Atrial fibrillation following lung transplantation: double but not single lung transplant is associated with long-term freedom from paroxysmal atrial fibrillation

Geoffrey Lee, Harry Wu, Jonathan M. Kalman, Don Esmore, Trevor Williams, Greg Snell, and Peter M. Kistler

1Department of Cardiology, The Melbourne Royal Melbourne Hospital, University of Melbourne, 3004 Melbourne, Australia; 2The Department of Cardiology, The Alfred Hospital, Melbourne, Australia; 3Department of Medicine, University of Melbourne, Melbourne, Australia; 4The Department of Respiratory Medicine, The Alfred Hospital, Melbourne, Australia; and 5The Baker IDI, Melbourne, Australia

Received 23 February 2010; revised 25 March 2010; accepted 30 May 2010; online publish-ahead-of-print 11 July 2010

See page 2708 for the editorial comment on this article (doi:10.1093/eurheartj/ehq241)

Introduction

The cornerstone of catheter ablation for atrial fibrillation (AF) is pulmonary vein electrical isolation (PVI). Recurrent AF post-PVI is a major limitation of the procedure with PV reconnection present in most patients. Single (SLT) and double (DLT) lung transplant surgery involves a ‘cut and sew’ PV antral isolation analogous to a catheter-based approach providing an opportunity to assess the efficacy of durable PVI.

Methods and results

A total of three hundred and twenty-seven consecutive lung transplant patients were compared with 201 control non-transplant thoracic surgery (THR) patients between 1998 and 2008. The primary analysis was the incidence of ‘early’ post-operative AF and ‘late’ AF (AF occurring following discharge from hospital after the index operation). Risk factors for the development of late AF were analysed using regression analysis. Acute post-operative AF was more common post-lung transplant (DLT 58/200 (29%) and SLT 36/127 (28%) vs. THR 28/201 (13.9%), P = 0.001) occurring at 4.7 ± 5.0 days in DLT, 3.4 ± 2.5 days after SLT, and 7.4 ± 11.2 days in the thoracic group (P = 0.001). At a mean follow-up of 5.4 ± 2.9 years late AF occurred in 1/200 (0.5%) in DLT vs. 16/127 (12.6%) in SLT and 23/201 (11.4%, P = 0.001) in THR groups. Kaplan–Meier survival analysis demonstrated the association of DLT with long-term freedom from AF. Significant variables [hazard ratio (HR) on univariate regression analysis for late AF were: DLT 0.06, age 1.09, LA diameter 1.2, hypertension 3.0, preoperative AF 12.2, early AF 8.8, rejection 3.2].

Conclusion

Double but not SLT provides long-term freedom from AF despite a similar early post-operative incidence. This supports the critical role of the pulmonary veins in the pathogenesis of atrial fibrillation and the importance of durable electrical isolation of the pulmonary veins as the cornerstone in strategies for the long-term prevention of AF.

Keywords

Atrial fibrillation • Lung transplantation • Catheter ablation
Atrial fibrillation post-lung transplant provides a unique opportunity to assess the efficacy of pulmonary vein isolation on the treatment of AF. During lung transplantation, recipient pulmonary veins are amputated and donor pulmonary veins and a cuff of left atrium (LA) is anastomosed to the recipient LA akin to a catheter-based ablation approach. Importantly, this model differs from orthotopic heart transplantation, which typically involves an en bloc surgical isolation of the posterior wall of the recipient right and left atria including the vena cavae.8

The Cox Maze surgical approach to AF similarly involved a ‘cut and sew’ approach with an en bloc posterior LA isolation with excellent long-term results but also includes extensive additional biatrial surgical incisions9 with the ultimate goal of ‘precluding the development of re-entry anywhere and everywhere’.9–11 Despite the reported efficacy of the Maze procedure, routine adoption of the technique has been hampered by its complexity and reproducibility.9,10,12

The primary aims of this study were to determine the: (i) incidence of AF long term following lung transplantation and (ii) the impact of single (SLT) vs. double lung transplant (DLT) surgery on AF outcomes.

