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Seminars AATS International Roundtable of Lung Transplantation for COVID-19

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Dr. R. Taylor Ripley (Houston, Texas): On behalf of the American Association for Thoracic Surgeons, thank you for joining us for Seminars International Roundtable Discussion of Lung Transplantation for COVID-19. My name is Taylor Ripley, and I'm the Thoracic Editor for Seminars in Thoracic and Cardiovascular Surgery, as well as a thoracic surgeon at Baylor, College of Medicine in Houston, Texas.

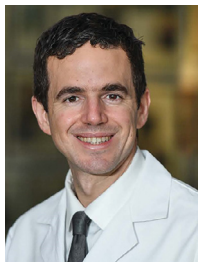
As everyone is aware, COVID-19 continues to ravage all of our communities. Based on World Health Organization data from the end of July, 2021, over a 196 million confirmed cases and 4.2 million deaths have occurred worldwide. While these numbers are huge, they may significantly underestimate the actual disease burden, given that many patients contract the disease and some die without an established diagnosis.

Fortunately, vaccinations are effective against COVID-19 and 735 million people worldwide are fully vaccinated (July, 2021). However, a large percentage of the population remains unvaccinated. Additionally, mutations in the virus such as the Delta variant are changing the rate and methods of transmission. These factors are contributing to the continued disease burden which indicates that we will deal with this disease for the foreseeable future.

For many patients who have the disease, chronic respiratory failure develops—even with clearance of the virus. Which leads us to the topic of our discussion today.

It is my pleasure to introduce the panel of internationally distinguished lung transplant surgeons and members of the American Association of Thoracic Surgeons, who have all performed lung transplantation from COVID-19. Today, I'd like to thank Dr. Bharat from Northwestern, Dr. Hoetzenecker from the Medical University of Vienna, Dr. Machuca from the University of Florida, Dr. Cypel from University of Toronto, and Dr. Loor from Baylor College of Medicine for joining us for this discussion of their experience.

I'd like to start off the discussion with our panelists by noting that Dr. Cypel, in Lancet Respiratory Medicine, discussed 10 considerations that should be assessed for patient under evaluation for lung transplant. The first question I would like to propose a group is: How do you determine whether lungs will recover from COVID-19, or whether the damage is irreversible and transplantation is indicated?



Dr. Gabe Loor (Houston, Texas): I think that's a very important question. I think that Dr. Bharat's paper in Science brought awareness that there are fundamental fibrotic changes that occur in these lungs. And that, in and of itself, is not sufficient as to warrant transplantation for a patient.

But how we decide when it is time for transplant is extremely difficult and I'm very interested to hear the panel's discussion. I think its risks and benefits waiting versus the risks of transplant. The upfront risks aren't huge, but the long-term risks can be substantial in terms of chronic lung dysfunction.

Dr. Ankit Bharat (Chicago, Illinois): I can give my 2 cents here. This is a question that I think we're going to just have to continually work on understanding. Right now, this question is just a matter of opinion and institutional experiences. I don't think we can set any hard criteria right now. But what I will tell you is based on a lot of work done by our research group and some of our collaborators, we clearly have established that some patients with severe COVID-19 end up developing permanent lung damage. There's no question about that. And one of the fundamental differences in these patients compared to other types of infections, for example, a bacterial infection and even influenza, is that in that subset of patients who have severe COVID-19 and develop permanent lung damage have the damage to the fundamental framework of the lung.

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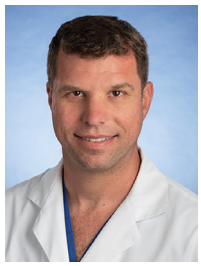
So, the actual architecture of the lung gets completely destroyed and that then established irreversibility in these patients, and that is something that we don't see commonly in influenza and other types of respiratory illnesses. The second thing that we found is that in some patients when that permanent damage starts to occur, they start to show specific markers. One of the things that we have discovered was the presence of these keratin 17 cells. These are cells that represented a differentiation defect between AT1 and AT2 cells. It's also a common hallmark in—as we are understanding more and more about this—some other types of fibrosis like IPF (interstitial pulmonary fibrosis). And then one of the things we're trying to do right now is to develop an ELISA (enzyme-linked immunosorbent assay) based assay from the BAL (bronchioalveolar lavage) that would help maybe predict this question about irreversibility.

A lot of work is being done, but I will say that clearly there is a subset of patients who are going to need transplants. So how do we, at the current time, determine which patients need it versus waiting too long? I think that the way we approach this at our center is to bring in multiple people from different specialties and having these discussions over and over again about individual patients. The things that have come out is number 1, you want to give every patient sufficient time. And that sufficient time period is also somewhat arbitrary, but we always try to give patients minimum of 4–6 weeks on the best medical treatment. Now, that doesn't mean that at the end of 4–6 weeks you list them for transplant. What that means is, after 4–6 weeks we continue to assess these patients and as long as they're making recovery, or if there is a consensus among the group that there is a possibility of further lung recovery, we will continue to support those patients.

The trigger to pull lung transplant is based on once we see specific changes radiographically with diffused end stage bronchiectasis changes, development of extreme Ebola or extensive lung necrosis, which the team does not think can be a reversible process. The other thing is, in some patient's development of long-term fibrosis but really bad compliance over the weeks and months. Or finally, one of the important things that we always consider is a potential for lethal complications. They're starting to develop things like severe pulmonary hypertension, that's setting off severe lung necrosis and damage and then multi-drug resistant nosocomial infections. In those patients you may want to—or at least we think that we may want to pull the trigger for transplant a little bit sooner.

It's a complicated question. Something I think, because the group of these patients are so heterogeneous and our understanding is evolving, we have to look at it case by case. And I cannot overemphasize the importance of this multidisciplinary discussion. Not just 1 discussion, but over days and weeks that discussion for each patient.



Dr. Marcelo Cypel (Toronto, Canada): I can also follow on that. I totally agree with everything that Ankit just mentioned. We also take a similar approach. We start looking at the patient after 6 weeks. They are on ECMO (extracorporeal membrane oxygenation). That's when we start looking. And we do ICU (intensive care unit) rounds, and we say, this patient is over 6 weeks, now could this patient be a candidate? And that's when we start the multidisciplinary discussion.

I think we've been very impressed also in—as Ankit was saying—in one way, some patients develop this fibrosis. We've also been very impressed with the capability of the lungs to improve after looking completely destroyed on imaging. We had the benefit here of having a very centralized ECMO system where basically almost every ECMO for COVID-19 in the catchment area, 15 million of the provinces of Ontario, come to our center. So, we treated over 150 patients on ECMO for COVID here. And we had the chance again to observe many patients developing lung recovery after several weeks or months after being very diseased.

