

# Patent ductus arteriosus ligation under high-frequency oscillatory ventilation in two critically ill pre-mature newborns

## Brief Report

**Cite this article:** Rzayev T, Karakurt Y, Ugurlucan M, Tastekin A, and Demirel G (2023) Patent ductus arteriosus ligation under high-frequency oscillatory ventilation in two critically ill pre-mature newborns. *Cardiology in the Young* **33**: 669–671. doi: [10.1017/S1047951122002669](https://doi.org/10.1017/S1047951122002669)

Received: 26 July 2022  
Revised: 29 July 2022  
Accepted: 30 July 2022  
First published online: 30 August 2022


### Keywords:

High-frequency oscillatory ventilation; patent ductus arteriosus ligation; preterm neonate

### Author for correspondence:

Gamze Demirel, Division of Neonatology, American Hospital, Koc University Hospital, Tesvikiye, Guzelbahçe Sokak, No: 20, 34365 Sisli/Istanbul, Turkey. Tel: +90 532 454 01 56. Fax: 0212 3112190. E-mail: [kgamze@hotmail.com](mailto:kgamze@hotmail.com)

All authors approved the final manuscript as submitted and agreed to be accountable for all aspects of the work.

Turkey Rzayev<sup>1</sup>, Yakup Karakurt<sup>2</sup>, Murat Ugurlucan<sup>3</sup>, Ayhan Tastekin<sup>2</sup> and Gamze Demirel<sup>4</sup> 

<sup>1</sup>Division of Neonatology, Istanbul Medipol University, Esenler Hospital, Istanbul, Turkey; <sup>2</sup>Division of Neonatology, Istanbul Medipol University, Istanbul, Turkey; <sup>3</sup>Department of Cardiovascular Surgery, Istanbul Medipol University, Istanbul, Turkey and <sup>4</sup>Division of Neonatology, American Hospital, Koc University Hospital, Istanbul, Turkey

### Abstract

Information on the use of high-frequency oscillatory ventilation in neonatal surgeries is very rare. In this report, we discuss two pre-term infants who had to receive high-frequency oscillatory ventilation as a rescue treatment due to severe pre-maturity. These two cases underwent successful bedside patent ductus arteriosus ligation under high-frequency oscillatory ventilation, and this shows us that patent ductus arteriosus ligation can be performed successfully in neonates even under high-frequency oscillatory ventilation.

There is limited information in the literature on the use of high-frequency ventilation mode during surgeries performed under general anaesthesia. Studies are mostly related to the use of high-frequency oscillatory in adult burn patients and diaphragmatic hernia surgeries in the neonatal period.<sup>1–4</sup> Information on the use of high-frequency oscillatory in other surgeries is rare, and there are few reports on this subject. The purpose of this case report is to emphasise that high-frequency oscillatory mode may be an alternative option during patent ductus arteriosus ligation surgery in critically ill premature neonates who do not tolerate conventional mechanical ventilation.

## Case report

### Case A

Our patient was a female baby born at 22 5/7 gestational weeks from the first pregnancy of a 22-year-old mother, via vaginal delivery. Her birth weight was 585 grams. The mother had a 24-hour premature rupture of membranes and received two doses of antenatal steroids. The baby was intubated in the delivery room. Apgar scores were evaluated as 1, 5, and 7 at 1, 5, and 10 min of life, respectively. Umbilical cord sampling for blood gas revealed a pH: 7.42 CO<sub>2</sub>: 43 mmHg; HCO<sub>3</sub>: 25.6 mmol/L; BE: 3 mmol/L, Lactate: 2.0 mmol/L.

The patient was admitted to the neonatal intensive care unit with the diagnosis of extreme prematurity and administered two doses of intratracheal poractant alpha for respiratory distress syndrome. She was followed up under volume guarantee mode of mechanical ventilation.

Echocardiographic evaluation on post-natal 4th day revealed 2 mm patent ductus arteriosus, and left atrium/aorta was 1.52. The patient was given two courses of intravenous paracetamol treatment. There was no response to the treatment and hemodynamically significant duct patency continued. In the follow-up, the patient was hypotensive and had impaired peripheral perfusion. The patient could not tolerate conventional mechanical ventilation, and ventilation was continued in high-frequency oscillatory mode, and ventilator parameters were gradually increased. On the 10th postnatal day, patient had pulmonary haemorrhage. Supportive treatment with fresh frozen plasma, erythrocyte suspension, inotropes, and surfactant was applied.

