/j.athoracsur.2007.08.100
8. Lloyd R, Okada R, Stagg J, et al. The treatment of recurrent ventricular tachycardia with bilateral cervico-thoracic sympathetic-ganglionectomy. A report of two cases. Circulation. 1974;50:382–8.
9. Moss AJ, Liu JE, Gottlieb S, et al. Efficacy of permanent pacing in the management of high-risk patients with long QT syndrome. Circulation. 1991;84:1524–9. http://dx.doi.org/10.1161/01.CIR.84.4.1524
10. Moss AJ, McDonald J. Unilateral cervicothoracic sympathetic ganglionectomy for the treatment of long QT interval syndrome. N Engl J Med. 1971;285:903–4. http://dx.doi.org/10.1056/NEJM197110142851607
11. Moss AJ, Zareba W, Hall WJ, et al. Effectiveness and limitations of beta-blocker therapy in congenital long-QT syndrome. Circulation. 2000;101:616–23. http://dx.doi.org/10.1161/01.CIR.101.6.616
12. Reardon PR, Matthews BD, Scarborough TK, et al. Left thoracoscopic sympathectomy and stellate ganglionectomy for treatment of the long QT syndrome. Surg Endosc. 2000;14:86–7.
13. Schwartz PJ, Priori SG, Cerrone M, et al. Left cardiac sympathetic denervation in the management of high-risk patients affected by the long-qt syndrome. Circulation. 2004;109:1826–33. http://dx.doi.org/10.1161/01.CIR.0000125523.14403.1E
14. Hughes J. Endothoracic sympathectomy. Proc R Soc Med. 1942;35:585–6.
15. Kux E. Thorakokoskopische Eingriffe in Nervensystem. Stuttgart: George Thieme Verlag; 1954.
16. Adu-Gyam Y, Said A, Chowdhary UM, et al. Anaesthetic induced ventricular tachyarrhythmia in Jervell and Lange-Nielsen syndrome. Can J Anaesth. 1991;38:345–6. http://dx.doi.org/10.1007/BF03007627
17. Brown M, Libarthson RR, Ali HH, et al. Perioperative management of a patient with long QT syndrome (LQTS). Anesthesiology. 1981;55:586–9. http://dx.doi.org/10.1097/00000542-198111000-00020
18. Das SN, Kiran U, Saxena N. Perioperative management of long QT syndrome in a child with congenital heart disease. Acta Anaesthesiol Scand. 2002;46:221–3. http://dx.doi.org/10.1034/j.1399-6576.2002.460219.x
19. Benumof JL. The position of double-lumen tubes should be routinely determined by fiberoptic bronchoscopy. J Cardiothorac Vasc Anesth. 1993;7:513–4. http://dx.doi.org/10.1016/1053-0770(93)90303-3
20. Collura CA, Johnson JN, Moir C, et al. Left cardiac sympathetic denervation for the treatment of long QT syndrome and catecholaminergic polymorphic ventricular tachycardia using video-assisted thoracic surgery. Heart Rhythm. 2009;6:752–9. http://dx.doi.org/10.1016/j.hrthm.2009.03.024
21. Goldberg I, Moss AJ. Long QT Syndrome. J Am Coll Cardiol. 2008;51:2291–300. http://dx.doi.org/10.1016/j.jacc.2008.02.068
22. Jervell A, Lange-Nielsen F. Congenital deaf-mutism, functional heart disease with prolongation of the Q-T interval and sudden death. Am Heart J. 1957;54:59–68. http://dx.doi.org/10.1016/S0002-7164(76)90079-0
23. Hofferberth SC, Cecchin F, Loberman D, Fynn-Thompson F. Left thoracoscopic sympathectomy for cardiac denervation in patients with life-threatening ventricular arrhythmias. J Thorac Cardiovasc Surg. 2014 Jan;147(1):404–9. http://dx.doi.org/10.1016/j.jtcvs.2013.07.064
24. Costello JP, Wilson JK, Louis C, et al. Nath DS. Surgical cardiac denervation for the treatment of congenital ion channelopathies in pediatric patients: a contemporary, single institutional experience World J Pediatr Congenit Heart Surg. 2015;6(1):33–8.
25. Staikov C, Stamolos M, Stavroulakis E. Impact of anaesthetic drugs and adjuvants on ECG markers of torsadogenicity. Br J Anaesth. 2014;112(2):217–30. http://dx.doi.org/10.1093/bja/aet412

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