Original Article

Seminars in Cardiothoracic and Vascular Anesthesia
1–11

DOI: 10.1177/1089253219867695
journals.sagepub.com/home/scv
SAGE

Statement From the Society for the Advancement of Transplant Anesthesia: White Paper Advocating Desirable Milestones and Competencies for Anesthesiology Fellowship Training in the Field of Lung Transplantation

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Abstract

The clinical, educational, and research facets of lung transplantation have advanced significantly since the first lung transplant in 1963. The formation of the International Society for Heart and Lung Transplantation (ISHLT) and subsequent Registry has forged a precedent of collaborative teamwork that has significantly affected current lung transplantation outcomes. The Society for the Advancement of Anesthesia (SATA) is dedicated to developing educational platforms for all facets of transplant anesthesia. Additionally, we believe that the anesthetic training for lung transplantation has not kept pace with other advances in the field. As such, SATA presents for consideration these educational milestones and competencies for anesthetic fellowship training in the field of lung transplantation. The proposed milestones were designed on the framework of 6 core competencies created by the Accreditation Council on Graduate Medical Education. The milestones were identified by combining the expert opinion of our Thoracic Transplant Committee, our experience as educators, and literature review. We offer this White Paper to the anesthesiology and transplant communities as a starting point for the discussion and evolution of perioperative anesthetic care in the field of lung transplantation.

Keywords

cardiopulmonary bypass surgery, thoracic surgery, transesophageal echocardiography, transplantation, fellowship training, ECMO

Introduction

The sciences of lung transplantation, anesthesiology, and medical education have all evolved significantly since the first human lung transplant by Dr James Hardy in 1963.[1-3] Whereas developments in the advancement of lung transplantation were primarily surgical in the beginning, soon breakthroughs in medical therapies followed, with multidisciplinary collaboration resulting in the creation of the International Society for Heart and Lung Transplantation (ISHLT) Registry in 1983.[4,5] Educational advancements, including the development of the Accreditation Council

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for Graduate Medical Education (ACGME) in 1981 followed by the development of Anesthesiology milestones in 2014, have been aimed at assessing and improving success of residency training programs in furthering patient care.[2,6] Similarly, the evolution of anesthetic techniques for the perioperative care of lung transplantation patients has been well documented, with key areas of innovation including anesthetic medications, analgesic techniques, mechanical circulatory assist systems, and transesophageal echocardiography (TEE).[3]

It is within this historical and present context that we submit for consideration these milestones for anesthetic fellowship training in the field of lung transplantation. In this article, we propose several options for implementation of these standards, as well as further justification for including specific training regarding lung transplantation in the current Adult Cardiothoracic Anesthesia (ACTA) fellowship requirements.

Evolution and Methods of the Working Group for Lung Transplant Anesthesiology Fellowship Recommendations

The Society for the Advancement of Transplant Anesthesia (SATA) is a clinician-based society created to "advance the recognition of transplant anesthesiology" and to "support the specialized expertise and educational needs of anesthesiologists involved in perioperative transplant care." As such, the SATA executive board forwarded a motion to support fellowship training in transplant anesthesia and the membership voted to support this motion. SATA leadership then appointed Working Group Chairs. The Lung Transplant Working Group Chair recruited lung transplant anesthesiologists from academic institutions throughout North America to form a writing group. The writing group developed milestones from literature review, their expert opinions, and experience as educators. The milestones were then sent to the SATA Thoracic Transplant Committee for review and input. After incorporation of feedback from the Transplant Committee, the milestones paper was sent to members of the SATA executive committee who reviewed and approved this publication.

Justification for More Specific Milestones in Lung Transplantation Anesthesiology

Lung transplantation has become increasingly more complex over time and patients have become much sicker over time. Over the past decade, the median lung allocation score at the time of transplantation, as well as the percent of patients transplanted over the age of 60, has increased.[7] Intraoperative events, such as fluid resuscitation, have been linked to primary graft dysfunction.[8] The use of extracorporeal membranous oxygenation (ECMO) as mechanical support during lung transplantation has increased, and it may in fact result in more favorable outcomes than cardiopulmonary bypass (CPB) such as less primary graft dysfunction, less transfusion, shorter intensive care unit stays, and better pulmonary function studies within the first postoperative year.[7,9] The field is progressing to the point that even in-operating-room extubation of lung transplant recipients is being trialed.[10,11]