Methods
A retrospective study of 327 consecutive lung transplant patients (127 SLT and 200 DLT) performed at a single institution between July 1998 and August 2008 was undertaken. An additional 201 consecutive thoracic surgical patients were included over the same study period as a control group to determine the background incidence of AF in patients undergoing thoracotomy, which did not involve instrumentation of the pulmonary veins or LA. Patients who also underwent cardiac transplantation were excluded.

Lung transplant procedure
The donor organ procurement is performed utilizing 1–2 mL infusions of cold (4°C) cardioplegia and neuromuscular block, the intact heart–lung allograft subsequently being removed as an en bloc diathermy dissection. The left and right pulmonary allografts are then ‘separated’ from the heart, retaining a suitable cuff of donor LA on each side, the surgical margin being well clear (2–3 cm) of the thinner more fragile pulmonary venous orifices. During the lung transplant procedure, recipient pneumonectomy is again performed at the mid-atrial level, creating a recipient atrial cuff. At the time of pulmonary allograft implantation, the donor and recipient LA cuffs are anastomosed using a continuous 5/0 proline running suture (Figure 1). The donor and recipient atrial transection technique described above, in effect leads to antral isolation of the pulmonary veins, analogous to catheter-based pulmonary vein isolation and the surgical ablation procedures for AF, that utilize either radiofrequency or cryotheraphy techniques. Cardio-pulmonary bypass is infrequently used during SLT or DLT, being reserved for recipients with significant pulmonary hypertension or requiring an attendant cardiac procedure.

Clinical details and patient follow-up
All patients underwent 24 h ambulatory Holter monitoring and daily ECGs during the acute post-operative period. The transplant database records all aspects of patient and donor data, preoperatively, at the time of transplant and during long-term longitudinal follow-up. In particular, the database record specifies heart rhythm during outpatient follow-up. After index lung transplantation procedure patients are intensively followed up every 3 months by the transplant team and subsequent data are entered prospectively. The mean follow-up period was 5.4 ± 2.9 years.

Episodes of AF were determined by three methods (i) review of lung transplant database and intensive care unit database records; (ii) an extensive search of individual patients medical record, including all recorded admissions, 12 lead ECG, ward and ambulatory Holter monitoring (iii) lastly all patients were contacted and underwent a telephone interview. During this interview, we determined if the patient had: (i) experienced symptoms suggestive of atrial fibrillation (ii) been diagnosed on ECG or treated for AF (iii) been prescribed anti-arrhythmic medications.

The diagnosis of AF required ECG substantiation to be included in the analysis. If AF was suspected based on routine follow-up evaluation, telephone interview obtained during the review of inpatient reports, outpatient charts, discharge summaries, operative reports and any other electronic or paper medical record the corresponding ECG or monitor tracing was analysed. On Holter monitoring, an AF episode is defined as the occurrence of AF lasting >30 min. If the corresponding ECG/tracing could not be localized, that episode was excluded from the analysis.

Study endpoints
The primary endpoint was the occurrence of AF after index surgery. For the purposes of this study ‘early post-operative’ AF was defined as new AF diagnosed in the post-operative period during index hospital admission. ‘Late AF’ was defined as any clinically documented AF occurring following discharge from hospital after the index operation. The ‘time to AF’ was calculated as days from date of index surgery to the date of the first documented episode of AF.

Statistical analysis
Statistical analysis was performed using commercially available statistical software, SPSS. Data are presented as mean ± SD unless otherwise stated. Normality was assessed by Kolmogorov–Smirnov test. For normally distributed variables, a students t-test or an analysis of variance with post hoc least-significant difference tests was used to compare mean values. For non-normally distributed data non-parametric tests (Kruskal–Wallis) were performed. Comparison of
categorical variables was tested using a $\chi^2$ test. Statistical tests were two sided.