By the 11th postnatal day, it was decided to perform bedside patent ductus arteriosus ligation surgery under the high-frequency oscillatory mode of ventilation (MAP 20 cmH<sub>2</sub>O; amplitude 29 cmH<sub>2</sub>O; FiO<sub>2</sub> 100%, frequency 10 Hz).

At induction of anaesthesia, 2 mg rocuronium and 5 µg fentanyl was administered. Fentanyl (4 µg/kg/min) and midazolam (6 µg/kg/min) infusions sustained during the perioperative period. Ventilator settings during the operation were as follows; 20 cmH<sub>2</sub>O MAP, 10 Hz frequency, 29 cmH<sub>2</sub>O amplitude and 100% FiO<sub>2</sub>. Venous-blood gas analysis indicated as pH: 7.38 pO<sub>2</sub>: 36.2 pCO<sub>2</sub>: 39.2, and his SpO<sub>2</sub> was 95%.

A left posterior thoracotomy was performed, the pleura was opened, and the patent ductus arteriosus was ligated. The patient was hemodynamically stable during the procedure; we did

not need to change the ventilator settings during the surgery. The operation was terminated without any complications.

The patient was followed up under high-frequency oscillatory mode in the post-operative period. There was no deterioration in vital signs, and blood gas values were within normal limits. On his 3rd post-operative day, high-frequency oscillatory ventilation was stopped, and conventional ventilation mode was initiated, the patient tolerated well. In the follow-up, the general condition of the patient deteriorated on post-operative 19th day and she died next day due to sepsis and severe acute respiratory distress syndrome.

### Case B

Our patient was a female baby born at 24<sup>5/7</sup> gestational weeks from the first pregnancy of a 44-year-old mother, via vaginal delivery. Her birth weight was 720 grams.

The baby was intubated in the delivery room, and Apgar scores were evaluated as 1, 5, and 7 at 1, 5, and 10 min of life, respectively. The patient was admitted to the neonatal intensive care unit with the diagnosis of severe pre-maturity and was followed up intubated under synchronised intermittent mandatory ventilation mode (PIP: 18 cmH<sub>2</sub>O; PEEP: 6 cmH<sub>2</sub>O; frequency: 40/min; IT: 0.35 s and FiO<sub>2</sub>: 30%). She was administered two doses of intratracheal poractant alpha treatment for respiratory distress syndrome.

Echocardiographic evaluation on the postnatal 3rd day revealed 2 mm patent ductus arteriosus and left atrium/aorta 1.62. The patient was treated with two courses of ibuprofen and one course of paracetamol. In the follow-up, the patient's respiratory parameters were gradually increasing, and ventilation was started in high-frequency oscillatory mode. In the follow-up, the patient was hypotensive and infusion of 5 mcg/kg/min dobutamine was started. It was decided to surgically close the patent ductus arteriosus on the postnatal 24 days in the patient who was unresponsive to medical treatment and did not tolerate ventilation in synchronised intermittent mandatory ventilation mode.

Left posterior thoracotomy and bedside patent ductus arteriosus ligation were performed under the high-frequency oscillatory mode (MAP 18 cmH<sub>2</sub>O; amplitude 30 cmH<sub>2</sub>O; FiO<sub>2</sub> 70%, frequency 10 Hz) with general anaesthesia. At induction of anaesthesia, 2 mg rocuronium and 5 µg fentanyl was administered. Fentanyl (4 µg/kg/min) and midazolam (6 µg/kg/min) infusions sustained during the perioperative period. The patient was haemodynamically stable during the procedure, arterial blood pressures were within normal limits, and we did not need to change the ventilator settings during the surgery. The operation was terminated without any complications.

The patient was followed up under high-frequency oscillatory mode in the post-operative period. There was no deterioration in vital signs, and blood gas values were within normal limits. On his 7th post-operative day, high-frequency oscillatory ventilation was stopped, and conventional ventilation mode was initiated. In the follow-up, the patient was extubated on 43th day of life. After follow-up in neonatal intensive care unit, patient was discharged on 134th day of life, with 4600 g.

