Feasibility and safety of on table extubation after corrective surgical repair of tetralogy of Fallot in a developing country: A case series

Mohammad Irfan Akhtar, Mohammad Hamid, Anwar-Ul-Haq, Fauzia Minai, Naveed Rehman

Department of Anesthesia, 1Department of Pediatrics, Aga Khan University Hospital, Karachi, Pakistan

ABSTRACT

Fast-track extubation is an established safe practice in pediatric congenital heart disease (CHD) surgical patients. On table extubation (OTE) in acyanotic CHD surgical patients is well established with validated safety profile. This practice is not yet reported in tetralogy of Fallot (TOF) cardiac surgical repair patients in developing countries. Evidence suggests that TOF total correction patients should be extubated early, as positive pressure ventilation has a negative impact on right ventricular function and the overall increase in post-TOF repair complications such as low cardiac output state and arrhythmias. The objective of the case series was to determine the safety and feasibility of OTE in elective TOF total correction cardiac surgical patients with an integrated team approach. To the best of our knowledge, this is the first reported case series. A total of 8 elective male and female TOF patients were included. Standard anesthetic, surgical and perfusion techniques were used in these procedures. All patients were extubated in the operating room safely without any complications with the exception of one patient who continued to bleed for 3 h of postextubation at 2–3 ml/kg/h which was managed with transfusion of fresh frozen plasma at 15 mL/kg, packed red blood cells 10 mL/kg and bolus of transamine at 20 mg/kg. Apart from better surgical and bypass techniques, the most important factor leading to successful OTE was an excellent analgesia. On the basis of the case series, it is suggested to extubate selected TOF cardiac surgery repair patients on table safely with integrated multidisciplinary approach.

Key words: On table extubation; Safety; Tetralogy of Fallot; Total correction

INTRODUCTION

Fast-tracking in cardiac surgery refers to the concept of early extubation, mobilization, and hospital discharge in an effort to reduce costs and perioperative morbidity.[1] Fast-track extubation is an established safe practice in pediatric congenital heart surgical patients.[2] The surgery for congenital heart disease (CHD) using cardiopulmonary bypass (CPB) requires mechanical ventilation, which in many cases is continued postoperatively in the cardiac intensive care unit (CICU). Institutional differences exist with respect to patient management.

Certain centers attempt extubation in the operating room (OR), whereas others routinely continue mechanical ventilation postoperatively in the CICU. Positive pressure ventilation has a negative impact on right ventricular (RV) function as intermittent positive pressure ventilation decreases systemic venous inflow due to increase in intrathoracic pressure. It can increase in right ventricle afterload if lungs are inflated beyond functional residual capacity. Hence, it’s logical to get the tetralogy of Fallot (TOF) patients off positive pressure ventilation soon, as TOF patients have restrictive or under filled right ventricle physiology. Delaying extubation on
fast-track mode increases the health cost of the patients, which is a major factor to be considered in developing countries with cost constraint patient population. Fast-track strategy also reduces the parents’ anxiety about the well-being of their child when they meet them in the CICU without ventilators’ support. Early discharge from CICU also facilitates patient’s turn over allowing more sick patients with CHD to get operated.

On table extubation (OTE) in acyanotic CHD surgical patients is well established with validated safety profile.[1] There was concern regarding OTE in TOF total repair surgical patients among the anesthesiologists and the surgeons at our center due to postsurgical repair coagulopathy, RV dysfunction, and conduction blocks in the postoperative period.

Objective
The objective of this case series was to determine the safety and feasibility of OTE in TOF total correction cardiac surgical patients with integrated team approach keeping the rationale of positive impact of spontaneous breathing on RV function and cardiac output.