Significant variables were evaluated by Cox regression and confirmed with stepwise forward Cox regression analysis. Variables tested for significance by Cox regression analysis included age, gender, weight, hypertension, smoking, previous history of atrial fibrillation, underlying lung condition, surgical procedure performed, coronary bypass at time of index surgery, transplant rejection, echocardiographic data included: LA area, LV size, LV function, LV fractional shortening, mitral valve E/A velocities, E'ax, RVSP, pulmonary acceleration time. Transplant donor factors used in analysis included donor age, weight, mode of death, lung cold ischaemia time.

Kaplan–Meier analysis was used to assess freedom from AF in the three groups. A P-value $< 0.05$ was considered statistically significant.

The majority of deaths following lung transplantation occur in the first 2 years after transplantation. Given the higher incidence of deaths in the lung transplantation groups compared with the thoracic surgical group in our study, we performed a separate univariate Cox regression analysis for the development of ‘Late AF’ from time of discharge to 1, 2, and 5 years after the index surgery.

For the purpose of our analysis, patients with emphysema, Alpha 1 antitrypsin deficiency, chronic obstructive lung disease were classified as chronic obstructive lung disease (COPD). Primary, secondary, idiopathic pulmonary hypertension and Eisenmenger’s syndrome were all classified as pulmonary hypertension (PHTN).

**Results**

**Patient demographics (Table 1)**

During the study period, a total of 327 patients underwent lung transplantation comprising 200 DLT patients and 127 SLT patients. In the same period, 201 patients underwent thoracic surgery unrelated to lung transplantation.

The DLT group was significantly younger (DLT, 48.5 ± 11 years; SLT, 56.3 ± 7.3 years and thoracic, 52.1 ± 48.5 years, P < 0.001). Left atrial diameter was larger in the thoracic group (38 ± 7 mm vs. DLT 33 ± 7 mm vs. SLT 36 ± 7, P = 0.01). Left ventricular diastolic dimensions tended to be greater in the thoracic group compared with the transplant groups (48.1 ± 7.7 mm THR vs. 44.8 ± 6.6 mm SLT vs. 45.3 ± 10.5 mm DLT, P = 0.7). RVSP was higher in the DLT, 57 ± 25 mmHg compared with thoracic patients 39 ± 12 mmHg and SLT 42.3 ± 16.2 mmHg, P = 0.001 with significant PHTN an indication for DLT.

**Primary outcome**

**Early post-operative AF (Table 2)**

In the present study, 122 (23%) patients developed ‘early’ post-operative AF. Early post-operative AF occurred in equal proportions of single (36 patients, 28%) and double (58 patients, 29%) lung transplants compared with 28 (14%) thoracic patients, P < 0.001. Differences in patient characteristics among the three groups were: age, LA diameter and RVSP. Mean LA diameter was smaller in the DLT (35 ± 6 mm) vs. the SLT (37 ± 5 mm) and thoracic group (37 ± 7 mm, P < 0.001). Mean RVSP was significantly higher in the DLT (71 ± 26 mmHg) vs. SLT (51.5 ± 20 mmHg) and thoracic group (44 ± 11 mmHg, P < 0.001).

The time to first episode of AF following surgery was 4.7 ± 5.0 days in DLT, 3.4 ± 2.5 days after SLT, and 7.4 ± 11.2 days in the thoracic group (P < 0.001). Twenty patients in the transplant group that had early post-operative AF underwent cardioversion prior to discharge (14 DLT patients and 6 SLT patients). Sinus rhythm at hospital discharge was present in all (200/200) patients in the DLT group, 124/127 (97%) patients in the SLT group and 173/201 (86%) in the thoracic group. A similar proportion of patients were discharged on anti-arrhythmic medications after their index procedure (Table 1). Amiodarone was prescribed on discharge in 9% in the thoracic group compared with 12.5% in the DLT and 12.6% in the SLT patients, P = 0.45. Similarly, sotalol was prescribed in 4.8% of the thoracic group vs. 3.5% DLT and 2.5%, P = 0.7. No transplant patients were taking anti-arrhythmic medications 3 months after their index surgery and recommended only if recurrent symptoms.