### Discussion

The use of high-frequency oscillatory ventilation in surgeries performed under general anaesthesia is rare. The fact that the high-frequency oscillatory mode is not widely known by anaesthesiologists, difficulties in administering inhaler anaesthetics

during the use of high-frequency oscillatory, difficulties in performing high-frequency oscillatory during transport of patients, and possible negative effects of high-frequency oscillatory on the cardiovascular system are important factors limiting the use of this method.<sup>1,5,6</sup>

A patient who was born at 38 weeks and was successfully operated under high-frequency oscillatory mode due to congenital diaphragmatic hernia at post-natal 4 days has been reported.<sup>7</sup> Tobias et al. reported the use of high-frequency oscillatory under general anaesthesia in three newborn patients. In order to minimise lung movements during patent ductus arteriosus ligation in a 14-day-old baby born at 27 weeks, the high-frequency oscillatory mode was used. It was decided to switch to high-frequency oscillatory mode during the operation due to the gradual increase in respiratory parameters and high PIP requirement in a 1-day-old patient who was born at 37 gestational weeks and was operated for gastroschisis. In the operation performed for necrotising enterocolitis in a 30-day-old baby born at 30 GH, ventilation in high-frequency oscillatory mode, which was started before the operation, was successfully continued during the operation.<sup>5</sup>

Unlike these cases, our cases were born extremely premature and did not tolerate conventional mechanical ventilation. Considering that the patent ductus arteriosus shunt that does not respond to medical treatment will worsen the heart and respiratory failure of the patient, it was decided to perform patent ductus arteriosus ligation and the patient who did not tolerate mechanical ventilation was successfully operated under the high-frequency oscillatory ventilation. The purpose of this case reports is to emphasise that ventilation in high-frequency oscillatory mode may be an alternative option during patent ductus arteriosus ligation surgery in critically ill premature neonates who do not tolerate conventional mechanical ventilation.

Close monitoring of arterial pressure during the intraoperative management is important, since the distention pressure caused by high-frequency oscillatory ventilation may diminish both venous return and cardiac output. Both of our patients were premature babies with severe lung immaturity who could not tolerate conventional ventilation. Follow-up with high-frequency oscillatory ventilation during the operation did not cause any deterioration in the clinical condition of the patient, and the cardiac surgery team did not experience any difficulties during the procedure.

High-frequency oscillatory ventilation is an ideal tool for lung-protective ventilation as it allows effective pulmonary gas exchange with the delivery of a very small tidal volume below dead space and diminished risk of atelectrauma.<sup>8</sup> Therefore, it may provide advantage during surgery. Further studies are needed to determine the effects of patent ductus arteriosus ligation under elective high-frequency oscillatory ventilation in pre-term infants in terms of haemodynamics, its effect on the duration of post-operative mechanical ventilation, hospitalisation duration and neurodevelopmental effects in the future.

As conclusion, high-frequency oscillatory mode is sometimes preferred as the first choice in the neonatal period and sometimes as a rescue mode, especially in preterm infants who do not respond to conventional ventilation. If it is the rescue mode, mode changes from high-frequency oscillatory to conventional modes before surgery may lead to severe hypoxia and respiratory deterioration in infants. In this report, we showed that bedside patent ductus arteriosus ligation can be performed successfully with high-frequency oscillatory ventilation.

**Financial support.** This research received no specific grant from any funding agency, commercial, or not-for-profit sectors.

**Conflict of interest.** None.

## References

1. Walia G, Jada G, Cartotto R. Anesthesia and intraoperative high-frequency oscillatory ventilation during burn surgery. *J Burn Care Res* 2011; 32: 118–123.
2. Cartotto R, Ellis S, Gomez M, Cooper A, Smith T. High frequency oscillatory ventilation in burn patients with the acute respiratory distress syndrome. *Burns* 2004; 30: 453–463.
3. Fuyuki M, Usui N, Taguchi T, et al. Prognosis of conventional vs. high-frequency ventilation for congenital diaphragmatic hernia: a retrospective cohort study. *J Perinatol* 2021; 41: 814–823.
4. van den Hout L, Tibboel D, Vijfhuizen S, et al. The VICI-trial: high frequency oscillation versus conventional mechanical ventilation in newborns with congenital diaphragmatic hernia: an international multicentre randomized controlled trial. *BMC Pediatr* 2011; 11: 98.
5. Tobias JD, Burd RS. Anaesthetic management and high frequency oscillatory ventilation. *Paediatr Anaesth* 2001; 11: 483–487.
6. Fuyuki M, Usui N, Taguchi T, et al. Japanese Congenital Diaphragmatic Hernia Study Group. Prognosis of conventional vs. high-frequency ventilation for congenital diaphragmatic hernia: a retrospective cohort study. *J Perinatol* 2021; 41: 814–823.
7. Edipoglu IS, Celik F, Ozdogan T, Comert S, Guvenc BH. Anesthetic management of a neonate with congenital diaphragmatic hernia under high-frequency oscillatory ventilation. *Clin Pract* 2018; 8: 1057.
8. Bojan M, Gioanni S, Mauriat P, Pouard P. High-frequency oscillatory ventilation and short-term outcome in neonates and infants undergoing cardiac surgery: a propensity score analysis. *Crit Care* 2011; 15: R259.