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A scale for decision making between whole lung transplantation or lobar transplantation[☆]

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Abstract

Objective: In lung transplantation, appropriate size matching is of crucial importance to achieve satisfactory outcomes. Tailoring of the lung has been repeatedly described as successful means of overcoming size disparities. The goal of this study was to define a parameter helping the surgeon in the decision whether a standard lung transplantation or a lobar transplantation should be anticipated. **Methods:** We retrospectively analysed the ratio between donor total lung capacity (TLC) and recipient TLC in all lung-transplant procedures performed in our institution from 1 January 2008 to 30 November 2008. The utility of this ratio using predicted recipient TLC (D/pR index) and real recipient TLC (D/rR index) in discriminating between whole lung transplantation and lobar transplantation was studied with the receiver operating characteristic (ROC) analysis. **Results:** The median D/pR index in whole lung transplantations was 1.01 (range: 0.69–1.26) and 1.19 in lobar transplantation (range: 1.09–1.54). In the range between 1.12 and 1.14, sensitivity and specificity are both above 90%. The area under the ROC curve for D/pR index was 0.96. The median D/rR index in whole lung transplantations was 0.95 (range: 0.56–2.74) and 1.58 in lobar transplantation (range: 0.85–2.56). The area under the ROC curve was 0.73. **Conclusions:** We conclude that the D/pR index is more useful than D/rR index in discriminating between whole lung transplantation and lobar transplantation. With an area under the ROC curve of 0.96, this seems to be a suitable indicator in deciding between whole lung transplantation and lobar transplantation.

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Keywords: Lung transplantation; Lobar transplantation; Tailoring of the lung

1. Introduction

In lung transplantation, adequate size matching between donor and recipient is of crucial importance. Different approaches in finding the best match have been described, with total lung capacity (TLC), gender, recipient and donor height being the most important [1–3]. Sometimes, to overcome size disparities, tailoring of the lung has to be performed. We have previously demonstrated that size-reduced lung transplantations can be considered reliable procedures that provide results comparable to standard lung transplantations [4]. Further, Santos et al. concluded that downsizing the lung graft is safe, with no additional morbidity and with early and midterm outcomes similar to those in standard lung transplants [5]. The surgeon has to implant the

right size of the lung to achieve a physiological ventilation pattern.

In general, the surgeon decides about tailoring of the lung on the basis of size disparities between donor lung and recipient pleural space. The decision can also be affected by the experience of the surgeons and by the grade of inflation of the donor lung, when the donor lung is at the surgical table before implantation. This could be a critical factor. Therefore, the lung should be transported in a physiological inflation status to the transplant centre.

This results in three possible scenarios: (a) the whole lung can be transplanted, without any kind of tailoring; (b) simple wedge resection have to be performed on the transplanted lung with the middle lobe and lingular being preferred targets; and (c) a uni- or bilateral lobar transplantation has to be performed.

There is an important difference between the last two situations: while extra-anatomical resections can be performed before or after the implantation, the decision for a lobar transplantation has to be taken before implantation. For these reasons, to find a possible parameter helping the

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surgeon to anticipate whether a standard lung transplantation or a lobar transplantation has to be performed, we have studied retrospectively the relationship between anthropometric features of the donor, anthropometric features of the recipient and the kind of tailoring of the lung in lung-transplanted patients, with particular reference to the ideal borderline for lobar transplantation.

2. Materials and methods

We retrospectively analysed the ratio between TLC predicted of the donor and TLC predicted of the recipient (D/pR index), and the ratio between TLC predicted of the donor and TLC real of the recipient (D/rR index) in 94 consecutive lung transplantations performed in a single institution between 01 January 2008 and 30 November 2008. The predicted TLC of all donors and recipients was calculated using the regression equations of the European Respiratory Society (ERS) [6,7].

For males : $TLC\ predicted = 7.99 \times H - 7.08$

For females : $TLC\ predicted = 6.60 \times H - 5.79$

where H represents body height in metres. These equations apply for persons of Caucasian descent. The study has been approved by the institutional ethics committee. The patients are divided in two groups: group A of 85 consecutive whole lung transplantations and group B of nine consecutive lobar transplantations. The characteristics of the patients are summarised in Table 1.

In group A, all whole lung transplantations, including those with wedge resections, are included. In group B, all uni- or bilateral lobar transplantations are included.

For each group, the authors have studied the distribution of the D/pR index and the distribution of the D/rR index. The utility of the D/pR index and D/rR index in discriminating between whole lung transplantations and lobar transplanta-

Table 1
Characteristics of the patients. Data are expressed as median (range), unless otherwise stated. TLC: total lung capacity; COPD: chronic obstructive pulmonary disease; PPH: primary pulmonary hypertension.

