Many years ago, I wrote a paper about recipient/donor size mismatch and downsizing lungs to “fit” small patients with cystic fibrosis (CF). We showed that our surgeons were correcting for differences in predicted Total Lung Capacity (TLC).

When I chaired the OPTN’s lung allocation subcommittee, I tried (unsuccessfully) to get listings based on % predicted TLC, instead of listing with a weight or height range. Some committee members understood that the concept was correct, but thought it would be difficult for physicians and lay people to understand. Eurotransplant physicians have been using TLC to list patients since 1990 (personal communication, Patrick Evrard).

In normal humans, lung size is a function of height, sex, race and age. Each lung fills a pyramidal box with a height and radius. Height is the distance from base (diaphragm) to apex of the box. Because of racial differences in limb:trunk length ratios, there is a racial correction for height. A 6-foot tall Caucasian has shorter legs (and therefore a longer trunk) than a 6-foot tall African American. A 6-foot tall North American Indian or Hispanic has even shorter legs (and therefore a longer trunk), than a Caucasian. So for the same height, different races have different lung volumes (lung sizes). African Americans have 10% less TLC than Caucasians for the same height, and Hispanics about 10% more.

As an aside, this racial difference in limb:trunk ratio may explain the racial mix in the NBA. For the same height, African Americans have longer limbs, meaning a longer arm reach, and longer legs, which means they have a mechanical advantage over Caucasians in the jumping department. Although there are some Hispanics in the NBA, there aren’t as many in proportion to the U.S. population.

Radius of the box is related to sex. Women are smaller around for the same height as men, so their radius is less for the same height. The volume of the thorax is related to the square of the radius, so females have much smaller lungs than men for the same height. Just look at % predicted TLC on a set of PFTs from men and women. Also, look at lung size on a CT scan. Tall people have more slices (height), and women have smaller lungs. Weight is related to the soft tissue around the lungs, but only adds a “restrictive component” because it’s harder to contract the diaphragm against all that abdominal content. Age is the least important predictor, but relates to the height of the box. As we age, our thoracic spines “shrink”. So a 6-foot tall 70-year old male has smaller lungs than a 6-foot tall 25-year old male. Chances are when the 70-year old was 25, he was taller.

What happens with disease? Patients with obstructive lung diseases (COPD and CF), develop larger sized boxes, due in part to flattened diaphragms and increased AP diameters. After lung transplant, the flattened diaphragm corrects right away, but the increased AP diameter may persist for a long time. For that reason, our CF patients sometimes have >100% predicted FVCs 1 year after lung transplant. Conversely, patients with restrictive lung diseases have reduced thoracic volumes. Their AP diameter (radius) is less than normal, and may not completely correct. So, you can undersize patients with restrictive disease to some extent. If you undersize patients with obstructive lung disease, you may pay a price.
What’s the bottom line? Calculate % predicted TLC of your recipient - if they were healthy - and the donor, based on their height, sex, race, and age. Then decide how much mismatch you will tolerate. DO NOT waste your time measuring lung height on a chest X-ray. Want more height? Increase the tidal volume (VT). Want less? Decrease TV. Also beware whether the film was shot during full inspiration or expiration. That’s all the measurement tells you. Now with “protective” ventilation strategies in ICUs, lungs are often small on CXR because of low VT ventilation. Some centers make coordinators waste time with a tape measure. There are reliable equations for predicted TLC with correction for race. The equations are different for adults and children, and may not be reliable for adolescents during a growth spurt (particularly males), because of limb:trunk length ratio discrepancies.

When I posted some of this information in the lung transplant forum in response to a question about donor/recipient lung size matching, someone wrote that older donors often have larger lungs, especially when they have a smoking history. If the lungs look large, it’s because the donor has emphysema or COPD, not because they grow with age.

Finally, beware of the indeflatable donor lung upon disconnecting the ventilator. We once transplanted a CF patient who had a previous right lower lobectomy, so the right hemithorax was quite small. Our plan was to place a right lower lobe in the right chest, then go on bypass to replace the left lung. The donor lobe did not deflate when we opened the bronchus, and the implant was difficult. We had the same problem on the left side. The recipient always had poor FEV-1 post-transplant. He later met his donor’s mother, and learned that the donor was being treated for asthma, but in her grief at the time of his death, she forgot to mention this. Although some centers claim that asthmatic lungs are safe to transplant, we routinely turn them down. Sadly, our recipient died of BOS after 2.5 years. Poor deflation was missed by the retrieving surgeon.

You can always make a big lung smaller.¹ You can't do the reverse.

Disclosure statement: Dr. Egan served on the OPTN Thoracic Organ Committee and the Lung Allocation Subcommittee from 1998-2005. He chaired the Lung Allocation Subcommittee from 1999-2005. He has no financial disclosures relevant to this article.

References: