TECHNIQUES AND EARLY RESULTS OF MINI LEFT THORACOTOMY APPROACH FOR REPAIR OF TETRALOGY OF FALLOT

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ABSTRACT

BACKGROUND
Right minithoracotomy and lower partial sternotomy are usual approaches for mini-invasive repair of congenital cardiac defects with a better cosmetic outcome. These approaches have been inadequate for repair of TOF due to limited exposure of the Right Ventricular Outflow Tract (RVOT) and pulmonary artery. Mini-left thoracotomy approach is sternal sparing and has the advantages of a cosmetic mini incision for surgical correction of patients with Tetralogy of Fallot (TOF).

MATERIALS AND METHODS
From December 2013 and January 2015, 27 paediatric patients (15 females) with mean age 13.2 years and mean weight 26.7 kg underwent intracardiac repair for TOF. A mini-left thoracotomy in third intercostal space involving a 3-5cm skin incision was used in all the patients. In 12 patients, pulmonary annulus was preserved and infundibular muscle resection was performed through RVOT. Fifteen patients received transannular patch. Ventricular Septal Defect (VSD) was closed through right ventriculotomy in all the patients.

RESULTS
There was no mortality or significant morbidity in the postoperative period or during follow up. Mean cross-clamp time was 48.33 minutes and mean cardiopulmonary bypass time was 83.66 minutes. All patients were weaned off mechanical ventilation within 14 hours of surgery. There was no residual defect in any patient. All patients were in NYHA class I during follow-up. During follow-up, one patient (preserved annulus) had residual gradient of 40 mmHg across right ventricular outflow tract without symptoms.

CONCLUSION
The left minithoracotomy is a safe and effective alternative to a classical median sternotomy in selected group of patients for surgical repair of TOF with satisfactory results and better cosmesis.

KEYWORDS
Tetralogy of Fallot, Right Ventricular Outflow Tract, Ventricular Septal Defect.


BACKGROUND
Since the inception of paediatric cardiac surgery, results have gradually improved with present day surgical mortality of <5% even for most complex congenital cardiac lesions. Over the years, midline sternotomy has remained the standard and preferred approach for most paediatric cardiac surgery procedures performed on cardiopulmonary bypass. However, sternotomy has its own complications. Apart from being associated with cosmetically disfiguring scar, there are risks of complications, e.g. sternal instability, dehiscence and deformity, wound infection and postoperative sternal and scar pain. In last three decades, minimally-invasive cardiac surgery with peripheral cannulation has gained widespread acceptance in adults.
angiography was performed in all patients. All patients were operated on by the same surgeon. In all the patients with TOF, arterial cannulation was through femoral artery and venous cannulation was through femoral vein. Six patients received additional SVC cannula (direct insertion of angled metal tip). Five patients required transannular patch (TAP) and in rest of four patients repair was done through right ventriculotomy with preservation of pulmonary annulus. Hypertrophied muscle bundle were resected and VSD was closed through ventriculotomy approach in all the patients.

Patients were shifted to intensive care unit intubated and managed as per our intensive care unit protocol. As a common practice, we extubated and discharged the patients from the intensive care unit early if the clinical condition of the patient permitted. Also, they were discharged from the hospital early if postoperative course was uneventful. All the patients were followed up with a physical examination at 1 week, 1 month, 3 months and then 6 monthly after surgical intervention. Postoperatively, TTE was performed during the stay in the intensive care unit, 3 months after hospital discharge and at any time during follow-up if warranted.

**Operative Technique**

The submammary skin incision was started 1 cm lateral to sternal border extended for a length of 3 to 5 cm and the pleura was opened at the level of the third intercostal space. The pericardium was opened 2cm anterior to phrenic over the RVOT and stay sutures were applied. Cardiopulmonary bypass, cardioplegic arrest and mild hypothermia (28°C-30°C) were used in all operations. SVC cannulation and looping if required was done through the main incision after institution of femorofemoral bypass. IVC looping was done after cardioplegic arrest. Placement of the purse-string suture and insertion of an aortic root cannula were performed after gentle downward movement of the vessel. The left atrial appendage was cannnulated to vent the heart with vent catheter passing through drain site small incision at the mid axillary line sixth intercostal space.

