Title of Study or Project:	**Management of ventilation for esophagectomy – impact on clinical outcomes:** A report from the Multicenter Perioperative Outcomes Group and Society of Thoracic Surgeons Database
Primary Institutions:	University of Virginia, University of Michigan, Washington University (St Louis)
Principal Investigator:	Randal S. Blank, M.D., Ph.D.
Co-Investigators:	Wash U Anes – Mark Willingham, MD, Michael Avidan, MBBCh Wash U Surgery – Varun Puri, MD, Benjamin Kozower, MD UVA Anes – Bhiken Naik, MD, Marcel Durieux, MD, Jacob Raphael, MD, UVA Surgery – Dustin Walters, MD UM Anes – Michael Mathis, M.D., Sachin Kheterpal, MD; Douglas Colquhoun, MB, ChB, MSc; Milo Engoren, MD, Amy Shanks, Ph.D. UM Surgery – Andrew Chang, MD Yale Anes – Robert Schonberger, MD, Wanda Popescu, MD Yale Surgery - Justin Blasberg, MD
Type of Study:	Retrospective Observational – Outcomes Study
Specific Aims	**Primary Aim** **1**) To assess the relationship between ventilator parameters – V_T, PEEP, and airway pressure (including mΔP) and the development of postoperative complications. This aim will include the following sub aims: **1a**) To determine whether the use of a putative LPV strategy conforming to expert recommendations for LPV (defined as a $V_T \leq$ 8 ml/kg PBW and PEEP $\geq$ 5 for 2LV and $V_T \leq$ 5 mL/kg PBW and PEEP $\geq$ 5 cm H_2O for 1LV) predicts improvements in postoperative respiratory complications. While these ventilation guidelines currently conform to our understanding of protective ventilation, results of ongoing studies, including that of a larger MPOG protective ventilation outcome study may inform our definition of LPV and may, as such, result in post-approval modification of the definitions. **1b**) To determine whether the use of a putative LPV strategy predicts improvements in postoperative morbidity. **Secondary Aims** **2**) To determine whether ventilatory correlates of dynamic alveolar strain – notably PIP and/or mΔP (PIP-PEEP) are predictive of postoperative complications. **3a**) To determine whether patients known to be at higher risk for receiving high V_T/kg PBW – patients with high BMI, short stature, and female gender - are more likely to be subjected to ventilator regimens associated with higher levels of mΔP, and consequently, **3b**) Whether, after adjustment for other risk predictors, these patients are at higher risk for postoperative complications. **4**) To assess the role of ventilation pressures during 1LV on outcomes after esophagectomy.
Number of Patients/Participants:	Esophagectomy cases performed at MPOG STS institutions between January 1, 2012 and start of study (projected 2018) **Contributing data** – WUSTL, UVA, UM, Yale, OHSU **Developing** – UW, Colorado, UVM, MSK
Statistical test/analysis:	Multiple tests as described in Methods
Resources	Will query institutions with MPOG-STS Thoracic integrated data, performed via IT support. Financial support as per the departmental funding at participating sites. Multiple investigators at included sites.

Introduction

Esophageal cancer afflicts more than 450,000 people worldwide and is the sixth leading cause of cancer-related mortality.[1-4] In the US, the age-adjusted incidence has been rising 20-40% every five years.[4] The prognosis is poor: expected survival is less than 50% at one year and 15-25% at five years.[3,4] Esophagectomy is the primary treatment for local disease, and despite advances in surgical and anesthetic management, the procedure remains technically challenging and is associated with a high rate of complications.[5-7] Pulmonary complications of thoracic surgery are variably defined in the literature but include pneumonia, aspiration pneumonitis, ARDS, bronchopleural fistula, atelectasis, and pulmonary embolism. Any individual or cluster of these complications can result in respiratory insufficiency or respiratory failure, which may require specific therapies including the continuation or reinstitution of mechanical ventilation. The overall incidence of serious respiratory morbidity is highly variable but is between 10 and 30% in most large series[8 9 10 11].