CASE REPORTS
After taking the informed consent from the parents, eight elective classic TOF patients scheduled for intracardiac total repair with no signs of infection (C-reactive protein <0.5) were included. The emergency cases, prolonged bypass time patients (bypass time >140 min), coagulopathic and very young patients (under 2 years old) were excluded. All the cases were operated in cardiac operation theaters of Aga Khan University Hospital. Average age of the patients was 5.8 years; average weight of 16.5 kg and average height was 106 cm. Male: female ratio was 2:6.

Surgery in all cases was performed by the same surgeon with the same technique: Ventricular septal defect (VSD) closed with Dacron patch, infundibular muscle resected and transannular pericardial patching done. The surgical repair was done through transatrial and transpulmonary approach. Postoperatively, surgical repair optimization confirmed by measuring direct systemic, right ventricle and pulmonary artery pressures and further confirmation by intraoperative epicardial echocardiography (ECHO).

A standardized anesthetic technique was used in all cases. Standard NPO guidelines were followed. All patients were premedicated with peroral midazolam 0.5 mg/kg 1 h before coming to the OR. Inhalational induction with sevoflurane 8% in 100% O₂ was done in the presence of parents. Intravenous (IV) line maintained after sedation. Fentanyl 3–5 μ/kg was given for analgesia. Atracurium 0.5 mg/kg was used for intubation. Uncuffed endotracheal tube was used in all cases. Propylactic cefazolin 40–50 mg/kg was given 45 min prior to incision. Anesthesia maintenance was done with isoflurane. Analgesia was maintained with fentanyl and atracurium infusion was used for muscle relaxation throughout the procedure. During CPB, anesthesia was maintained by fentanyl infusion at 4–5 μ/kg/h and isoflurane at 1% through bypass anesthetic vaporizer. American Society of Anesthesiologist recommended monitoring and invasive monitoring including arterial and central venous pressure (CVP) monitoring was done in all cases.

Milrinone infusion was started at 0.3 μ/kg/min for pulmonary vasodilatation and RV diastolic function support at the start of surgery. Coming off bypass, Milrinone was increased to 0.5 μ/kg/min. Other inotrope added according to the requirement. Nitroglycerine infusion titrated to control hypertension. Atrioventricular (AV) epicardial pacing wires put in as a back up to manage AV blocks and sinus bradycardia.

Crystalloid cardioplegia was used with moderate hypothermia (32°C) during bypass. ACT and arterial blood gasses (ABGs) were monitored half hourly along with continuous systemic venous oxygen saturation monitoring. The average bypass time was 130 min and cross-clamp time (CXT) of 80 min. Priming was done with crystalloid and one pack of fresh frozen plasma (FFP). Packed red blood cells (PRBCs) added to keep hemoglobin (Hb) of 10 g/dL if required. Mean arterial pressure (MAP) of 40–50 mmHg maintained during the bypass period. Urine output maintained at 2 mL/kg/h. Modified ultrafiltration was done in all TOF repair patients. Heparin was reversed with protamine after removal of venous cannulae. Meticulous surgical hemostasis was secured. Transamine infusion at 5–10 mg/kg/h was used in all cases starting postinduction and continued in the postoperative phase until the bleeding minimized (5–10 mL/h) in the chest drains.

Atracurium infusion stopped before sternal wiring. Analgesia optimized with morphine 0.1 mg/kg, paracetamol 15 mg/kg before sternal wiring started and local bupivacaine skin infiltration before skin closure. Muscle relaxation reversed with glycopyrrolate (10 μ/kg) and neostigmine (40 μ/kg). Adequacy of tidal volume,
R/R, hemodynamics, chest tube drainage, temperature, ABGs were assessed before OTE decision. After extubation, all patients shifted to CICU with O₂ mask, mandatory monitoring, emergency drugs and an emergency airway apparatus. Analgesia maintained with Fentanyl infusion (0.5–1 μg/kg/h) and paracetamol IV bolus six hourly. Chest X-ray, ABGs and ECHO done after shifting. Average stay in the CICU was 48 h after which patients were shifted to step down.