**AF late after surgery**

After a median follow-up of 5.4 ± 2.9 years, 40 patients were diagnosed with late AF (> 6 months) post-surgery. There was a highly significant difference in the incidence of ‘late AF’ between the three groups. AF occurred in 1/200 (0.5%) in the DLT group vs. 16/127 (12.6%) in the SLT group and 23/201 (11.4%) patients in the thoracic group (P < 0.001). The time to late AF occurrence was not statistically different (934 ± 393 days in the thoracic group and 1075 ± 862 days in the transplant group, P = 0.6 (Table 2). A comparison of clinical characteristics between those with and without ‘late AF’ is shown in Table 3.

In addition to episodes of AF, there were 12 other arrhythmias documented during the post-lung transplant period. This included six atrial flutters, two atrial tachycardias and four SVTs.

**Predictors of late post-operative AF**

Predictors for the late development of post-operative AF were determined using Cox regression analysis (Table 4). Age [hazard ratio (HR) 1.09 (P < 0.001), Hypertension (HR 2.98 P < 0.001), preoperative AF (HR 12.2 P < 0.001), early postoperative AF (HR 8.8 P < 0.001), LA diameter (HR 1.2 P < 0.01), transplant rejection (HR 3.2, P 0.04) were significant univariate predictors of AF. The only protective factor for the development of late AF was double lung transplantation (HR 0.06, P < 0.005).

Additional factors included in the univariate analysis not shown in Table 4 included: type of thoracic surgery, indication for surgery, donor cause of death, donor gender, and cardiopulmonary bypass during procedure. These factors did not have an effect on the development of late AF.

A Kaplan–Meier curve for the development of late AF demonstrates that double lung transplantation is associated with long-term freedom from AF compared with SLT and thoracic surgery (Figure 2, P-value < 0.001).

There were a higher number of deaths in the lung transplantation groups compared with the thoracic surgical group (Table 2), which occur predominantly in the first 2 years after surgery. A separate univariate cox regression analysis was performed at 1, 2, and 5 years for the development of ‘late AF’. During the first year, DLT did not reach statistical significance (HR = 0.02, P = 0.09); however, subsequent to this at 2 and 5 years it was protective with an HR = 0.02, P-value < 0.001.
The present study is the largest to report the incidence of AF after lung transplantation with long-term follow-up to 5.4 ± 2.9 years. The major findings were the following.

(i) Early post-operative AF was more common after lung transplantation (29%) than with non-transplant thoracic surgery (14%). The incidence of early AF was similar following DLT (29%) and SLT (28%).
(ii) The incidence of late AF following DLT is very low (0.5%) compared with SLT (12.6%) and general thoracic surgery (11.4%).

(iii) Despite early post-operative AF, patients who undergo DLT are free from AF during long-term follow-up. In contrast, 33% of SLT patients continue to experience AF.

By using DLT and SLT surgery as models for unilateral and bilateral pulmonary antral isolation akin to the catheter-based approach, we were able to explore the long-term efficacy of durable pulmonary vein isolation in providing freedom from AF. The present study demonstrates the new finding that double lung but not SLT provides long-term freedom from AF. These findings highlight the importance of durable electrical isolation of all four pulmonary veins for the long-term maintenance of sinus rhythm.

**Previous studies**

AF is a common occurrence early following thoracic surgical procedures with a reported incidence of 10–40% after pulmonary resection, 10–30% after coronary graft surgery and 60% after coronary graft and concomitant valve surgery.13–15 The incidence of acute AF in our lung transplantation population was 29%, similar to earlier smaller series.5,16,17 Following hospital discharge, we

---

**Table 2** Primary outcomes and patient outcomes

<table>
<thead>
<tr>
<th></th>
<th>Thoracic group (n = 201)</th>
<th>Single lung Tx (n = 127)</th>
<th>Double lung Tx (n = 200)</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary outcomes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Early AF</td>
<td>28 (14%)</td>
<td>36 (28%)</td>
<td>58 (29%)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Early to late AF</td>
<td>15 (54%)</td>
<td>12 (33%)</td>
<td>0</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Late AF</td>
<td>23 (11%)</td>
<td>16 (13%)</td>
<td>1 (0.5%)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td><strong>Patient outcomes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Death</td>
<td>38 (19%)</td>
<td>78 (61%)</td>
<td>67 (34%)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Age at death (years ± SD)</td>
<td>56.9 ± 11.1</td>
<td>51.7 ± 10.6</td>
<td>59.4 ± 7.2</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Rejection</td>
<td>N/A</td>
<td>81 (40.5%)</td>
<td>74 (47.5%)</td>
<td>0.02*</td>
</tr>
</tbody>
</table>