Mechanical ventilation is a necessary supportive therapy for critically ill patients and those undergoing major surgeries, including esophagectomy. However, phasic lung expansion under positive pressure subjects the lungs to a variety of potentially injurious stimuli, which can ultimately result in clinically significant ventilator induced lung injury (VILI). The demonstration that high tidal volume (conventional) ventilation resulted in significantly higher mortality in patients ventilated for respiratory failure due to ARDS[12], led to the concept of “protective” ventilation strategies – that is limiting alveolar overdistension through the application of smaller physiologic tidal volumes. Subsequent studies of high tidal volume ventilation of critically ill patients without preexisting lung injury[13-17] and in surgical patients at risk for lung injury confirm that a similar approach may decrease systemic and pulmonary inflammation[18-20], improve

postoperative pulmonary function[18,21] and clinical outcomes including pulmonary complications[22,23] and hospital stay [22].

Patients presenting for thoracic surgery may be at elevated risk for complications as a result of preexisting disease processes, the nature of the planned surgery, loss of functional lung parenchyma (for pulmonary resection procedures), and the detrimental effects of mechanical ventilation, particularly one lung ventilation (1LV). Of patients presenting for elective thoracic surgery, those undergoing esophagectomy appear to be at the highest risk for pulmonary complications postoperatively. Thus, these patients could potentially derive even greater benefit from the application of protective ventilation principles and are deserving of targeted study in this regard. Despite significant advances in our understanding of protective ventilation in patients subjected to two-lung ventilation (2LV), considerably less evidence is available to guide management of 1LV, a technique commonly used to optimize operating conditions for a variety of surgical procedures within the thorax, including transthoracic esophagectomy. Very little data exists to specifically support a particular approach to management of 1LV with regard to clinical outcomes. Most, but not all[24,25] prospective studies examining putative protective 1LV (reduced V_T, moderate PEEP), have demonstrated a reduction in pulmonary[26] or systemic inflammation[18], extravascular lung water[27], or pulmonary complications[26]. Small prospective trials in esophagectomy patients have demonstrated attenuation of systemic inflammation and improvements in postoperative pulmonary gas exchange [18] and a reduction in the incidence of pulmonary complications[26] in patients randomized to receive lower V_T ventilation with PEEP.

It is important to note that the pathophysiologic effect of a delivered positive pressure tidal breath, if any, derives from the generated transpulmonary pressure (P_L) and its subsequent impact on tissue deformation (strain). Driving pressure (plateau pressure minus PEEP) has

arisen as a potentially useful surrogate for dynamic strain and has been identified as the best predictor of pulmonary complications in a large meta analysis of randomized trials for surgical patients[28] as the best risk predictor of mortality in a large study of patients with ARDS[29].

In light of our recently enhanced understanding of the biomechanics of VILI and resulting interplay of forces acting upon the alveoli during mechanical ventilation, the following tentative conclusions appear to be justified. First, although high V_T may be injurious, particularly when accompanied by low PEEP levels, the primary determinant of VILI appears to be the level of tidal alveolar tissue deformation – or dynamic strain. Secondly, it then follows that no absolute level of V_T or PEEP is inherently injurious or "protective". This assertion is well supported by prospective clinical trials[24,30], retrospective clinical studies[31] and elegant studies in animal models[32,33]. Third, discrepancies in the results of published studies are likely to be explained by a) whether administered PEEP and/or recruitment maneuvers were sufficient to eliminate atelectasis and prevent tidal derecruitment and b) whether the combination of administered V_T and PEEP and the resultant generation of a transpulmonary pressure resulted in pathologic levels of tidal alveolar tissue deformation (strain).