Currently, though the ACGME requires that the ACTA fellow must "demonstrate knowledge of how cardiothoracic diseases affect the administration of anesthesia and life support to adult cardiothoracic patients, including . . . cardiac surgical procedures, to include . . . lung transplantation," there is no further description of learning milestones specifically related to lung transplantation.[12] We argue that while many of the fundamental concepts of lung transplantation *may* be touched on during an ACTA fellowship, the rather complex and precise care during lung transplantation requires specific learning goals, milestones, *and practice* to achieve. For example, an ACTA-trained physician is likely to have managed major cardiothoracic operations with CPB. However, the level of understanding and skills required to conduct lung transplantation anesthesia with different types of ECMO support is different from the competency needed to perform a major cardiothoracic operation with CPB. Finally, while all ACTA trainees will achieve proficiency in advanced perioperative TEE, there are specific echocardiographic considerations with regard to lung transplantation, such as detailed assessment of the vascular anastomoses, which fall outside of the standard perioperative CPB TEE examination.

We are not alone in our belief of super-specialty training within the specialty of thoracic organ transplantation. There are published educational milestones for cardiologists undergoing heart failure and cardiac transplant fellowship.[13] Though there is not a consensus on educational requirements for pulmonology lung transplant fellowships, these fellowships have been available to pulmonologists for decades because it was long ago recognized that management of these patients required a specific skill set that would be difficult to attain in a general pulmonology fellowship.[14] On the surgical end, "super fellowships" in both heart and lung transplantation are offered after completion of a general cardiothoracic surgery fellowship. The variability of case load and education is significant in these super fellowships. In response, a recent publication in the *Journal of Surgical Education* advocates the development of educational milestones for these super fellowships in order to ensure adequate training and possibly standardize a surgical thoracic transplant curriculum.[15]

Developing a standardized curriculum is difficult, particularly in a field with small numbers of cases spread over a large geographical area and a paucity of outcomes data related to the practice of lung transplant anesthesiology. In order to be a lead lung transplant surgeon, the United Network for Organ Sharing bylaws require a surgeon to perform at least 15 lung transplants "as the primary surgeon or the first assistant under the direct supervision of a qualified lung transplant surgeon and in conjunction with a lung transplant physician at a lung transplant program."[16] Based on this, we recommend that to achieve appropriate competency, a fellow must direct and/or perform the intraoperative anesthetic management for at least 15 lung transplants from start to finish. Each of these cases should include the use of TEE in order to further develop skills specific to lung transplantation. Given the lack of data regarding the incidence of ECMO use during lung transplantation, we cannot suggest any specific number of ECMO cases to reach competency, just that cases must be performed both with veno-venous ECMO and venous-arterial ECMO, and the fellow must demonstrate competency. Options for centers with low or no ECMO utilization during lung transplantation may include simulation center training or integration into a cardiothoracic surgery program's ECMO curriculum. Ideally, programs with lung transplantation fellowships would perform at least 30 lung transplants per year. Higher volume centers have been associated with sicker recipients and greater infrastructure.[17] Additionally, a program with at least twice the number of required cases would help ensure completion of the case number requirement and theoretically allow the fellow to be exposed to a wider degree of disease processes and perioperative approaches.

Options for Implementation

We recognize that not all ACTA fellowship programs have associated lung transplantation centers. This variability is likely why clinical experience in lung transplantation is an optional criterion for ACGME ACTA fellowships. The question then becomes how to implement our desired educational program.

There are several possibilities, including but likely not limited to the following:

1. The formation of a separate lung transplantation anesthesia "super fellowship" after completion of an ACGME general ACTA fellowship in order to allow completion of these educational milestones and competencies. Depending on the center volume, this would likely range from a 6- to 12-month commitment.
2. The formation of a separate thoracic organ transplantation "super fellowship" after completion of an ACGME general ACTA fellowship. This would likely be a 12-month commitment. Additional milestones specific to cardiac transplant would need to be created.
3. Expanding the criteria of the current ACGME ACTA fellowship to mandate completion of these milestones and competencies for graduation. Centers that do not have lung transplantation programs would be obligated to affiliate with larger centers that could provide the necessary exposure to achieve milestones. Fellows would rotate outside their home institutions to these major centers to receive their supplementary education. In high-volume thoracic transplant centers, this could be done without compromising the goals of a traditional ACTA fellowship.
4. Inclusion of these specific milestones into the current ACGME ACTA curriculum as an optional part of the ACTA education (as elective rotations in lung transplantation), but not compulsory for graduation. Fellows that complete these milestones and competencies during ACTA fellowship could possibly have a certificate of "special competency" in the field of lung transplantation anesthesiology. Theoretically, this could facilitate preferential employment of these candidates in lung transplantation centers.