**Case 1**
A 6-year-old male child weighing 16.5 kg with TOF having functioning Rt BT shunt is right Blalock Taussig shunt (A palliative shunt to optimize pulmonary blood flow in TOF) was scheduled for total correction. Reason for operation was an increase in hypercyanotic spells on exertion. Standard anesthetic, surgical and perfusion techniques were used. Bypass time was 110 min, and CXT was 62 min. Baseline room air saturations were 84% and Hb of 15.3 g/dL. All the other labs were within normal limits.

Postoperatively, patient was extubated on table after fulfilling the extubation criteria and optimization of analgesia. He was kept in the CICU for 48 h and then shifted to step down. Postoperative ECHO revealed tiny residual VSD, mild TR, and normal biventricular function. No respiratory, hemodynamic and bleeding complications were noted during 48 h of ICU stay.

**Case 2**
A 10-year-old female child weighing 20.5 kg with a diagnosis of TOF was scheduled for total correction. Reason for operation was the cyanosis on exertion. Baseline oxygen saturations were 84% on room air, and Hb was 17 g/dL. Standard anesthetic, surgical and perfusion techniques were used.

Postoperatively, patient was extubated on table after fulfilling the extubation criteria and optimization of analgesia. He was kept in the CICU for 48 h and then shifted to step down after chest tube removal. Postoperative ECHO was normal. No respiratory, hemodynamic and bleeding complications were noted during 48 h of ICU stay.

**Case 3**
A 10-year-old female patient weighing 26 kg with TOF was scheduled for total correction. Baseline saturations were 88% on room air (R/A). Baseline Hb was 17 gm/dl. Rest of the labs were within normal limits. Standard anesthetic, surgical and perfusion techniques were used. Total CPB time was 140 min, and CXT was 110 min. Postoperatively, the patient was extubated on table after fulfilling the extubation criteria. Patient was shifted to step down without any untoward events.

**Case 4**
A 5.6-year-old female child weighing 14 kg with a diagnosis of TOF and blocked BT shunt was scheduled for total correction. Reason for operation was shortness of breath with increase in frequency of cyanotic spells. Baseline room air (R/A) saturations were 80%, and Hb was 18.2 g/dl.

The patient was operated with the same standardized anesthetic, surgical and perfusion technique. Total bypass time and CXT time was 120 and 90 min, respectively. At the end of the procedure, the patient was extubated and shifted to CICU where she stayed for 48 h and after that shifted to step down with no untoward events with removal of chest drains.

**Case 5**
A 2.9-year-old female child weighing 12.5 kg with a diagnosis of TOF was scheduled for total correction. Clinical reason for the operation was increase in frequency of cyanotic spells. Room air saturations were 72% and Hb of 17.2 g/dl. The patient was operated with the standard anesthetic technique. Pump time and CXT time was 125 and 73 min, respectively. At the end of the procedure, the patient was extubated on the table after fulfillment of the standard extubation criteria. Postoperative events included increased drain output at 3–4 mL/kg/h for few hours. She was transfused with PRBCs (15 mL/kg), FFP (15 mL/kg) and transamine. She was shifted on 3rd postoperative day after chest drain removal to step down.

**Case 6**
A 3.4-year-old female child weighing 18 kg with TOF was scheduled for TOF total correction. R/A saturations were 88% and baseline Hb of 15 g/dL. At the end of the procedure, the patient was assessed for extubation on table. The patient was extubated on table after fulfilling the extubation criteria. She stayed in the CICU for 48 h after which she was shifted to step down without any complications.

**Case 7**
A 5.2-year-old male child weighing 17 kg with the diagnosis of TOF was operated for TOF total correction. Room air (R/A) saturation of 88% and baseline Hb of 16 g/dL. The procedure was conducted on pump
using the standard anesthetic, surgical and perfusion technique.