Results of primary and secondary outcomes of the analysis. Early to late AF signifies those patients that developed early AF that also went on to have late AF. A *P-value < 0.05 is significant.

**Table 3** Comparison of clinical characteristics between those with and without ‘late AF’

<table>
<thead>
<tr>
<th></th>
<th>Absence of late AF (n = 488)</th>
<th>Late AF (n = 40)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>56.4 (1.3)</td>
<td>68.4 (8.4)</td>
<td>0.001*</td>
</tr>
<tr>
<td>Male</td>
<td>277 (56.7%)</td>
<td>26 (65.0%)</td>
<td>0.31</td>
</tr>
<tr>
<td>Hypertension</td>
<td>79 (16.2%)</td>
<td>14 (35.0%)</td>
<td>&lt;0.01*</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>53 (10.9%)</td>
<td>7 (17.5%)</td>
<td>0.20</td>
</tr>
<tr>
<td>Pre-op AF</td>
<td>14 (2.9%)</td>
<td>12 (30%)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Paroxysmal</td>
<td>14 (2.9%)</td>
<td>8 (20%)</td>
<td>&lt;0.01*</td>
</tr>
<tr>
<td>Persistent</td>
<td>0</td>
<td>4 (10%)</td>
<td>&lt;0.01*</td>
</tr>
<tr>
<td>Acute post-operative AF</td>
<td>95 (19.5%)</td>
<td>27 (67.5%)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Echocardiography</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LV (mm ± SD)</td>
<td>34.7 ± 6.7</td>
<td>39.8 ± 8.6</td>
<td>0.30</td>
</tr>
<tr>
<td>LVEDD (mm)</td>
<td>45.9 ± 7.7</td>
<td>44.5 ± 11.5</td>
<td>0.25</td>
</tr>
<tr>
<td>FS</td>
<td>0.37 ± 0.08</td>
<td>0.39 ± 0.09</td>
<td>0.89</td>
</tr>
<tr>
<td>RVSP (mmHg)</td>
<td>49.7 ± 22.5</td>
<td>40.7 ± 13.6</td>
<td>0.01*</td>
</tr>
<tr>
<td>Surgery</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Double lung transplant</td>
<td>199 (40.8%)</td>
<td>1 (2.5%)</td>
<td>&lt;0.01*</td>
</tr>
<tr>
<td>Single lung transplant</td>
<td>111 (22.7%)</td>
<td>16 (40%)</td>
<td>&lt;0.014*</td>
</tr>
<tr>
<td>Thoracic surgery</td>
<td>178 (36.5%)</td>
<td>23 (57.5%)</td>
<td>&lt;0.008*</td>
</tr>
</tbody>
</table>

Comparison of clinical characteristics between those with and without ‘late AF’. Late AF (+), patients with ‘late AF’; late AF (–), patients without ‘late AF’; DLT, double lung transplant; SLT, single lung transplant; DM, diabetes mellitus; LA, diameter; left atrial diameter; LVEDD, left ventricular end diastolic dimension; FS, left ventricular fractional shortening; RVSP, right ventricular systolic pressure. A *P-value < 0.05 is significant.
found a very low incidence of AF (0.5%) in patients undergoing DLT but not SLT (12.6%). After an episode of AF in the immediate post-operative period no patients undergoing DLT demonstrated AF. Sinus rhythm was restored long term following ablation to complete pulmonary vein isolation.27

Certain baseline characteristics in the DLT group (younger age, smaller LA size, normal LV size and underlying disease pathology) may have contributed to a lower prevalence of late AF as these characteristics may protect against the development of AF. Following multivariate analysis to address differences in baseline characteristics DLT was the only significant factor preventing the development of late AF. One may speculate as to the proposed mechanisms to explain the observation in the present study that DLT provides long term freedom from AF. These include the following.