The aorta was cross-clamped through a separate small parasternal incision in the second intercostal space and cardioplegic arrest was achieved by infusion of cold hyperkalemic blood into the aortic root with vent placed through the left atrial appendage.

After cardioplegic arrest, RVOT was opened for hypertrophic muscle bundle resection and assessment of pulmonary valve and annulus.

Three retraction sutures 6-0 polypropylene (Prolene) were placed on either side of RVOT and septal leaflet of tricuspid valve and gently pulled. A patch of Gore-Tex was sutured on the right side of the septum with a running stitch of 6-0 polypropylene as described for VSD closure through right ventriculotomy. The patch was inserted with a continuous 6-0 polypropylene suture starting at the posterior limb of the septomarginal band.
After assessment of pulmonary annulus, RVOT and pulmonary artery was augmented with fixed autologous pericardial patch and if pulmonary annulus was hypoplastic, a transannular patch was applied. The cross-clamp was removed with continuous suction on the cardioplegic line. The lungs were gently ventilated till the heart recovered in sinus rhythm. Aortic root vent was removed after complete de-airing under TEE guidance. After complete rewarming, cardiopulmonary bypass was weaned in the usual fashion. Left thoracotomy was closed after complete haemostasis routinely.

RESULTS
Demography
Mean age of the patients was 13.2 years (range 4 to 35 years) and mean weight was 26.7 kg for patients. Demographic profile of the patients is given in Table 1.

<table>
<thead>
<tr>
<th>Total Number of Patients (n=27) Mean±SD</th>
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<tbody>
<tr>
<td>Age (months)</td>
<td>13.2±9.77</td>
</tr>
<tr>
<td>Sex (male)</td>
<td>M=04</td>
</tr>
<tr>
<td>Weight</td>
<td>26.7±18.6</td>
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<tr>
<td>Hypoplastic pulmonary annulus</td>
<td>27</td>
</tr>
<tr>
<td>ICR with TAP (no.)</td>
<td>15</td>
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<tr>
<td>ICR with RVOT (no.)</td>
<td>12</td>
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<tr>
<th>Total Number of Patients (n=27) Mean±SD</th>
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<tr>
<td>Bypass time</td>
<td>83.66±26.65</td>
</tr>
<tr>
<td>Cross-clamp time</td>
<td>48.33±15.73</td>
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<tr>
<td>RVOT gradient</td>
<td>30.88±8.26</td>
</tr>
<tr>
<td>pRV/LV</td>
<td>0.51±0.14</td>
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<tr>
<td>Drainage output</td>
<td>161.1±89.36</td>
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<tr>
<td>Mechanical ventilation time (hrs.)</td>
<td>7.55±5.24</td>
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<tr>
<td>ICU tay (days)</td>
<td>41.66±14.37</td>
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<tr>
<td>Hospital tay(days)</td>
<td>7±0.86</td>
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Hospital Outcomes
In all the patients, the length of the skin incision varied between 3 cm and 5 cm according to the size of the patient. There were no severe intraoperative complications regarding exposure, cannulation or bleeding. None of the patients required conversion to a classic full sternotomy. Mean cardiopulmonary bypass time was 83.66 minutes ranging from 56 to 127 minutes. Mean aortic cross-clamp time was 487.33 minutes ranging from 36 to 83 minutes. None of our patients showed any significant fall in cardiac function at the postoperative TEE or required major postoperative inotropic support.