Postoperatively, the patient was extubated on table after the extubation criteria were fulfilled. After 48 h, the patient was shifted to step down following postprocedure transthoracic ECHO and chest X-ray. No complications noted during 48 h of CICU stay.

Case 8
A 4-year-old female child weighing 8 kg with classical TOF presented for total correction. Her R/A saturations were 92% with Hb of 12 g/dL. At the end of the procedure, the patient was assessed for extubation on table. The patient was extubated on table after fulfilling the extubation criteria. She stayed in the CICU for 36 h after which she was shifted to step down without any complications.

RESULTS
All patients were extubated on table safely with an exception of a patient who continued to bleed for few hours and was managed with transfusion of FFP at 15 mL/kg and bolus of transamine at 20 mg/kg. A transient hypercapnia of 45–50 mm/Hg was the common finding in all extubated TOF patients with no impact on the postoperative outcome.

DISCUSSION
In recent years, postoperative intensive care management of the child with congenital cardiac disease has placed an emphasis on earlier weaning from mechanical ventilation, as positive pressure ventilation has a negative impact on RV function. OTE in cyanotic CHD surgical patients like TOF is not yet reported in the literature from developing countries.

In the society of thoracic surgeons CHD complexity database, TOF surgical repair with a transannular patch has total basic score of 8, complexity level of 3 and difficulty level of 3.\(^3\)

In TOF, cardiac output is exquisitely dependent on a high CVP and the maintenance of a low pulmonary vascular resistance. Early extubation in the children after repair for TOF is associated with improvement in PaO\(_2\), tachycardia, and MAP, with a decrease in inotrope score.\(^4\) The extubation failure results in a longer hospital stay.\(^4\)

In TOF posttotal repair patients, cardiac output and cerebral oxygenation increased significantly during the spontaneous respiration, latter suggesting that the brain was in or approaching an oxygen supply-dependent state before extubation. Despite the increase in cardiac output, the presumed increase in respiratory pump perfusion, as well as the concurrent increase in cerebral perfusion, came at the expense of mesenteric perfusion, while renal oxygenation remained unchanged with extubation.\(^5\)

A prospective study including 76 intra-cardiac repair TOF patients was done to document the feasibility of early extubation and to identify the effects of age, weight, and postoperative right ventricle/left ventricle ratio on early extubation in intracardiac repair for TOF. The patients were tried to be extubated within 4 h of arrival in CICU. The overall success rate was 60%. There was no correlation between the duration of ventilation with age, weight, and right ventricle/left ventricle ratio. Early extubation in patients after intracardiac repair in TOF is safe and effective.\(^6\)

In the current study of 8 patients of TOF total correction, all the patients were extubated on table safely. This evolving strategy of OTE of TOF cardiac surgical patients undo the myth behind elective postoperative ventilation in these cyanotic CHD category patients.
This strategy of OTE leads to overall health cost reduction and less postoperative morbidity. It also leads to the reduction in parental anxiety when they see their child without mechanical ventilation support. Apart from better surgical and bypass technique, the most important factor leading to successful OTE was an excellent analgesia comprising of morphine (0.1–0.2 mg/kg bolus), paracetamol 15 mg/kg before sternal wiring and local infiltration with bupivacaine before skin closure.

Patient safety was the priority. Decision regarding OTE was an ongoing decision taking into account the intraoperative course, optimization of surgical correction and immediate postoperative behavior of the patient. At the end of the procedure, at least 15–30 min were given in the OR for optimization of patient spontaneously ventilation and oxygenation apart from hemodynamic and biochemical stability. A transient hypercapnia of 45–55 mm/Hg was a common finding in all extubated TOF patients on first ABGs done in the CICU.

CONCLUSION

On the basis of the case series, it is suggested to extubate selected TOF cardiac surgical patients on the table with the help of integrated multidisciplinary approach. This strategy reduces patient health care cost, improves patient turn over and reduces the patient morbidity related to conventional postoperative elective ventilation in TOF total repairs.

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