And I think radiologically there are some observations which I think are important. When you have a completely consolidated lung, that's something we don't get too worried about because consolidation, and opacities, and so on. Of course, we get more worried when we start seeing bronchiectasis or traction bronchiectasis, and also bullous destruction of the lung because those will be very hard to go back to a more normal state. When you have those changes associated with poor physiology and over 6 weeks, that's when we start to screen those patients.

Dr. Tiago Machuca (Gainesville, Florida): If I can share the experience here at University of Florida, I think we follow very similar approaches. I think that imaging is important for us, but I don't think we can jump into making any definitive conclusions with 1 snapshot. Time is very important. The more time you give for these patients you're going to improve their rehabilitation potential.

What we do is essentially follow the patient and when they start to develop some signs of fibrosis or bullous destruction, we want to make sure that that is progressive—that it's not with 1 isolated, focal area of fibrosis, or bronchiectasis or bullous destruction. You're going to follow that patient and when that severity starts to become more diffused is when we really start thinking about transplantation. I really think that the determination of irreversibility is really the most important and pressing aspect of lung transplantation for COVID. I think we need to be careful not to list these patients early on. Obviously if you transplant this patient that can have a potential of lung

recovery, you're going to be limiting the patient's life expectancy. And as Marcelo alluded, I think we are learning a lot in the field with COVID in terms of how resilient the lung can be. We did consider several patients that were transferred to us, and they were only placed on ECMO because transplantation was a possibility.

So late ECMO initiations—and as long as the radiological findings are related to ground-glass opacities or consolidation I think that there's still a very high likelihood of lung recovery. So, I think timing and when you see the lesions like fibrosis, bullous destruction, and other hallmarks of chronic lung disease such as bronchiectasis, pulmonary hypertension and when they are progressive over time, I think is when you really start thinking about transplantation. And I think the other aspect that Ankit mentioned is, we all know that these patients eventually start to develop complications. When these complications start to be life-threatening—repeated episodes of a secondary bacterial infection, septic shock, or bacteremia—you really need to be worried about timing, right? You want to wait to determine that that lesion is irreversible, but you also do not want to have that patient in repeated life-threatening complications to a point that he is no longer a viable transplant candidate.

Dr. Konrad Hoetzenecker (Vienna, Austria): I agree with a lot of things that have just been mentioned. I don't honestly agree with the timeframe of 6 weeks or to state that 6 weeks is the absolute minimum you should wait before considering a patient for transplantation. Similar to the Toronto experience, most COVID ECMOs of the eastern region of Austrian had been inserted in the hospital where I work. Therefore, the Lung Transplant Program follows these patients immediately after they are put on ECMO. Some patients became transplant candidates after 2 weeks, 3 weeks because they developed lung necrosis because they had repeated septic episodes.

If you just wait for 6 weeks before considering a patient for transplantation, you will lose these patients with a complicated course — I always refer to them being the "real" ARDS patients. The other portion of patients that become transplant candidates after 6–8 weeks, are more like IPF patients. They're in a chronic state of disease with scars in their lungs and they simply fail to recover. Also, in regard to technical aspects of the transplantation, I have the feeling these are 2 different kinds of diseases. The ARDS patients are more complex to transplant. They usually lose a lot of blood, and the transplantation itself is more difficult. But the chronic fibrotic patients are more like bridged IPF patients. There is less blood turnover and they quickly recover after the procedure. And I think talking only about when is the right time to consider transplantation misses a lot of patients who die before they could even reach the 6-week time point. And we must not forget that mortality despite best conservative treatment is still about 50%, even in experienced ICUs.

A lot of patients that could be saved with a transplantation are lost by arbitrarily defining a time when you can start to consider them for lung transplantation. At the end of the day, it's a very individual situation. Some patients might become a candidate after 3 weeks if there are big abscess formations or if they develop ECMO related complications. I remember 1 patient who had severe bleeding, with recurrent hemothoraces. And of course, the lung never sealed the thoracic cavity because it could not expand. After the transplantation everything was much better and I'm sure we would have lost the patient would we would have waited for 6 weeks. Time to consider transplantation is a moving target, we don't have any data yet to guide us. At the end of the day, it's a very individual decision and we still learn with every single case.

Dr. Ripley:

This discussion leads to a question about timing. We're debating 6 weeks as being too long or the optimal period. Are you talking about 6 weeks after respiratory failure for COVID or 6 weeks on ECMO? And do you distinguish ECMO and time on ECMO from the actual time of the disease process to when the patients either were first sick or at least first admitted to an ICU?

Dr. Bharat:

We look at the onset of severe ARDS. That's the time period that we start looking at someone who was admitted with mild symptoms for a few days—that for us, doesn't start the clock. But it's not, as Konrad and everybody pointed out, about a hard stop or start-or-stop. It's really putting everything in perspective. In our experience we've seen that most patients do tend to get better or at least start to show signs of recovery within that 4–6 weeks window. And I think consideration of transplant sooner than that—I mean you can encourage their risk of over treating that, which I think for something like lung transplant is quite burdensome.

You don't want to be over treating a lot of these patients. And a lot of these patients are quite young, and you've shortened their overall lifespan compared to a spontaneous recovery. But as other speakers mentioned, if they have severe complications that cannot be managed with the ECMO and ventilator we would escalate the timeline a little bit. But to what you said, Taylor, we generally look at the onset of severe ARDS as when we start to assess lung recovery, not necessarily from when patients were admitted or had mild symptoms.

Dr. Cypel:

I also agree with the clock start in the respiratory failure. And I take Konrad's point quite well. Vienna has a long tradition of doing transplant for ARDS patients before COVID, so they do have good experience on that. You know, I think when we put it on paper, like we're writing on the back of the tutorial, and we say 6 weeks—I think as we speak here, we have to be careful. And the reason to put an arbitrary timeline is that of course we are expert centers here, but the major worry we have is that people would start transplanting patients

after a very short time because of significant ARDS across the board and I think that clearly wouldn't be right.

I think 1 thing is what we set as a potential guideline, but of course, there is the individualization of cases that we all need to make. But I think we all feel that around the 6-week mark is when we should start looking more seriously. But again, individualizing cases more.

Dr. Loor:

Taylor, I agree with Marcelo on all accounts. I think you certainly feel better about it if you've allowed some time to transpire. Some centers have certain built-in mechanisms where, as you know Taylor, in our place we have this 30-day positivity and negativity situation where they try to make sure that it's been at least 30 days from a contracting a virus standpoint. So that alone sets up a little bit of a barrier. That notwithstanding, what Konrad mentioned, which is not missing these patients who you do have to catch early, I think that some programs have some already. Some stop gaps where the transplant team is probably not even fully aware until 30 days have transpired.

And with those lenses, the amount of times that they've asked us to evaluate patients, those patients either get transplanted, they're not candidates, and by that time I've seen very few recover unfortunately. Once they're on ECMO and it's been past 6 weeks, I think it's been very few that have had a full recovery. The ones that have not been candidates for transplant, a few of those have actually recovered. And you had to wait for a variety of reasons, but I think you definitely feel better about it once it gets past 30 days or 4–6 weeks.

Dr. Machuca:

I think it's very important for us to reinforce the concept that this timeline of 4–6 weeks from respiratory failure, we consider that just to start transplant conversations and considerations. I think it's not uncommon, all of you here probably face that when you're talking about lung transplantation for COVID. That some may miss this concept and mention that, 'I had a patient that was on ECMO for 2, 3, 4 months and recovered'. I really think we need to stick with the idea that 6 weeks of respiratory failure is to start consideration to look at other transplantation criteria. Does this patient have signs of irreversible lung damage? And does it meet the other proposed criteria? Does a multidisciplinary team of experts that have experience with ECMOs bridge to recovery and determined that this is really irreversible? The 6-week proposed time frame is so you can consider more strongly transplantation and look at additional criteria. It doesn't mean that by 6 weeks that patient did not recover on ECMO so now let's list. I think that's very important.

Dr. Ripley:

I want to briefly mention that patients over time have increasing complications. So, should lung transplantation for patients on ECMO be limited to single organ failure? And as a corollary, should patients be able to provide first-person consent in order to undergo the transplantation?

Dr. Loor:

I'd be really interested to see what the group thinks. That's the huge question. Typically, we like a patient to be awake. Awake on ECMO, at least. Ideally, maybe ambulatory. We do ideally like to have single organ, but COVID has tested a lot of our criteria. You have patients presenting in a comatose state, who are young, and they have single organ, and they can't get them off sedation. Sedation is a very challenging thing to try to wean some of these patients off without them desalting. As you know, we do like to wait until they're awake and we can get that sedation down and we do whatever it takes from an ECMO status to try to get to that point.

But a lot of times, I do wonder, and I worry that there's some patients that they don't get the option of a transplant because you can't quite get them there. So, curious to see what the rest of the group is doing.

Dr. Machuca:

For us, we really push hard to have patients awake. And I think probably you all have dealt with the scenario of patients being transferred to you after 1 month on ECMO. The patient doesn't even have a tracheostomy and is sedated and often paralyzed for a long time. This is a lengthy process, and in our experience, it is not uncommon to see a patient taking a month to start waking up and starting to participate in physical therapy, but we really feel that that is the ideal scenario. This patient should be at least participating in physical therapy and awake to be able to make decisions.

And with regards to multi-organ transplant, we have embarked on that. We have performed two combined double lung kidney transplants. I think this is the scenario that often times we face in terms of additional organ failure and in very, very specific selected cases of patients that have proven that they have a great rehab potential—very strong family support, and their willingness to really work with the team to overcome all the barriers to recovery. I think it's important and at the end of the day, it all comes to the morbidity potential. That additional organ that you are considering, how much of a morbidity are they going to add? How much of a recovery is going to be impaired by that? And I think in what we saw in these two cases recovery was very uneventful and we did not have any additional issues when you compare them to the double lung after COVID ARDS.

Dr. Bharat:

I agree with what Tiago said. I think multi-organ transplant is definitely a reasonable consideration in a highly select group of patients.

Now, I would say a couple of things—we have a few patients also listed for lung-kidney. We haven't done one yet. They've been listed for a while. The issues that we face; number 1, patients who are really sick from COVID and have been on ECMO and have many complications, the intraop blood loss is quite significant in these patients.

They go through this period—they become quite unstable and then coming out of the lung transplant they could be on

lot of pressers, and you could be requiring a lot of fluid. In those circumstances, consideration of a second organ, particularly things like kidneys, could be challenging. Certainly, it can be done. A lot of things that could potentially be considered as a strategy, separated by 12—14 hours or so. But you just have to be careful because the intraop events from a double lung transplant for COVID could be quite dramatic. That could have substantial implications on a second organ.

The other thing is a number of these patients because they've been in the hospital for a while, they could be highly sensitized so they could have a lot of high PRA and those kind of things. And certainly, that requires a lot of blood transfusion, so that could also have impact in organs, like kidneys and so forth and you don't want to be dealing with a lot of rejection soon after the transplant. The point I'm trying to make is this has to be a highly select group of patients, but it should be considered.

And then the other thing about getting the patient's awake, I think Konrad may want to chip in a little bit more, the first patient that we transplanted was in the same situation where we could not wake her up. She was 28 years old, and we had to just pull the trigger here. But what we've tried to do is what's been mentioned; tried to give these patients enough time to wake them up. And as our ICU team, and our pulmonologist, and critical care team become more comfortable weaning the sedation off, getting them off the PEEP. Once the decision is made that transplant is a consideration, we are seeing a lot of these patients are able to get woken up. In the thirty or so transplants we've done, except for the first one, we've been able to wake every single patient up.

And the point of that is number 1, we always want to make sure that this is consistent with the patient's wishes. Families always trying to say don't do it, they're trying to do everything to save their loved one, but is this something that the patient wants? Is it going to be compliant? You also want to make sure there is no neurological effects from the coronavirus itself, which is being more and more well described. I would say that I certainly recognize the importance of leaving that open ended for a select group of patients, who we think clearly would want the transplant, clearly would not cover, and clearly don't have coronavirus induced neurological damage. Absolutely could be considered in a highly select group of patients, but I think for the majority of the cases we should absolutely try to wake them up and give them sufficient time before we make the consideration for transplant.

Dr. Loor:

What's the group's experience been with hyperbilirubinemia? My experience has been that I really don't like to operate in that setting, when the bilirubin's too high, because then you get into liver dysfunction and what Ankit was mentioning in the blood loss, vasoplegia, etc. We try to wait until it comes down, but I feel like there's some phenotypes of COVID where you get this hyperbilirubinemia, and it doesn't resolve. Has anybody considered a lung-liver in these cases? What's your experience been like?

Dr. Hoetzenecker:

I think that's a very good question. We haven't considered this as a contraindication and many of our 21 patients had heightened bilirubin levels, which we considered not that important. Traditionally, in ARDS literature there is a cut-off of 1.9 milligrams per deciliter bilirubin when considering lung transplantation.

We know now and I've just read a recent publication from Hannover, that 30% of post-COVID ARDS patients have significant liver damage despite their lung recovery. In our transplanted patients we saw a similar number, 30%—40% who developed liver dysfunction after the transplantation. Many of them had normal bilirubin levels before the transplantation. Some had slightly elevated levels, which we considered to be consistent with critical illness cholangiopathy, cholangitis maybe, but we didn't pay that much attention. Now we see that this can be a significant problem after the lung transplantation. All of their grafts are fully functional, many of them are discharged home, and then they suddenly developed a picture similar to a secondary sclerosing cholangitis.

We have two patients now who will even require liver transplantation. They're on the liver list. This is a very interesting topic. We haven't really realized this scenario before and I think that's important during the decision process if you plan to list a patient for lung transplantation. In contrast to this, kidney failure is not a big issue. 20% of our transplanted COVID patients had a temporary kidney failure at the time of listing. We knew that their kidney was well-functioning before the COVID infection, and all of their kidneys fully recovered after the transplantation.

I don't think any of those would have been candidates for a combined liver-kidney, and we usually just do the lung transplantation, wait and the kidney usually recovers. In terms of awake bridging, we again follow a somehow different strategy in Vienna. We don't consider an awake status as a necessity for being listed, if the indication for a lung transplantation is given, if the team thinks that the native lungs cannot recover or there are secondary hits like an infection, which makes the recovery very unlikely, then a next of kin consent is enough to list the patient.

Once the indication is set, we don't want to waste time by trying to wake-up a patient so that he can participate in physiotherapy. The likelihood, at least in our hands is very low, only about 20% of acute ARDS patients can be bridged awake Therefore, we transplant up front and then recover the patients afterwards. And this is the same rough road which Tiago, Ankit, or Marcelo described in their pre-transplant patients. Recovery after the transplantation is similarly difficult, it takes a couple of weeks until patients regain their muscular functions, but it is feasible to do this after the transplantation.

Dr. Cypel:

If I can just follow up on that Konrad, I think that's a great comment. For us, we also try to wake up everyone and have a conversation. For the COVID patients it is very difficult to get them awake, especially in the first 3 weeks. And I think it's part of

this inflammatory process, and as Ankit mentioned, there is a much higher incidence of brain injury as well related to COVID that is probably under recognized that's a part of this difficulty waking these patients in this inflammatory phase. But once they go beyond that inflammatory phase, I think it becomes easier to wake them up when you get to the fourth or fifth week.

The other important part is to work very closely with your ICU team on that because it's very common that these patients will desaturate when they are getting more awake. And the first thing that they will do is to sedate them again, right? So, we had to go to a lot of persistence to say, let the guy sat 80% that's fine, his lactate is normal, and look at the oxygen delivery more than oxygen saturation. I think that's a process which we are learning as well and it's very important.

Another thing is, I agree that the family can have a very good idea of the patient wishes. But interestingly, we did have a couple of patients that we discussed about transplantation while they were on the ECMO, and they didn't want to go through with it. We do see situations like that. Those are the patients that could be a bad situation if you had transplanted without their consent, so I think we still have to try to persist on getting first person consent.

Dr. Ripley:

On a related topic, we've been talking about transplant patients who have ARDS, are critically ill, and are on ECMO. Are you all seeing patients in clinic who've actually recovered from acute illness but have chronically high oxygen requirements similar to pulmonary fibrosis?

Dr. Loor:

We have a follow-up COVID clinic, and we have seen several of these patients. But all of the patients that I've been involved with transplanting, at least 80%−90% of them, have been in hospital situation—maybe only 1 or 2. The other ones seem to very gradually be getting better but sometimes it takes a year or 2 years. But they're on the radar screen.

Dr. Bharat:

Similarly, we also have what we call a Comprehensive COVID Care Center and we are following a number of these patients on an outpatient basis. A number of them are requiring oxygen. They've had a significant decline in their PFTs. But we are just following them right now. Because their hearts are fine, they're not developing PH (pulmonary hypertension) with artery failure—yes, they are on oxygen, but they're able to continue on with their lives. Right now, because we just don't know what the next 6 months or 10 months or a year is going to bring, our approach is to just follow them right now (obviously very closely) and if they start to get worse, we'll have no hesitation in considering for transplant. But right now, every one of the transplants that we've done, they are there the patients who had ARDS and they never left the hospital. Or they may have left briefly to a rehab, and they bounced back and so forth. We haven't done anybody so far being of mild to moderate disease and never was hospitalized and just being followed up. But I have no doubt we are going to see those patients down the road.

Dr. Hoetzenecker:

Maybe a little different input here. We have done a tracheal resection in two patients after COVID, after mild COVID, so their lung function was okay. Their CT scans were okay, no remnants of disease, but they desaturated quickly. Usually, patients tolerate apnea phases lasting a couple of minutes, but these 2 patients didn't tolerate this at all. So, there is some kind of subclinical damage still present in these lungs. We don't know whether they will eventually fully recover. We follow Ankit's approach, just wait, watch, and don't transplant those chronic patients too early. I agree that some of them might recover.

Dr. Machuca:

In our experience here, I think it's similar. We see very positive recovery. Once the patients are out of the ARDS phase and decannulated. We followed them and the great majority eventually evolves to being on room air. But this process can be lengthy;6, 9, 12 months, but they eventually recover. We did have one case that we transplanted, there was a patient that was on the ventilator for 2 months and went to rehab, and the patient developed diffuse fibrosis. And after a period of 9 months is still on oxygen, 3−4 liters, and resembling a diffuse interstitial pulmonary fibrosis so that patient was transplanted. But I think we're seeing a lot less and we would imagine, and I think as well, it's important to follow this patient and see what's going to be their pathway for recovery.

Dr. Loor:

Taylor, I don't know if you're going to discuss this but one thing—maybe it's not as much a question anymore—but early in the experience there was a lot of question about the infectivity. At what point is it safe to do the transplant? for the surgeons? for the team? for the patient? for getting a new infection? We've experienced that here, where if somebody's still positive and you're worried that it reflects a reinfection, that it may not be safe to transplant. Is that something that you were going to discuss?

Dr. Ripley:

I think Gabe, you're exactly right. We've briefly touched on this discussion so far, but I'd like to go through a few questions on the virus itself. As you bring it up and as we all know, the mortality after surgical procedures for non-transplant is higher with patients with PCR detectable disease, but Dr. Hoetzenecker reported a patient who did reasonably well with persistently positive disease.

Additionally, Gabe and I have had the experience with similar patients, where they were good candidates for transplant other than persistently positive for disease. One patient had disease that was negative for multiple days and then reappeared with positive tests weeks later. This topic leads to several questions. The first I'd like to propose to the group is, should negative tests be required to transplant patients? And how long?

And second, should we do deep, respiratory infectivity assays as a true negative test? And then, I'd also like to hear if the group has had any experience with either reinfections of

COVID in the lung transplant or even infections of something like the more transmittable Delta variant in patients who've already had transplantation.

Dr. Hoetzenecker:

Yeah, maybe I can start here. The first case we did in Vienna was not infectious. This was a PCR positive patient, but the CT-value was above the threshold. Nevertheless, we did virus cultures, twice from deep alveolar lavages, both of them were negative. This was, at least for us, a prerequisite for listing a patient - that the patient is not infectious any longer.

We have not transplanted a true PCR positive patient yet. On the other hand, the time when we consider a patient being a transplant candidate is several weeks after the onset of infection. Every patient in Vienna so far has been repeatedly tested negative for the virus, even in deep brushings or lavages. I don't think persistent infectivity was an issue in any of the worldwide transplanted patients so far.

Dr. Bharat:

Yes, I agree with Konrad. I think if you have viral cultures then that should be utilized. If you look pretty much every report that's been published in some of these top journals, they've shown that from the symptom onset, by about 10 days most patients don't have replication competent virus. Now, that doesn't hold true if a person was immunocompromised. For some reason their reports close to 200 days have been reported for replication competent virus.

The dilemma here is these patients with unclear past medical history—we just don't know what their true status has been. If the viral cultures were available in patients beyond that 7—10 day window, absolutely I think that should be used. But the reality is most of the centers in the US, including ours, we don't have access to viral cultures. It requires the BSL-3 level labs which we're working on. But in the absence of that how do we make the decision? I think that we've got to stick with negative cultures because a couple of things.

Number one, it does reduce the chance of a possible scenario that you're transplanting someone who could have relapsed and could be really bad, and it could expose a number of the people caring for that patient in the process as was highlighted in one of the reports in Michigan. That was a different context, but it does show that these lung transplants in patients who have some kind of replication competent virus could be really damaging to the care team.

The second thing is, by allowing negative PCRs, it also forces the team to give sufficient time to allow lung recovery in my mind. If someone is still positive, let's say 3—4 weeks, we use that as an argument to give the patient more time. Because not only does it give you some time to allow the PCR to get negative it also forces us to give more time for lung recovery, reducing the chances of a premature lung transplant.

So, what I would say is that I strongly feel in the absence of viral cultures we should still stick with a negative PCR because the risk of transplanting someone with a replication competent virus are too great and I just don't think they're warranted in the current circumstances.

Dr. Cypel:

I would agree with that. And I think every patient, by the time we consider transplanting, we're already negative on PCR but I think that certainly should be looked that. I think the CT values are good as well. If you have CT values above like 24—25, be certain that that virus no longer has infectious capability, but I think we will still use a negative PCR as a criteria.

Dr. Machuca:

Same thing for us here. I think we rely on a negative PCR and since these patients are so far out from the initial infection. I think most of them have been a negative PCR by the time they were considered for transplant. The other thing you alluded to, about reinfection with the Delta variant, I think our system is being stressed now with the amount of patients being admitted with COVID from probably the Delta variant. I think Florida is becoming an epicenter now, so we are having a lot of patients that were recently transplanted that did have exposure. But so far, we did not have any case of a reinfection from COVID and I hope we don't see any.

Dr. Ripley:

This point brings us to our next topic of conversation. Recently, the authors on this panel reported 1-year survivals of 94% with their collective experience. Will you all briefly discuss what your expectation is for long-term survival of patients after lung transplant compared to lung transplant for other indications?

Dr. Loor:

Anecdotally, in the dozen or so that we've done it's not been very good outcomes. They're younger, they're in good shape, they're selected, they meet all the criteria for good outcomes on ECMO. I have to map it out, but I think that the expectation is that if they're selected well that they should do well.

Dr. Hoetzenecker:

We are heading to a 1-year survival of about 85%, maybe even higher. Obviously, at this time we only have a couple of patients who survived longer than 1 year because this pandemic started not that long ago. The survival data we have so far is consistent with the ARDS literature. If you select your ARDS patients well, you get a survival which is close to the one of chronic lung failure indications. And this is a very strong argument in favor of t transplantation — also considering that without a lung transplant those ARDS patients have almost a 100% mortality rate. I'm not aware of any other treatment with such a huge difference between lethal outcome without it and excellent outcome with the treatment. That's a very strong argument to favor transplantation for COVID ARDS despite that there's a high number of patients on the waiting list.

And the waiting list's mortality rates are, at least in some parts of the world, increasing but the outcomes are just so good that we cannot simply refuse to do a transplantation for post COVID ARDS.

Dr. Bharat:

I concur with both Konrad and Gabe. We've done about thirty so far and we have a 100% survival. Three of our patients

have crossed the 1-year mark. And they've surprised us. Despite how critically ill they were they've had multiple complications, including just a really rough ICU course prior to the transplant with thoracotomies, hemothoraces, nosocomial infections and so forth, but they're post-transplant recovery has been tremendous.

A couple of things I will share with the group; number 1, there were several debates we went through like nosocomial infections, which are multidrug-resistant, should they be considered? patients who've had these prior thoracotomies? And then what about the blood transfusion rates? And so forth.

I will say that we've not seen any patient, and obviously this is just 1 institution, but we've not seen any recurrences of those nosocomial infections after the transplant. And again, the hypothesis is it just mimics the cystic fibrosis patients who once you have normal lungs they probably are not going to recover when you have structural damage with bronchiectasis changes like necrosis, then those organisms don't clear. Frailty was also a big debate in our center for pre-transplant, because all of them are extremely frail. Should we be considering them in that situation? But I tell you, these patients dramatically got better, and their frailty indices kept getting better and better very quickly. And again, a lot of this is patient selection. There are relatively young they were normal prior to the transplant, and they had a short duration in this unlike a 65-year-old IPF patient that has been struggling for many, many years.

The other thing that we've seen; interestingly, despite all the blood transfusions and so forth—and I recognize this is just at my center—we've not seen acute rejections post-transplant in these patients, which is quite intriguing to us. We are looking into why that may be happening. In normal patients who have chronic established lung diseases we see up to 30% incidence of acute rejection within the first year of different severity. But in these patients, we're seeing a substantially lower incidence of de novo DSA, the donor specific antibodies, and so forth. All these things make me kind of speculate that these patients are going to do similarly as the chronic, if not better, over the long term. It's something that we'll have to constantly monitor but I don't see any reason to think that these patients would not have a similar or better long-term survival.

Dr. Hoetzenecker:

Maybe I can ask a to the other panelists. Ankit, I know that you have not seen acute antibody-mediated rejections in your patients despite—and this is similar to here in Vienna—despite the fact that some of those patients, have pre-formed donor specific antibodies. Most likely because they received lots of red blood cell concentrates.

Has anyone else seen an AMR as a significant problem during the first couple of months? Marcelo? Tiago?

Dr. Cypel:

Our experience is certainly smaller in terms of the numbers that you have, but we haven't seen them. I share the same passion that Ankit mentioned, that it's amazing how these patients recover post-transplant—much different than you would expect someone in the ICU on ECMO for 3 months. Even based on our experience with an IPF patient on ECMO pre-transplant just for a few weeks. They tend to recover much more slowly than this population. I think it reflects not having chronic lung disease for years, and steroid use, and other things. I think the concept of frailty here, it has to be totally reassessed, because it's a different situation. But no, Konrad, we haven't seen AMR in these patients.

Dr. Hoetzenecker:

Gabriel?

Dr. Loor:

We had 1 of 12 and we hypothesized that it was because we had to reduce her cellcept. Her platelet counts with very low afterwards and we wondered if that was the issue. But I agree, it has not been a major issue.

Dr. Hoetzenecker:

I've just talked to one of my transplant pulmonologists early today. We routinely, in every single lung transplant patient, measure the virus activity, which is a virus present in every single human being. It's non-pathogenic, but you can actually monitor the effectiveness of your immune suppression without just looking at FK levels. And we have seen that the immune system in post-COVID ARDS patients is not as strong as it is in other transplant indications. Maybe that's the reason why we don't see any rejection—we don't see ACR nor AMR. That could be an explanation, that the virus has a long-standing effect on the immune system.

Dr. Cypel:

I think for the question about the long-term outcomes that I totally agree. I think we need to look at that very carefully. I think the other comparison that could be very interesting for us is again, we're talking a lot about how it's better to have the patient recover its own line and I think we generally agree of that. But I think we also need to look at what is the outcome of the patient that stays in the ICU for 3 months and recover from ARDS at that point. How is this patient doing at 1 year compared to the patient we transplanted 6 weeks and had a very speedy rehabilitation after transplant? I just think that would be an interesting aspect to look at as well.

Dr. Bharat:

Yes, it's a great point Marcelo. Actually, we just started to explore that and it's very intriguing. People who are saying transplant should not be considered the code discharge mortality in these patients. But that's not where the story stops. You can show that 60% survival to discharge, but then there's the language and the rehab center and all that. In our metropolitan area, post-discharge mortality in some centers is upwards of 40%. Like when these patients get discharged to a rehab center, they're either on the vent or they're doing all these things. So, with that complication itself our mortality is approaching 40%. That's a really high mortality that doesn't get factored into it. I think you're absolutely right to look at how those patients are doing and then factor those things. And then even the patients who survived post discharge with severe ARDS, what is that long-term in terms of their recovery? That's a very important topic that I think needs to be urgently addressed.

Dr. Machuca:

If I can share the experience here at UF, I think what we believe is that in well selected patients and in centers, they have the expertise and experience. I think what we're really going to see is that the outcomes are going to be very similar to non-COVID patients. The fact that these patients had been previously healthy even though they become heavily deconditioned, after period of 3—4 months, I think that the ability of them to recover is phenomenal. I think we're all learning that right now. And when you transplant these patients, we know that they're going to have a longer post-transplant course. What we experience is usually two weeks on the ventilator, and a month in the ICU, and an average time in the hospital for about a month and a half. That is significantly longer than the usual lung transplant that we do. But I think what is clear is that once these patients recover, they get discharged. We see a very, very low readmission rate, and we see a very low complication rate, acute rejection rate. I think this has been very clear to us that these are different patients and once they do recover it appears that they have a very favorable course.

Dr. Loor:

We have a lot of talented surgeons here and a lot of folks are going to start seeing COVID and they're going to have to decide if they want to go in and transplant the lungs. I think we've mentioned that the outcomes are pretty reasonable and have outlined some selection criteria and timing, but what should folks expect when they go in there? Do you guys have any technical pearls or interesting stories. I found it to be like a box of chocolates, you don't know what you get. Sometimes it's straightforward and sometimes it's surprisingly very difficult. I just wonder what your thoughts are what kind of precautions people should take in these kinds of cases.

Dr. Hoetzenecker:

Well, I think you should have sufficient experience with transplantations of ECMO-bridged patients. And this means that you should know how to substitute your patients during the transplantation. I think that the role of your anesthetists is extremely important to help you.

I agree that some patients are not too difficult to transplant but some can be a nightmare. There can be a lot of bleeding, and this can be difficult. One thing I consistently found in the COVID transplantations is that the hilar structures are different to chronic indications. There is this inflamed mediastinal fat, which makes the mediastinal dissection more difficult, and there are hyper-inflamed lymph nodes that tend to bleed a lot if you open the lymph node capsule.

I think these are 2 main things which makes transplantation different from bridged IPF patients, for example, and you need to have good control over the bleeding at the end of the operation. I also think that in this specific indication you must not oversize your lungs. Patients usually have a quite contracted chest and I have the feeling that oversizing will result in more problems after the transplantation. I tend to accept 80% of forced vital capacity after the procedure, but no complications compared to a 100% FVC and but a prolonged complicated post-operative ICU stay.

Dr. Bharat:

Yes, I will just add to that a little bit. What I would say is, for people who are considering this, I would say that surgery is a very important part of it but that's probably a small part of the success of this. I think for centers that are considering that, they have to do a very thorough evaluation of what kind of team they have, what kind of resources they have. And I'll mention small things intraoperatively; Can the blood bank give 20 units of blood at a short notice if they want? Do they have astute anesthesiologists that can support these patients through potentially some very rocky ups and downs? Do they have the right infectious disease team, pathologists, who can look at biopsies and distinguish complex lung pathology? Do they have the right ICU care team to get these patients post-op with their recovery?

I think it will be a mistake to just think that surgical skills exist in that center and that's sufficient to take on something like this. And that could really backfire. I think without this comprehensive team, it would be in my opinion and my view, it will be a mistake for centers to take on these cases.

And 1 or 2 mishaps—I mean these results that are being shared they're really exceptional, but the people need to recognize these are being performed at centers like Toronto, Vienna, Florida, Northwest, and Houston. These are really big programs that have that team, so that's very important. And if a center decides to pursue it, I will also say to stick to the basics of doing a good double lung transplant, using cardiopulmonary bypass of whatever support. I would say that until the papers that have come out, I would try and stick to the basics and not try to alter the fundamentals of the operation too much otherwise it may end up not going well.

Dr. Cypel:

Yeah, I agree. Just maybe one comment from a technical perspective. I think doing all these cases on VA ECMO is probably the way to go. I don't know if you guys have done some patients—because they all come on VV ECMO. And at least the cases we've done, we converted them to central VA ECMO for the transfer. Many of them will have similar disfunction too, so I think that's probably the safest way. And I think many of these patients won't need any ECMO post-transplant too, so if they need to go back on VV you just go back on VV. I know Konrad prefers VA for post-transplant mostly, but whatever your preference is I think it's okay. I put that also as a question to the group. Have you all converted these cases for VA ECMO during transport?

Dr. Bharat:

Yes, we always use VA ECMO. That's a very good point Marcelo. I think these patients should be done on VA ECMO. The way I look at it, unlike chronic patients who have maybe IPF or clamping without on VA ECMO I feel like their hearts are probably a little bit more conditioned in these acute patients. A lot of these patients already have RV dysfunction. They've not had chronicity to get accommodated to the clamping. And I

think that if you clamp an already marginal patient, that could be a recipe for disaster. I think using VA ECMO is a very, very important point here in my opinion and as you have pointed out. I also think that using a full cardiopulmonary bypass—again, this is just a matter of personal opinion—should not be used because they tend to bleed as is quite a lot. And the data that you've also shown in the past, VA ECMO against substantially reduced anticoagulation needs, it's such an important thing. In fact, we don't use any Heparin, we've done at least 3 cases who've had Heparin allergies hit and they were supported by bivalirudin in pre-op and then we just did it without any Heparin and did it just fine and there was much less bleeding.

If the patient was on VV ECMO, we do tend to switch back to VV ECMO and then give the patients 1 or 2 days and then decannulate them at the bedside rather than just take them out in the operating room. We just think it's a safety net. They're already cannulated so let's say they had a Protek Duo cannulation, we'll use that for drainage and put an aortic cannula in there and then at the end of the case go back to the Protek or whatever the VV is. Then we just take them out 1 or 2 days later if there is no PGD or any issues. But the VA ECMO is a very important point and thank you for bringing that up.

Dr. Loor:

That's what we do to Marcelo. When they come in with the Avalon, the only thing I haven't been super excited about is the drainage that you get from it. Sometimes I'll put in a second venous drainage cannula, usually through the groin, like a 25 multi-stage.

We try to keep our oxygenated inflow that goes to the tricuspid valve functional somehow, whether you clamp it or you give a little bit of IV fluid to keep it open so that we can use it at the end. Obviously being careful about air, but drainage has been the only thing that I try to be mindful about. But then once you get on VA ECMO, I agree it just smooths out the whole procedure.

Dr. Machuca:

I think this ECMO management may be the most important point in the operation probably that we could share. I think what we have been doing is when the patient comes on VV ECMO, when we anticipate that the pneumonectomy is going to be challenging with extra pleural dissection. Often times, you see patients with previous empyema so it can be very difficult. We attempted to do all the dissection on VV ECMO with no anticoagulation and then we convert to ECMO. And I completely agree that right ventricular dysfunction is very common in these patients, and I don't think it's possible to do it with no type of support or just staying on VV ECMO in the great majority of cases. I think avoiding bypass for obvious reasons. I think the amount of anticoagulation in the coagulopathy they're going to get into may be an additional stressor. We do tend to rely on converting back to VV ECMO in the end of the operation and running it without any anticoagulation, and then decannulating in the ICU later.

Dr. Ripley:

It's been a great discussion. We're nearing the end of our time together, but I'd like to ask the group if there's any specific cases that you'd like to discuss, or run by 1 another, or present cases are instructive for our audience?

Dr. Machuca:

I don't think I have a specific case, but I would like to ask the panel's opinion on—in our experience, we transplant a small percentage of these patients. We were talking about probably 10% of the referrals that we have. And what we've been consistently doing is trying to do most of the transplant evaluation and ruling out contraindications before the patient comes to us. Most of the time these patients are being transported from a long distance, they have been on ECMO for 2−3months and now they're considering transplantation and a transfer to us. So, we have encountered a lot of patients that they're clearly not transplant candidates—such as a patient with morbid obesity or severe comorbidities.

In the end we're talking about a small number of patients for a large denominator. So how has your experience been? And how do you see in terms of main contraindications that you face? And have you considered going beyond any of those, such as weight, and bringing a patient in and trying to work toward transplant candidacy?

Dr. Loor:

I totally sympathize with that. Our program is big and has a huge capacity, but despite that because of the cardiovascular Center, you can't deal with the COVID capacity. It's a huge number of cases that come in. And we have to be careful as transplant surgeons when you label a transfer as a bridge to transplant because then suddenly you have an ICU full of quote-unquote Bridge to transplants and then they're saying, 'Well, these patients aren't really moving through the system at all.' And you're only transplanting 1 or 2 of those. It's hard with these referring centers that need help and you want to try to accept everything.

But I do agree, I don't know what those criteria should be. It obviously depends on the individual experiences. But if we see some flaming criteria, like a bili of 10 or multi-organ—we try to have some pause and we try to work with them from a distance until the patient gets into a little bit better shape before coming in. And then we try to have them come in as a COVID transfer rather than a bridge to transplant so that it doesn't it doesn't get that label if possible. But it really is a logistical issue that probably many centers have to deal with.

Dr. Bharat:

First of all, I agree Gabe with what you said. What we found helpful is to work with the local center to get as much done as possible and get them, if they are truly transplant candidates, we accept them very close to the point that they would just come here and get transplanted. We made some mistakes early on in the pandemic where we accepted prematurely and we've learned that if these patients end up not getting to the point of transplant, the hardships that the family has to go through in relocating and just mobilizing resources is so substantial. And some of these patients—I remember 1 patient we got from the east coast, and it was like almost the emotional take because the family is almost begging us. We got this patient, then after

like 2 months, the patient could not get to the point of transplant and certainly prevented our ability to use the bed for someone else. So, what we've tried to do is we have an intake form, which we actually put it in the Lancet paper—it's evolved a little bit, and then we do as much as possible. Whether it's a cardiac cath—if the patient needs it, echoes, PRA testing. We get everything done in the process. And generally, if this is a transplant patient, we would not accept them until COVID PCR is negative because we're not going to transplant that patient anyways. At least based on our institutional philosophy. Then we have this team that will weekly touch base with the referring provider on a televisit to keep track of the progress on those patients. And once pretty much all the work up is done and the patient is awake and somewhat participating in the physical therapy and it's just a matter of fine-tuning a little bit, then we'll bring them here.

Now, this approach doesn't work for all patients. We recognize that. But it is what it is, we try to do the best, but I think that the consequences of getting a number of patients who just do not recover in your ICU at a center that is doing transplant could have a lot of effects not just to the family but also to your ability to help other people. So, we are quite selective in who we bring in now.

Dr. Cypel:

Yes, I agree too, and I would try to be bound to the same criteria that we normally would do for this transplantation coming out of an ICU. Maybe the BMI—we're a little bit more tolerant in this population then we would be otherwise in a regular transplant patient. But otherwise, we'll try to stay together.

Dr. Hoetzenecker:

What's your upper limit Marcelo?

Dr. Cypel:

Well, normally our upper limit will be 32. If we get a referral and a patient's 36—the thing is also these patients who lose weight while they're waiting, so by the time you're transplanting them they will be close to 32. And if the patient is young and good otherwise, and weight is the only issue—again discussing as a group, we may make an exception on that particular issue—obviously not a morbidly obese patient, but we would be a little bit more tolerant.

I have a question if we have a few more minutes. It's about the ethics of transplantation for COVID and whether anyone here got any pushback from other members of the team, and even from patients, on the waitlist—when this becomes more vocalized and sharing the donor pool with a population that has maybe an unknown outcome? Just putting this out there, not that I feel that way but putting this out there because we see that happening, so I want a perspective from the team here.

Dr. Bharat:

Yes. At least in the part of the world we live in, people are very vocal about things and they could be very inflammatory. We had a lot of pushbacks. When we were first starting the transplant, we even heard from some people that, "these are the patients who never follow precaution, they were not wearing the mask, do they even deserve to be transplanted?" Now, we are seeing a different narrative; "these patients chose not to get the vaccine, now they're getting sick, they shouldn't deserve a transplant."

Then there were ethics around, in a pandemic should you be using such resources when there are cases going up? And there are so many other patients that could be saved? There were questions about the long-term outcomes of spending all these resources without knowing what the long-term outcomes are in the circumstances of pandemic. And then certainly the question that you raised about balancing the needs of the patients who already are on the list or who may need a transplant, in other words non-COVID patients. I think those opinions will continue, just like any new thing, to surface.

I think we just have to maintain our focus and see if we can help these patients. That's our job as physicians. I think we must be creative. As we pointed out in the Lancet paper, collectively the centers did over a 145 transplants. There really is no waitlist mortality, so by extending the donor pool and using Hep C donors, using extended criteria donors, EVLP, all these things could really help mitigate those things. But yes, there's a lot of interesting narratives and the pushback that certainly we got, and we continue to get even to this day.

Dr. Hoetzenecker:

Yes, I think the strongest argument is that lung transplantation for ARDS is nothing new, right? It's been there for a long time. It's an established indication and patients receive a high LAS because they are super urgent. And, at least in Europe, with the ET-LAS they qualify for trans-border organ exchange. We had some discussion with transplant surgeons from other countries who had not adopted lung transplantation for ARDS or COVID ARDS and they have now started to do this. And they have changed their minds because they see that the outcome is good, that they can actually save patients. And as Ankit mentioned the waitlist mortality did not really, at least in our 4 centers, did not really rise. We got the chronic indications transplanted as well and there must be other ways to increase the donor pool than just saying that a certain indication is not allowed to receive an organ. I don't think this ethical—I don't think we should follow this way.

Dr. Loor:

I think you do bring up a really important point. The highest LAS typically gets the best donor offers and I do think that that's one thing to underscore here. I don't know what the collective experience is like, but I know that at our center we are more selective about these COVID transplants. We try to utilize that, to get the better donor for them, because they're so sick in so many other ways that that's one way to get them through. The other folks on the waitlist, not that they get submarginal, but you can play a little more with the donor pool in at least our experience.

Dr. Hoetzenecker:

Yes, I agree. If you have a lot of risk factors on the recipient side, you need to be sure that the risk factors of the donor side

are well under control. It doesn't mean that utilizing marginal donors is a bad thing, because in a good recipient it doesn't matter—the outcome is exactly the same. But if you have a recipient who is fragile, who after a long ICU stay is prone to have atelectasis and recurrent infections, you want a good organ. And I perfectly agree that maybe subcutaneously we tend to pair perfect organs with marginal recipients.

Dr. Machuca:

Here in Florida, I don't think we had many issues in terms of a patients, or internally our group, raising questions in terms of considering this patient for transplant. I think we were fortunate to have a very low waitlist mortality and we've been monitoring that. But I'm going to share a very interesting side, that I think the major criticisms that we receive often comes from the referring physician. The places where these patients are admitted—when the family finds their way to our group and requests us to consider a patient for transplantation it's not uncommon for us to face a lot of hesitation from the referring team or debates that what we're doing is experimental. Or that we are offering false hope and that the route for that patient should be withdrawal of life-sustaining therapies and allow the patient to die.

This is something that happens unfortunately commonly for us, and I think it's going to be our task to change that because I think we need to repeatedly show them that lung transplantation for COVID ARDS is not experimental. It can be lifesaving and it can have very good outcomes. What we often times do is that we communicate back and make sure that they are aware of the outcome, and I think that fortunately the response is very favorable. They understand, and they feel it's a true miracle having a patient that was 2—3 months on ECMO sedated and could not be awakened, transplanted and now resuming life. This is something that really in the beginning shocked us, how negative that reaction was, but hopefully that's going to change with time, and we'll have additional reports above mid and long-term outcomes.

Dr. Ripley:

We've come to the end of our session. On behalf of the editorial staff at Seminars in Thoracic Cardiovascular Surgery, I'd like to thank the panelists today for discussing lung transplantation for COVID-19. Additionally, I'd like to extend a thank you to Dr. Richard Weisel, Mr. Spencer McGrath and Ms. Amy Swartz for their assistance in this round table discussion. We appreciate everyone's time for listening and hope this discussion will help in the management of these complex patients.

Thank you all and we appreciate all of your time.

SUPPLEMENTARY MATERIAL

Scanning this QR code will take you to the article title page to access supplementary material.