There were no significant bleeding events and mean mediastinal drainage volume was comparable between groups. None of the patient required re-exploration. All drains were removed on the first postoperative day. Routinely performed postoperative TTE showed no significant residual defect in any patient. Two patients with TOF had tiny flow across VSD patch that did not warrant intervention. One patient operated for TOF with preserved pulmonary annulus had residual gradient of 45 mmHg on postoperative TTE. Though postoperative course was uneventful in the patient and was discharged from the hospital on postoperative day 7.Rest all patients had normal postoperative course with no complications regarding wound infection. There were no hospital deaths and no major surgical or postoperative neurologic complications. All patients were discharged from the hospital in good clinical condition without significant residual intracardiac defects. All patients were in sinus rhythm with no more than mild tricuspid valve insufficiency and no subaortic obstruction. The mean hospital stay was 7 days (range 6-8 days) (Table 2).

Follow-up
Follow-up was 100% complete. At last follow-up (median-7 months; range 3 months-10 months), there were no deaths during follow-up. All patients were in New York Heart Association Class I. One patient operated for TOF
with preserved pulmonary annulus had residual gradient of 40mmHg across RVOT at 3 months follow-up without symptoms. Patient is under regular follow-up for symptoms and gradient. The cosmetic results were considered good or excellent in most of the patients.

DISCUSSION
Median sternotomy is the gold standard of a surgical approach in the repair of TOF. However, long incision length, postoperative pain, a not-ideal cosmetic effect. Moreover, full length sternotomy is associated with higher incidence of postoperative bleeding, increased sternal movement and dehiscence and prolonged hospital stay after repair of TOF. The major advantage of minimally-invasive cardiac surgery is avoidance of sternotomy. The minimally-invasive nature of this procedure will reduce the incidence of postoperative mediastinitis and wound pain to a minimum. It can provide the promise of expediency, safety, minimal discomfort, less postoperative pain, quick functional recuperation, excellent cosmetic healing, shortened hospital stays and therefore savings in cost.

During last two decades, there has been considerable emphasis on sternal sparing and cosmetically superior approaches. Hence, several alternative minimally-invasive approaches have been described for repair of congenital cardiac defects. These approaches include anterolateral thoracotomy, full sternotomy with limited skin incision and the transxiphoid approach. All these technique though present several advantages, but are limited by the fact that cardiopulmonary bypass is commenced by cannulation through the incision. This not only makes the field cluttered, but also reduces the space for the instrument movement and exposure of area of interest. Moreover, all these techniques have limited exposure of the RVOT and are of practically of limited use in patients with TOF.

Mini left thoracotomy provides good exposure to RVOT for repair of TOF. If required, RV to PA conduit can be inserted and VSD can be closed through the right ventriculotomy, though we have not done any case so far.

In this series, there was no morbidity and no mortality. All patients were satisfied with the cosmetic healing. In minimally-invasive cardiac surgery, simple femoro-femoral or femoro-atrial cardiopulmonary bypass established satisfactory perfusion of all vital organs, including the brain. In our series, there was no organ failure postoperatively and the patients regained consciousness promptly after the surgeries indicating adequate tissue perfusion during cardiopulmonary bypass. The femoral artery and vein, although small in caliber in paediatric patients could be easily repaired without stenosis.

There were no vascular complications of the lower limbs in our patients. Prevention of air embolization is one of the most important procedures in minimally-invasive cardiac surgery. De-airing was adequately performed by enlarging the cardioplegia puncture site and guided by TEE. Before the heart started beating, transesophageal echocardiographic examination was performed to detect any residual air. There was no evidence of neurological defect postoperatively indicating adequate deairing.

Though, studies in adult cardiothoracic surgery have shown that sternotomy is less painful than thoracotomy and respiratory discomfort is lower than that following thoracotomy. However, we did not find any significant difference between thoracotomy and midline access for congenital cardiac surgery in terms of postoperative pain, length of intensive care unit and in-hospital stay. However, general application as a routine procedure needs further long-term analysis of a larger series with comparison with those approached through median sternotomy.

CONCLUSION
The left mini thoracotomy is a safe and effective alternative to a median sternotomy for surgical repair of TOF in selected group of patients with good results and better cosmetic outcome.

REFERENCES