	Whole lung transplantations	Lobar transplantations	P-value
Recipient data			
Patients n	85	9	
Single lung/double lung	6/79	0/9	
Age years	53 (7–67)	37 (13–57)	
Diagnosis n (%)			
COPD/emphysema	39 (46%)	2 (22%)	
Cystic fibrosis	15 (18%)	4 (45%)	
Fibrosis	14 (16%)	1 (11%)	
PPH	4 (5%)	1 (11%)	
Other	13 (15%)	1 (11%)	
Hospital time days	22 (15–164)	27 (21–112)	0.16
3-month survival (%)	93%	86%	0.21
TLC predicted	5.8 (3.2–8.1)	4.6 (3.2–5.9)	
TLC real	6.5 (2.5–11.6)	5.7 (3.1–8.3)	
Donor data			
Donor TLC predicted	6.5 (3.4–8.3)	5.4 (4.8–8.2)	

tions were studied with receiver operating characteristic (ROC) analysis. Statistical analysis was performed with Graph Pad Prism 5.0.

3. Results

The relationship between TLC predicted of the donor and TLC predicted of the recipient is shown in Fig. 1. The distribution of D/pR index in the two groups is shown in Fig. 2. The D/pR index in whole lung transplantations had a range between 0.69 and 1.26, with a median value of 1.01. The D/pR index in lobar transplantations had a range between 1.09 and 1.54, with a median value of 1.19. The distribution of the D/rR index is shown in Fig. 3. The D/rR index in whole lung transplantations had a range between 0.56 and 2.74, with a median value of 0.95. The D/rR index in lobar transplantations had a range between 0.85 and 2.56, with a median value of 1.58.

For the ROC analysis, we considered having a lobar transplantation the 'condition', and we can consider the test positive if the value of the test was above the value of the cut-off. So, we considered sensitivity the percentage of people who had the 'condition' that the test correctly identifies as positive. And we considered specificity the percentage of people without the 'condition' that the test correctly identifies as negative. The results of ROC analysis are shown in Fig. 4. For the D/pR index, the area under the curve was 0.96 (95% confidence interval (CI): 0.91–1.00). In the range of D/pR index between 1.12 and 1.14, sensitivity and specificity are both above 90%. For the D/rR index, the area under the ROC curve was 0.73 (95% CI: 0.57–0.88). For the D/rR index, in the range of values between 1.05 and 1.12, both sensitivity and specificity are above 65%.

4. Discussion

The parameters that have to be considered for the correct size matching in lung transplantation have been discussed by several authors. Ouwens et al. analysed the size matching using TLC predicted of the donor and TLC predicted of the recipient [3]. They studied 96 patients transplanted between 1990 and 1998. In their work, they found a median value for the ratio TLC predicted donor/TLC predicted recipient (D/pR

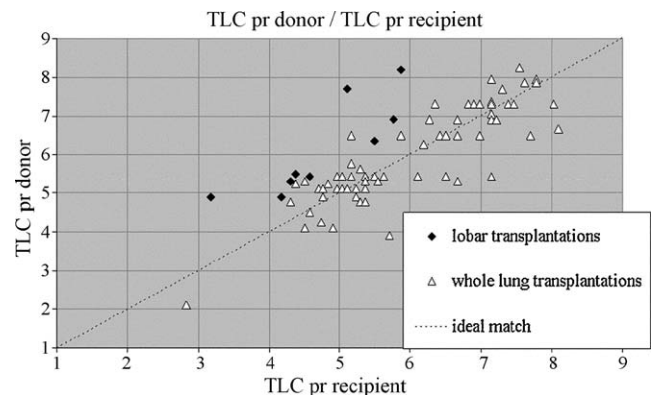


Fig. 1. Relationship between TLC pr of the donor and TLC pr of the recipient.