It is our opinion that making these milestones compulsory for graduation is an unrealistic expectation given the cost to centers and trainees that do not have their own institutional lung transplantation program. A "super fellowship" in lung transplantation anesthesiology may well be the future, but a structured, accredited program will be years in the making. Inclusion of these milestones and competencies into the existing ACGME ACTA curriculum as an additional, optional course of study with recognition of special competency may also take years. However, ACTA programs with institutional lung transplantation centers can start instituting these milestones and competencies immediately if they so desire.

Proposed Milestones and Competencies

The proposed milestones and competencies detailed in Table 1 were designed on the framework of 6 core competencies created by the ACGME. The levels of competency achievement were defined by Nasr et al in their publication on milestones for pediatric cardiac anesthesia fellowship (see Table 2).[18] ACGME definitions regarding different levels of supervision are outlined in Table 3.

Our milestones focus on skill sets that will advance the perioperative clinician, scientist, and humanist in our future transplant anesthesiologists. They are designed for

Table 1. Proposed Milestones and Competencies.

Practice-Based Learning and Improvement 1: Self-Directed Learning				
Level 1	Level 2	Level 3	Level 4	Level 5
Independently reviews available perioperative and transplant literature in preparation for patient care.	Uses self-directed feedback and spontaneous feedback to modify patient care plans.	Incorporates evidence-based literature into the development of effective plans for patient care.	Publishes literature in the field of lung transplantation.	Publishes literature that progresses the field of lung transplantation.
	Undergoes frequent self-assessments to identify personal areas for improvement.	Actively seeks to correct self-identified areas for improvement.	Attends and actively participates in regional or national conferences.	Is recognized as an expert in the field.
Practice-Based Learning and Improvement 2: Participates in Multidisciplinary Care Planning				
Level 1	Level 2	Level 3	Level 4	Level 5
Understands listing criteria for lung transplantation and the process of organ allocation	Attends transplant selection committee meetings.	Performs inpatient consults to optimize patients for transplantation with indirect supervision.	Performs inpatient consults to optimize patients for transplantation with conditional independence.	Develops multidisciplinary protocols for patient care.
		Involves other primary services in care planning with indirect supervision.	Involves other primary services in care planning with conditional independence.	
Practice-Based Learning and Improvement 3: Patient Safety and Quality Improvement				
Level 1	Level 2	Level 3	Level 4	Level 5
Identifies harmful/potentially harmful areas in their personal practice of medicine.	Modifies personal practice to mitigate risk to patients.	Attends morbidity and mortality conference both as presenter and feedback participant.	Attends multidisciplinary team morbidity and mortality conference.	Leads multidisciplinary morbidity and mortality conference.
	When available, participates in individual institution's quality improvement reporting system.		Compares personal outcomes to peers. Actively plans to mitigate risk to patients.	Uses published data to establish quality improvement mechanisms for his/her team.
Professionalism 1: Ethical Behavior				
Level 1	Level 2	Level 3	Level 4	Level 5
Is truthful in all communications.	Preemptively identifies patient-driven ethical conflicts with plans of care (eg, refusal of blood products).	Develops an ethical framework to address complex issues when dealing with colleagues, patients, and family members.	Finds a way to allow for patient autonomy while maintaining safe patient care.	Serves as a role model for ethical behavior to students, residents, and colleagues.
	Understands ethical issues specific to organ transplantation (eg, donation after cardiac death, organ allocation policies, etc)			

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Table 1. (continued)

Interpersonal and Communication Skills 1: Communication With Patients and Families

Level 1	Level 2	Level 3	Level 4	Level 5
Communicates effectively and sympathetically with patients and families.	Effectively delivers complex information to families and patients.	Effectively manages conflict with patients and families with indirect supervision.	Effectively manages conflict with patients and families with conditional independence.	Functions as a role model/ mentor in effective patient and family communication.
		Communicates medical errors to patients and families with indirect supervision.	Communicates medical errors to patients and families with conditional independence.	