(i) Electrical isolation of the pulmonary veins: Haissaguerre et al. demonstrated the critical role of the pulmonary veins as the predominant origin for the triggers responsible for paroxysmal AF. The majority of patients who present with recurrent AF following catheter ablation demonstrate PV reconnection.7,28,29

(ii) Isolation of rotors anchored at the PV–LA junction as described by Jalife et al.30–32

(iii) Substrate modification involving interruption of complex fractionated activity which clusters at the origins of the PVs and interatrial septum33 and

(iv) Modification of ganglionic plexi. Epicardial ganglionated nerves are present at the superior and inferior aspects of the PV antra. Parasympathetic stimulation shortens the atrial effective refractory period, increases dispersion and decreases the wavelengths of reentrant circuits that facilitate and maintain AF. The autonomic nervous system may play an important role in the modification of triggers and rotors located at the PV–LA junction.34

Further studies are required to determine the role of proposed mechanisms on the clinical observation of long-term freedom from AF following DLT. Nevertheless, these observations further emphasize the importance of the PV antrum to the mechanism of AF and the requirement of complete isolation for successful intervention.

Differences between cardiac and double lung transplant

There are important differences in the surgical procedures of cardiac transplantation, which involves posterior left atrial isolation and cardiac denervation compared with DLT, which is limited to the pulmonary venous antral region. The posterior LA contains a region of functional conduction delay, which may be responsible for circuitous wavefront propagation and likely relevant to the pathogenesis of AF in some patients.35 The pathogenesis of AF remains incompletely understood with a complex interplay between the triggers largely based on the pulmonary veins and atrial substrate both of which were under the influence of autonomic modulation. Pulmonary vein isolation is likely common to lung and cardiac transplantation with cardiac transplant involving posterior right and left atrial isolation and cardiac denervation providing added benefit in preventing AF.
Pulmonary vein reconnection: the ‘Achilles heel’ of pulmonary vein isolation

Despite achieving pulmonary vein isolation at the completion of catheter antral ablation, patients undergoing with recurrent AF typically demonstrate recovered PV–LA conduction. PV reconnection is seen in up to 90% of patients with recurrent AF following PV isolation. In the study by Nanthakumar et al. of patients with AF recurrence after PVI, 42 of the 51 (15 patients) previously isolated pulmonary veins had return of PV–LA connection at a mean of 100 days. All patients had return of conduction in more than two PVs with only one patient identified as having a non-pulmonary vein trigger. Gerstenfeld et al. reported recurrent PV–LA conduction or triggers from PV not targeted at the index procedure in 86% of patients with recurrent AF. By creating pulmonary vein isolation with a ‘cut and sew’ approach during lung transplantation, long-term freedom from AF can be achieved with four vein but not two vein isolation. Unilateral vein isolation by virtue of SLT was associated with a late incidence of AF in 12.5% of patients compared with 0.5% in DLT patients.

Early post-operative AF

The increased incidence of acute AF post-lung transplantation (29%) compared with non-transplant thoracic surgery (14%) is consistent with previous studies reporting a 20% incidence of AF peaking 2 days after lung transplant. The mechanism of acute post-operative AF is multifactorial and has been incompletely defined. Post-operative AF may be precipitated by changes in left atrial substrate induced by surgical manipulation, inflammation, oedema and neurohormonal activation. The mean time to AF was 4.2 ± 4.3 days after transplant with 89% of AF occurring within 7 days of the operation. Recently Dizon et al. reported a similar incidence of AF after DLT (18.9%) with 78% of AF occurring within 1 week of transplantation. At a mean follow-up of 1.3 ± 0.9 years, five AF episodes sometime after the first week, however is unclear when these events occurred in relation to timing of the index surgery.

The timing of acute post-operative AF corresponds to potential precipitants for AF such as pain, intravascular fluid shifts, hypoxia and early graft dysfunction. Consistent with resolution of these acute factors, AF spontaneously reverted in 76% of DLT and in 83% in the SLT patients prior to discharge, with a minority requiring cardioversion to restore SR. Acute post-operative AF did not predict the subsequent development of ‘late AF’ in DLT group as no DLT patients developed recurrent AF during long-term follow-up, compared with 33% in the SLT and 53% of thoracic patients. See et al. recently reported early AF in 31% post-lung transplant however AF was not documented beyond 1 year after
lung transplantation. The incidence of atrial tachycardia was 11% 1 year after transplantation compared with 2.4% in the present study.

Study limitations

The primary endpoint of this study is the occurrence of AF, which beyond the initial monitoring period in hospital was largely determined by symptoms. Holter cardiac monitoring was reserved for patients with symptoms suggestive of arrhythmia and as such the true incidence of AF is likely underestimated. However, the intensity and follow-up duration did not differ across the three groups and is consistent with large clinical follow-up studies.

The patient group undergoing DLT is inherently different from the SLTand thoracic surgical groups with a larger population of patients with cystic fibrosis, bronchiectasis and PHTN. Patient factors must also be considered when considering the observed differences.

Conclusion

Early post-operative AF occurs in 29% of patients after lung transplantation and is higher than the incidence observed following non-transplant thoracic surgery. Double lung but not SLT transplantation and is higher than the incidence observed following non-transplant thoracic surgery. Early post-operative AF occurs in 29% of patients after lung transplantation. The incidence of atrial tachycardia was 11% 1 year after transplantation compared with 2.4% in the present study.

Funding

Dr Kistler is supported by a Research Investigatorship from the Cardiovascular Society of Australia and New Zealand.

Conflict of interest: none declared.

References


Computed angiogram of the upper extremities for diagnosing a rare cause of brachial arterial embolism: the ‘Pitcher Syndrome’

Daniela Reutter1, Roger Hunziker2, and Marc Husmann1*

1Clinic for Angiology, University Hospital Zurich, 8091 Zurich, Switzerland; and 2Department of Radiology, University Hospital Zurich, Zurich, Switzerland
*Corresponding author. Tel: +41 44 255 3491/+41 44 255 2650, Fax: +41 44 255 4510, Email: marc.husmann@usz.ch

Embolic brachial artery occlusion most often originates from the heart, the aortic arch, or from subclavian artery aneurysms.

A 64-year-old man presented with acute upper limb ischaemia of the left arm. Duplex sonography confirmed a brachial artery occlusion, but no compression of the left subclavian artery or a subclavian aneurysm as source for the emboli. There were no signs for cardiac arrhythmia in the ECG nor cardiac thrombus by echocardiography. Computed angiogram of the thoracic and upper extremity revealed an aneurysm of the left posterior circumflex humeral artery (Panels A and B). Treatment consists in surgical embolectomy at the brachial bifurcation and in ligation of the aneurysm.

Aneurysms of the posterior circumflex humeral artery have been reported for volleyball and baseball players and named as the ‘Pitcher Syndrome’. Repetitive traumas to the arterial wall during throwing motions of the shoulder affect the posterior circumflex humeral artery at the quadrangular space at the neck of the humerus. Embolic occlusion may result from dislocation of the squeezed thrombus from the aneurysmatic sack during shoulder movements. Since this patient did never practice any other sports than yoga, it might be assumed that certain specific yoga exercises with shoulder movements might have provoked the artery trauma.

The absence of cardiovascular source for thrombo-embolism by echocardiography, ECG, and vascular sonography demands additional vascular imaging that allows an entire vascular assessment to detect rare sources for embolism.

Panel A. Three-dimensional volume rendering computed tomography image. Aneurysm of the left posterior circumflex humeral artery (white arrow) and thromboembolic occlusion of the left brachial artery bifurcation (white arrowhead).

Panel B. Transverse computed tomography image. Aneurysm of the left posterior circumflex humeral artery (white arrow).