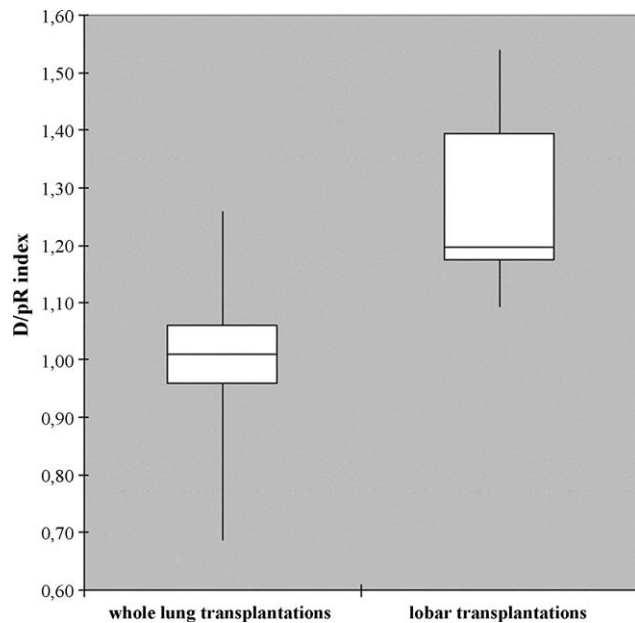


Fig. 2. Distribution of the D/pR index.

index in our study) of 1.01, with a range 0.72–1.41, but they did not mention tailoring of the lung.

In general, on the basis of size disparities, the surgeon has to decide about tailoring of the lung, between no resection, extra-anatomical resection or lobar transplantation. Sometimes, a decision to eliminate a damaged part of the lung is also taken.

While extra-anatomical resection can be performed before or after implantation, the decision for a lobar transplantation has to be made before implantation. The decision on the basis of size disparities can be affected by the experience of the surgeon and by the grade of inflation of the lung during the harvest.

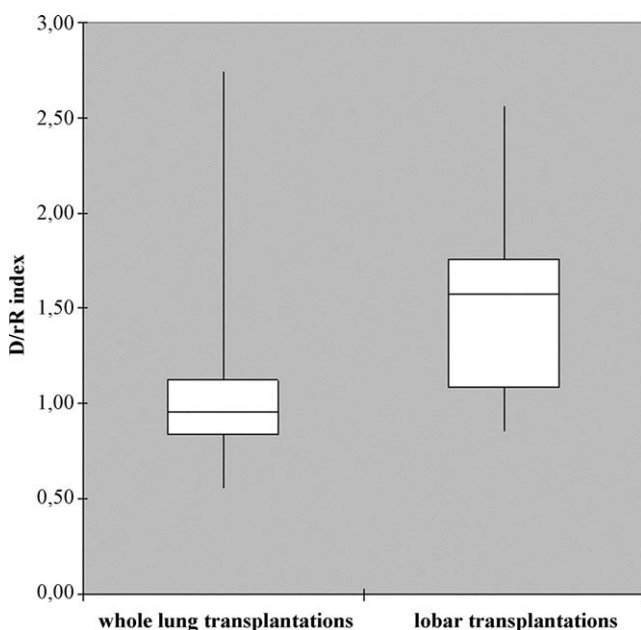


Fig. 3. Distribution of the D/rR index.

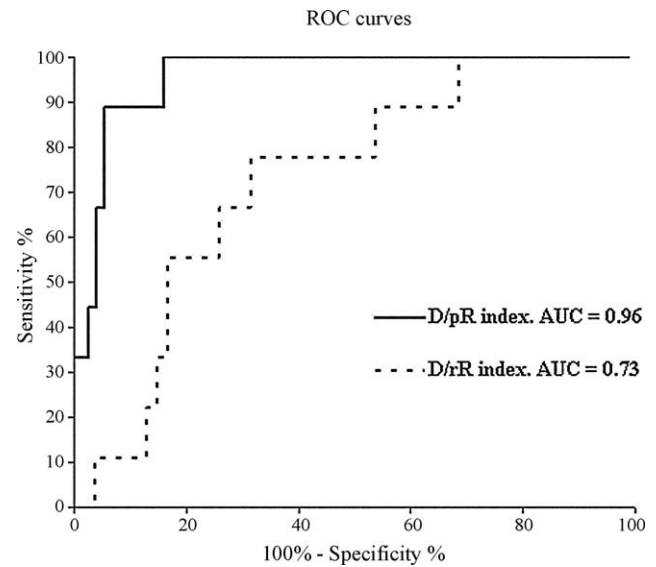


Fig. 4. ROC curves of D/pR index and D/rR index. AUC: area under the curve.

The distribution of the D/pR index in the two groups of the study showed important differences (Fig. 2). This means that D/pR index could be useful for discriminating the lobar transplantations from the whole lung transplantations, with or without extra-anatomical resections. The area under the ROC curve for the D/pR index is very close to the value of 1.00, the value of an ideal test, with a narrow 95% CI (0.91–1.00). However, the distribution of the D/rR index showed substantial overlapping between the two groups (Fig. 3). This is confirmed by the value of area under the ROC curve for the D/rR index: 0.78, with a broad 95% CI (0.57–0.88).

