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Informed Consent Statement
Written informed consent for publication of the patient’s clinical data and the accompanying images was obtained from the patient and his mother.

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Central Picture Legend

Living-donor basal segmental lung transplantation with concomitant Nuss procedure.

Central Message

Living-donor segmental lung transplantation and concomitant Nuss procedure may be effective for lung transplantation for small children with pectus excavatum.

Glossary of Abbreviations

CT computed tomography

CPB cardiopulmonary bypass

POD postoperative day

DSA donor-specific anti-human leukocyte antigen antibody
Clinical Summary

A 10-year-old male with pectus excavatum was referred to our hospital due to the worsening of respiratory condition. The patient had been waitlisted for deceased-donor lung transplantation since 1 year previously due to drug-induced interstitial pneumonia after chemotherapy for neuroblastoma. His oxygen requirement had increased during the waiting period, and intractable pneumothorax had developed. We considered it unlikely that the patient would survive until a deceased donor was allocated; therefore, we planned living-donor lung transplantation. His height had increased in the 1-year period after he started being waitlisted (122 cm→125 cm) and CT volumetry revealed that the volume of chest cavity had become smaller due to the progression of restrictive lung disease (right chest cavity 517 ml→410 ml, left chest cavity 272 ml→207 ml). Haller index was 8.8 (Figure 1). The donors were his older sisters who were both aged in their twenties. CT volumetry of donor lung was performed for anatomical size matching. The graft volumes of right and left lower lobes were 1294 ml (S6 385 ml, Basal segment 909 ml) and 955 ml (S6 286 ml, Basal segment 669 ml), respectively (Central picture). We used bilateral basal segments with CT-volumetric size-matching estimated to be 255%. Concomitant Nuss procedure was planned to expand the recipient’s chest cavity for oversized segmental grafts.
In the donor basal segmentectomy, intersegmental plane was developed and divided by a cautery *in situ* based on indocyanine green orientation to preserve S6 segment. The divided intersegmental planes were then covered with fibrin glue and polyglycolic acid sheet to prevent air leakage. Bilateral basal segmental graft implantation was performed through a clamshell incision under cardiopulmonary bypass (CPB). Donor basal bronchus, pulmonary vein, and pulmonary artery were anastomosed to recipient main bronchus, main pulmonary artery, and upper part of the pulmonary vein stump of left atrium, respectively. Right pulmonary venous anastomosis required an auto-pericardial conduit. The basal segments were vertically rotated 90° after reperfusion. After discontinuation of CPB, two pectus bars were placed to expand the chest cavity (Video 1). One pectus bar was placed at the cranial side of the sternotomy and fixed with bilateral costal cartilage using non-absorbable sutures. The other bar was placed at the caudal side of the sternotomy and fixed with chest wall using stabilizer. Delayed chest closure was required, and the chest was closed on postoperative day (POD) 7. Tracheostomy was performed on POD 10. The patient was weaned off mechanical ventilation on POD 43, and the tracheal tube was removed on POD 62. Complications related to pectus bars were not observed. The patient was discharged home without oxygen therapy 2 months after transplantation. One year after the operation, the patient
was doing well. His height was 127 cm. The pectus bar was still in place and the right and left chest cavity volume measured 608 ml and 638 ml, respectively (Figure 2).

Postoperative courses of the two donors were uneventful and the preserved S6 segments expanded well.

Discussion

Chest wall abnormality is considered a contraindication for lung transplantation in most lung transplant centers.\(^1\) Recently, this prevailing view has been challenged by some groups, which reported a satisfactory outcome of simultaneous repair of pectus excavatum with lung transplantation.\(^2-4\) A case series from the University of Vienna reported two pediatric patients who underwent deceased-donor lung transplantation with concomitant Nuss procedure that was performed with one or two bars.\(^4\) Complications related to bar placement were not reported. When considering simultaneous correction of pectus excavatum with pediatric living-donor lung transplantation in which large grafts from adult donors are transplanted, Nuss procedure may be preferable to repair without exogenous implants, as it enlarges the chest cavity more. However, in the present case, we were concerned that the pectus bar would make the chest wall too rigid, which would interfere with postoperative respiratory recovery and increase the risk of
infection around the bars under the post-transplant strong immunosuppression. As both concerns were not found on a literature search, we proceeded to do Nuss procedure with living-donor lung transplantation. In this case, 2 pectus bars at the cranial and caudal side of sternotomy were effective for stable thoracoplasty after clamshell thoracotomy with sternal division.

Regarding the procedure of pediatric living-donor lung transplantation, various procedures were undertaken to deal with the size-mismatch between adult lobar graft and the small chest cavity in children including single lobar transplantation and bilateral segmental transplantation. Using 2 different donor grafts might sensitize the recipient and increase the risk of de novo donor-specific anti-human leukocyte antigen antibody (DSA); however, the incidence of de novo DSA is less after living-donor lung transplantation than after deceased-donor lung transplantation. In addition, the contralateral unaffected lung graft may work as a reservoir when acute rejection or chronic lung allograft dysfunction occurs unilaterally (Suppl). We recently published a satisfactory short-term outcome of segmental transplantation in pediatric patients from adult donor.\(^5\) In segmental transplantation, implantation of two segmental grafts obtained from different donors is considered preferable, if two donors are available as in the present case.
Conclusions

Living-donor segmental lung transplantation and concomitant Nuss procedure is feasible for lung transplantation for small children with pectus excavatum.

Written informed consent for publication of the patient’s clinical data and the accompanying images was obtained from the patient and his mother. IRB approval was not required.
References


Figure Legends

Figure 1

Preoperative chest X-ray (A), CT (B) and patient’s appearance (C) showing right pneumothorax and drug-induced interstitial pneumonia with pectus excavatum (Haller index 8.8).

Figure 2

Postoperative chest X-ray (A), CT (B), and patient’s appearance (C) 1 year after surgery.

Video 1

Transplantation of bilateral basal segmental graft is performed through clamshell incision. Right pulmonary venous anastomosis requires an auto-pericardial conduit.

After reperfusion, two pectus bars are placed.
Central picture
Figure 1
Figure 2
Supplementary Material

Supplemental references