Interpersonal and Communication Skills 2: Communicates With Team Members

Level 1	Level 2	Level 3	Level 4	Level 5
Documents effectively in the medical record.	Communicates effectively with team members.	Maintains effective communication pre-, intra-, and postoperatively.	Resolves conflicts among team members.	Functions as a role model/ mentor in improving communication between team members.
	Shows respect for opinions of others.	Participates in conflict resolution.	Effectively manages crisis situations.	Influences surgical and postoperative patient care through effective communication of individual patients' diagnoses and management strategies.
		Participates in crisis management.	Effectively articulates anesthetic concerns and challenges as they relate to lung transplantation.	
			Participates effectively in perioperative patient handovers in accordance with regional best practices.	

Interpersonal and Communication Skills 3: Leadership

Level 1	Level 2	Level 3	Level 4	Level 5
Effective team member.	Identifies a team problem and develops a problem-focused plan for resolution.	Develops an organizational framework for the team.	Effectively leads teams in most situations.	Functions as a mentor/ role model for leadership among subordinates and peers.
		Delegates tasks within the team appropriately.		

Systems-Based Practice 1: Incorporates Patient Safety Improvement Practices Into Care

Level 1	Level 2	Level 3	Level 4	Level 5
Identifies system-based patient safety issues.	Develops a plan to mitigate individual and systems-based risks as applicable in their own patient care.	Gains understanding in the process of quality improvement and appreciates its utility in improving patient care.	Plans and completes a quality improvement project.	Employs a quality improvement project to improve patient care at own institution.
Consistently identifies clinical errors and near misses in individual practice.		Effectively mitigates systems-based issues as applicable in own patient care.		

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Table 1. (continued)

Systems-Based Practice 2: Collaborates With Other Medical Subspecialties to Improve Patient Care				
Level 1	Level 2	Level 3	Level 4	Level 5
Identifies need for subspecialty consultation.	Collaborates with other subspecialties for improved patient care with indirect supervision.	Collaborates with other subspecialties for improved patient care with conditional independence.	Develops a system for improved group planning and communication among subspecialty providers.	Recognized as a leader in collaborative patient care at own institution.

Systems-Based Practice 3: Invests in Postoperative Care of Lung Transplant Patients				
Level 1	Level 2	Level 3	Level 4	Level 5
Rounds on lung transplant recipients with intensivists and surgeons in the intensive care unit.	Can identify common challenges in the care of postoperative lung transplant patients.	Understands how to manage common postoperative issues in lung transplant recipients (graft dysfunction, immune suppression, nutrition, etc)	Can make management plans for common postoperative issues in lung transplant recipients.	Is recognized as a consultant for post operative care of lung transplant patients in the intensvie care unit.

Patient Care and Procedural Skills 1: Perioperative Assessment and Planning				
Level 1	Level 2	Level 3	Level 4	Level 5
Performs a relevant history and physical examination for the potential lung transplant recipient.	Identifies more subtle and complicated clinical issues related to the potential lung transplant recipient.	Identifies all relevant clinical issues related to the potential lung transplant recipient (psychological, social, nutrition, etc).	Creates a thorough and viable perioperative plan with conditional independence.	Is recognized as an expert in the field and is consulted for opinions on perioperative care.
Identifies fundamental clinical issues that may preclude listing or complicate intraoperative or postoperative care of the recipient.	Creates a basic perioperative plan for the recipient with direct supervision.	Creates a thorough and viable perioperative plan with indirect supervision.	Is ready for independent practice.	

Patient Care and Procedural Skills 2: Placement and Interpretation of Invasive Monitors				
Level 1	Level 2	Level 3	Level 4	Level 5
Consistently obtains arterial access in multiple sites with indirect supervision.	Consistently obtains arterial access in multiple sites with conditional independence.	Can perform ECMO cannulation through the femoral vein and superior vena cava with indirect supervision.	Can perform ECMO cannulation through the femoral vein and superior vena cava with conditional independence.	Recognized as an expert in placement of invasive monitors and interpretation of data.
Consistently obtains central venous access in multiple sites with indirect supervision.	Consistently obtains central venous access in multiple sites with conditional independence.			Recognized as an expert in ECMO cannulation.
Effectively employs the use of ultrasound guidance to improve efficiency and patient safety.	Trains in advanced clinical procedures such as ECMO cannulation through the femoral vein and superior vena cava.			
Can interpret pulmonary artery catheter data and/or noninvasive CO monitors (eg, FlowTrak) with indirect supervision.	Can interpret pulmonary artery catheter data and/or noninvasive CO monitors (eg, FlowTrak) with conditional independence.			

(continued)

Table 1. (continued)

Patient Care and Procedural Skills 3: Transesophageal Echocardiography (TEE) and Transthoracic Echocardiography (TTE)				
Level 1	Level 2	Level 3	Level 4	Level 5
Obtains the full perioperative examination for TEE in cardiac surgery as outlined by the ASE and SCA with conditional independence.	Obtains TEE data specific to lung transplantation with indirect supervision.	Applies TEE data to lung transplantation management with conditional independence.	Serves as expert perioperative echocardiography resource to multidisciplinary lung transplant team.	Recognized as an expert in TEE as it relates to its application in lung transplantation.
Obtains TEE data specific to lung transplantation with direct supervision.	Understands and can correlate the TTE/TEE examination with the pathophysiology end-stage lung disease with indirect supervision.	Understands and can correlate the TTE/TEE examination with the pathophysiology end-stage lung disease with conditional independence.	Can perform POCUS for DVT and airway evaluation under indirect supervision.	Can perform POCUS for deep vein thrombosis and airway evaluation with conditional independence.
Can apply findings on preoperative TTE to candidacy for lung transplantation with direct supervision.	Can apply findings on preoperative TTE to candidacy for lung transplantation with indirect supervision.	Can apply findings on preoperative TTE to candidacy for lung transplantation with conditional independence.		
Can perform transthoracic (cardiac and lung) Point of Care Ultrasound (POCUS) with direct supervision.	Can perform transthoracic POCUS with indirect supervision.	Can perform transthoracic POCUS with conditional independence.		
		Can perform POCUS for deep vein thrombosis and airway evaluation with direct supervision.		

Patient Care and Procedural Skills 4: Airway Management				
Level 1	Level 2	Level 3	Level 4	Level 5
Can perform lung isolation by multiple techniques in a patient with challenging airway anatomy with indirect supervision.	Can perform lung isolation by multiple techniques in a patient with challenging anatomy with conditional independence.	Can perform isolation of segmental lung anatomy with indirect supervision.	Can perform isolation of segmental lung anatomy with conditional independence.	Is recognized as a leader in airway management and anatomy.
Can perform more complex fiber-optic bronchoscopy, identifying all segmental and subsegmental bronchi with indirect supervision.	Can perform more complex fiber-optic bronchoscopy, identifying all segmental and subsegmental bronchi with conditional independence.			

Medical Knowledge 1: Pathophysiology of Indications for Lung Transplantation				
Level 1	Level 2	Level 3	Level 4	Level 5
Knows the pathophysiology of the most common conditions leading to lung transplantation (eg, COPD, cystic fibrosis, idiopathic pulmonary fibrosis, primary pulmonary hypertension)	Applies fundamental anesthetic management principles to pathophysiology in routine lung transplants.	Applies advanced anesthetic management principles to pathophysiology in complex lung transplants with indirect supervision.	Applies advanced anesthetic management principles to pathophysiology in complex lung transplants with conditional independence.	Recognized as an expert of anesthetic management in patients with complex pulmonary pathophysiology.

(continued)

Table 1. (continued)

Medical Knowledge 2: Organ Allocation and Optimization for Transplantation

Level 1	Level 2	Level 3	Level 4	Level 5
Knows basic procedures for organ allocation.	Exhibits understanding of national organ allocation systems.	Exhibits understanding of organ allocation immunology.	Applies organ allocation procedures in a systems-based fashion.	Recognized as an expert in organ allocation and optimization procedures.
Understands the concept of ex vivo lung perfusion.	Exhibits understanding of local hospital organ allocation systems.	Exhibits understanding of various ex vivo lung systems.	Communicates principles of organ allocation and optimization in a multidisciplinary setting.	Serves as anesthesia fellow representative at multidisciplinary organ allocation meetings.
	Exhibits understanding of donor risk stratification.	Exhibits understanding of donation after cardiac death.	Attends multidisciplinary organ allocation meetings.	
	Exhibits understanding of ex vivo lung perfusion components.	Exhibits understanding of donor preparation and optimization		

Medical Knowledge 3: Intraoperative Management of Lung Transplantation

Level 1	Level 2	Level 3	Level 4	Level 5
Knows the anesthetic and surgical steps to lung transplantation.	Can provide intraoperative medical management of lung transplantation with direct supervision.	Can provide intraoperative medical management of lung transplantation with indirect supervision.	Can provide intraoperative medical management of lung transplantation with conditional independence.	Is recognized as an expert in the intraoperative management of lung transplantation.

Medical Knowledge 4: Mechanical Circulatory Support (Extracorporeal Membrane Oxygenation [ECMO] and Cardiopulmonary Bypass [CPB])

Level 1	Level 2	Level 3	Level 4	Level 5
Understands the basic principles and potential roles of mechanical circulatory support (ECMO and CPB) for lung transplantation.	Applies principles of mechanical circulatory support for lung transplantation to guide anesthetic management with direct supervision.	Applies principles of mechanical circulatory support for lung transplantation to guide anesthetic management with indirect supervision.	Applies principles of mechanical circulatory support for lung transplantation to guide anesthetic management with conditional independence.	Is recognized as an expert in the use of mechanical circulatory support during lung transplantation.
Understands the different management issues of lung transplantation done with ECMO as opposed to CPB.	Applies principles of ECMO for lung transplantation to guide anesthetic management with direct supervision.	Applies principles of ECMO for lung transplantation to guide anesthetic management with indirect supervision.	Applies principles of ECMO for lung transplantation to guide anesthetic management with conditional independence.	Is recognized as an expert in right ventricular failure.
Understands the implications of mechanical circulatory support devices as they relate to the anesthetic management of lung transplantation.	Incorporates knowledge of mechanical circulatory support devices into anesthetic management with direct supervision.	Incorporates knowledge of mechanical circulatory support devices into anesthetic management with indirect supervision.	Actively contributes to the clinical decision-making process of employing mechanical circulatory support devices during lung transplantation.	

Medical Knowledge 5: Pain Management

Level 1	Level 2	Level 3	Level 4	Level 5
Understands the implications of suboptimal pain management in patients undergoing lung transplantation.	Plans and executes a pain management strategy with direct supervision (eg, regional anesthesia and multimodal analgesia).	Plans and executes a pain management strategy with indirect supervision.	Plans and executes a pain management strategy with conditional independence.	Is recognized as an expert in pain management for patients undergoing lung transplantation.

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Table 1. (continued)

Medical Knowledge 6: Coagulation Management				
Level 1	Level 2	Level 3	Level 4	Level 5
Understands how to apply point of care testing and conventional lab testing to component replacement and red cell transfusion strategy.	Applies principles of coagulation management and transfusion in mild to moderate blood loss cases with indirect supervision.	Applies principles of coagulation management and transfusion during massive blood loss in lung transplantation with indirect supervision.	Applies principles of coagulation management and transfusion during massive blood loss in lung transplantation with conditional independence.	Is recognized as an expert in coagulation management and transfusion in lung transplantation.
Understands potential complications of component replacement and red cell transfusion.	Clinically recognizes complications of component replacement and red cell transfusion.	Understands the role of blood conservation techniques (eg, cell saver, antifibrinolytic agents, and synthetic factor replacements).		
Medical Knowledge 7: Preoperative Diagnostic and Therapeutic Intervention				
Level 1	Level 2	Level 3	Level 4	Level 5
Interprets common preoperative testing for lung transplantation (eg, pulmonary function tests, echocardiograms, and cardiac catheterization).	Uses information from preoperative testing to guide anesthetic management with direct supervision.	Uses information from preoperative testing to guide anesthetic management with indirect supervision.	Uses information from preoperative testing to guide anesthetic management with conditional independence.	Recognized as an expert in applying preoperative testing to anesthetic planning in lung transplantation.
Medical Knowledge 8: Perioperative Ventilation and Oxygenation				
Level 1	Level 2	Level 3	Level 4	Level 5
Understands the basic principles of ventilation in a transplanted lung.	Applies the principles of lung protective ventilation strategy for a transplanted lung with direct supervision.	Applies the principles of lung protective ventilation strategy for a transplanted lung with indirect supervision.	Actively contributes in clinical decision making in altering the ventilation strategy after lung transplant and decision to institute additional support such as inhaled pulmonary vasodilators and ECMO.	Recognized as an expert in lung protective ventilation strategy.
Can manage hypoxemia, hypercarbia, and increased airway pressures during one lung ventilation with indirect supervision.	Can manage hypoxemia, hypercarbia, and increased airway pressures during one lung ventilation with conditional independence.			Recognized as an expert in oxygenation and ventilation post lung transplantation.
				Is recognized as an expert in the management of one lung ventilation.

Table 2. Definitions of Competency Levels.[18]

Level 1: The fellow demonstrates milestones expected of an incoming fellow.

Level 2: The fellow is advancing and demonstrates additional milestones but is not yet performing at a mid-fellowship level.

Level 3: The fellow continues to advance and demonstrate additional milestones, consistently including the majority of milestones targeted for fellowship.

Level 4: The fellow has advanced so that he or she now substantially demonstrates the milestones targeted for fellowship. This level is designed as the graduation target.

Level 5: The fellow has advanced beyond performance targets set for fellowship and is demonstrating "aspirational" goals, which might describe the performance of someone who has been in practice for several years. It is expected that only a few exceptional fellows will reach this level.

Table 3. Levels of Supervision Defined.[19,20]

Direct supervision: The supervising physician is physically present with the resident and patient.
Indirect supervision: With direct supervision immediately available, the supervising physician is physically within the hospital or other site of patient care and is immediately available to provide direct supervision.
Conditional independence: Graded, progressive responsibility for patient care with defined oversight. Oversight should fall within the rules of the institution of practice.

the physician who has already completed competencies outlined by the ACGME for residency training in anesthesiology. These milestones could be incorporated into an existing ACTA curriculum or stand-alone post ACTA training. In addition to the humanistic goals that we as physicians should all strive for, these training competencies focus on understanding the preoperative care of the donor and recipient, high-level anesthetic care of the lung transplant recipient, and postoperative care of the recipient. Though anesthesiologists typically do not participate in organ procurement, we consider a solid understanding of the process to be part of the "liberal arts" education of this profession. Given the unique perspective that anesthesiologists have on perioperative physiology, we believe that transplant anesthesiologists becoming true perioperative physicians functioning as part of a greater transplant team should be the future of this branch of medicine in order to maximize appropriate recipient selection and outcome. Our milestones reflect these concepts.

Conclusion

Medicine has been chronicled dually as an art and science, a mix of integral components required for delivery of patient care.[21] We believe that the practice of anesthesiology in transplantation must evolve in step with the associated science and patient acuity. Currently, prescribed anesthetic training in lung transplantation has not met this expectation.

The enclosed proposed guidelines incorporate facets of medicine encompassing core competencies of Practice-Based Learning, Professionalism, Interpersonal and Communication Skills, Systems-Based Practice, Medical Knowledge, and Patient Care and Procedural Skills. We aim for the levels of competence described to serve as both a gauge of individual fellow performance as well as guide for educational programs as they seek to develop comprehensive training standards for anesthesiologists in the field of lung transplantation. Upon completion of training, a candidate is expected to function as a subspecialist capable of an enhanced practice in this area of focused competence. The candidate must acquire a working knowledge of the theoretical basis of the discipline, including its foundation in science and research, as well as exhibit competency in delivery of complex care to a diverse population in an ethical and principled fashion.

As the field of lung transplantation evolves, milestones and competencies for training will need to evolve as well. This article is just a first step of many toward the creation of an accredited lung transplantation anesthesia subspecialty training program. We offer this White Paper to the anesthesiology and transplant communities as a starting point for the discussion and evolution of perioperative anesthetic care in the field of lung transplantation.

Acknowledgments

SATA would like to acknowledge the following individuals for their input on this article: Brandi Bottinger, MD, Duke University, Durham, NC, USA; Michael Boisen, MD, University of Pittsburgh Medical Center, Pittsburgh, PA, USA; Amit Bardia, MD, Yale School of Medicine, New Haven, CT, USA; and Sharon McCartney, MD, Duke University, Durham, NC, USA. The authors would also like to thank the SATA Executive Committee for their support of the project.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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