Due to this evidence, we consider the D/pR index more useful than the D/rR index in anticipating whether whole lung transplantation or lobar transplantation will be required.

We suggest considering, for the D/pR index, a range of cut-off between 1.15 and 1.20. Above the value of 1.20, when the TLC predicted of the donor exceeds more than 20% compared with the TLC predicted of the recipient, we think that the surgeon has to consider a lobar transplantation. The higher the D/pR is, the higher the probability that the surgeon has to perform a lobar transplantation on both sides. Obviously, we suggest this scale as indicative for the surgeon. This scale is useful for having a general idea about size disparities. We have studied a possible cut-off for lobar transplantations, but the D/pR index could also be used to decide about extra-anatomical resections in lung transplantation. However, planning an extra-anatomical resection is less useful.

This scale is developed by a retrospective study and needs a validation by a higher number of lobar transplantations.

Other factors contribute to the decision for a lobar transplantation. The pathology can contribute to the variability of the pleural space of the recipient. From our preliminary studies, we noticed that the big variability in the TLC real, due to the pathology, does not reflect the same variability in the pleural space. In many patients with small TLC real (generally fibrotic patients), implanting lung with TLC predicted of the donor more than double the TLC real of the recipient is possible, without it being necessary to do a lobar transplantation. In fact, in the group of whole lung

transplantations, the D/rR index may exceed the value of 2.50. This observation can be explained by realising that the TLC real is a spirometric value that studies the alveolar space. In many pathologies of the lung, the patients have an alteration of the ratio alveolar space/inter-alveolar space. The patients can also have atelectasis of a lobe. In these situations, the patient has in general substantial alterations of the TLC real, which do not reflect the same alterations of the pleural space. We think that this is the reason why, in our preliminary experience, the TLC real has not been useful to study the size of the pleural space, and so it is not so useful to predict size disparities in lung transplantations.

Particular situations are patients with asymmetry of pleural spaces. These situations are generally due to mediastinal shift, to different degrees of diaphragm elevation or to chest deformities. In each disease a certain degree of asymmetry in pleural spaces can develop. This asymmetry may be reversible after lung transplant, except for chest deformities, but this phenomenon is not yet well known. In lung transplantations, the surgeon has to consider this information to plan the right tailoring. It is helpful to respect the current anatomy of the patient, distributing the tailoring on both sides as needed. When there is substantial asymmetry in pleural spaces, the reduced pleural space is more likely to have a lobar transplantation, even in the absence of significant size disparities.

The evidence that in planning a lung transplant, the TLC predicted of the recipient is more useful than the TLC real of the recipient, may seem surprising. However, this makes us reflect on the fact that during a lung transplant, we are giving another chance to the patient. We know the recipient's TLC predicted and his TLC real, usually pathological. The TLC predicted of the recipient can also be interpreted as the TLC ideal of the recipient. Studies of physiology show that with the correct lung volumes, with the correct degree of expansion of the rib cage, the ventilatory work is reduced and ventilation is suitable for the patient. So, giving a chance to the patient, why do we follow the TLC real of the recipient, which not only fails to reflect the true extent of the pleural cavity, but is also a pathological condition? We know, for example, how much effort an emphysematous patient must make to breath, having the chest in maximum expansion. To suggest for that patient, his ideal volume expressed by TLC predicted of the recipient is correct, rather than repropose a large pathological volume, which is expressed by his TLC real. For fibrotic patients, we have more limitations; however, the reduction of the pleural space

is not correctly reflected by the TLC real of the recipient. Moreover, some alterations, such as diaphragm profile or rib orientation, are quickly reversible. Therefore, we can interpret the TLC predicted of the recipient as the TLC ideal of the recipient. So, it is fair to observe the relationship between the predicted values of the donor and recipient to plan a proper tailoring. Exceptions are chest deformities, which are situations that can hardly be traced to ideal situations.

The effects of a correct tailoring of the lung on the outcome have not been established. However, we have not found statistical disparities in survival between the two groups in our study (Table 1). Similar results have been reached by other studies [4,5].

We conclude that the ability of the ratio TLC predicted donor/TLC predicted recipient (D/pR index) in discriminating whole lung transplantations from lobar transplantations is higher than the ratio TLC predicted donor/TLC real recipient (D/rR index). We consider the D/pR index a good parameter to estimate the size disparities between donor lung and recipient pleural space in lung transplantations. The data from this study indicate that, when the TLC pr of the donor exceeds 20% the TLC predicted of the recipient, with high specificity, a lobar transplantation is predicted.

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