We hypothesize that:

1) management of mechanical ventilation during esophagectomy surgery affects the development of postoperative complications,

2) in the presence of low levels of PEEP, low V_T do not predict a decrease in complication rate,

3) ventilatory correlates of dynamic alveolar strain – notably modified ΔP ($m\Delta P$; peak inspiratory pressure (PIP)-PEEP) are more predictive of postoperative complications than is V_T,

4) that patients known to be at higher risk for receiving high V_T/kg PBW – patients with high BMI, short stature, and female gender are more likely to be subjected to ventilator regimens associated with higher levels of mΔP, and consequently

5) that after adjustment for other risk predictors, these patients are at higher risk for postoperative complications.

Methods

Specific Aims

Primary Aim

1) To assess the relationship between ventilator parameters – V_T, PEEP, and airway pressure (including mΔP) and the development of postoperative complications. This aim will include the following sub aims:

1a) To determine whether the use of a putative LPV strategy conforming to expert recommendations for LPV (defined as a $V_T \leq$ 8 ml/kg PBW and PEEP $\geq$ 5 for 2LV and $V_T \leq$ 5 mL/kg PBW and PEEP $\geq$ 5 cm H_2O for 1LV (these may be modified as results from MPOG OLV STS become available) predicts improvements in postoperative respiratory complications.

1b) To determine whether the use of a putative LPV strategy predicts improvements in postoperative morbidity.

Secondary Aims

2) To determine whether ventilatory correlates of dynamic alveolar strain – notably PIP and/or mΔP (PIP-PEEP) are predictive of postoperative complications.

3a) To determine whether patients known to be at higher risk for receiving high V_T/kg PBW – patients with high BMI, short stature, and female gender - are more likely to be subjected to ventilator regimens associated with higher levels of mΔP, and consequently,

3b) Whether, after adjustment for other risk predictors, these patients are at higher risk for postoperative complications.

4) To assess the role of ventilation pressures during 1LV on outcomes after thoracic surgery.

Study Design

The MPOG and STS-General Thoracic databases will be utilized for this multicenter, retrospective observational study. The MPOG database is a limited dataset containing perioperative data relevant to this study. Institutional Review Board approval has already been obtained for MPOG projects involving the University of Michigan, Ann Arbor, Michigan. Where required, additional institutional review board (IRB) approval will be sought and attained for contributing centers supplying Society of Thoracic Surgeons (STS) Database data. Centers to be included pending final confirmation and IRB approval are: University of Michigan Health System, University of Virginia Health System, Washington University School of Medicine, Yale University, Oregon Health Sciences Center, University of Colorado, Yale University, University of Washington, and the University of Vermont (Fletcher Allen Health Care). This proposal is compliant with the relevant Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

Patient Population – Inclusions/Exclusions

Procedures performed between the dates of January 1st 2012 and July 1st 2018 will be reviewed. Inclusion criteria will be all adult patients (≥18 years) undergoing esophageal resections captured in participating MPOG sites for whom matching STS outcome are available from earliest date available to present. Esophagectomy cases will be identified by STS procedure codes; 1LV cases will be identified by MPOG concepts related to the start of 1LV (see MPOG concept list below). The following subjects and cases will excluded from analysis: subjects less than 18 years of age, cases employing 1LV for less than 15 minutes and those for which patient height and weight data are not available.

Outcomes

Outcome data from the STS database include the following: unexpected return to OR, postoperative events, reoperation for bleeding, postoperative air leak greater than 5 days, atelectasis requiring bronchoscopy, pleural effusion requiring drainage, pneumonia, ARDS, respiratory failure, bronchopleural fistula, pulmonary embolus, pneumothorax, initial ventilator support > 48 hours, reintubation, tracheostomy, other pulmonary event, atrial fibrillation, ventricular arrhythmia requiring treatment, myocardial infarction, deep venous thrombosis requiring treatment, gastric outlet obstruction, ileus, anastomotic leak, empyema, wound infection, surgical site infection, sepsis, other infection requiring antibiotics, central neurological event, delirium, renal failure, unexpected admission to the ICU, discharge status, readmission within 30 days, and status at 30 days (mortality).

The primary outcome is postoperative respiratory complications, defined as any one or more of the following: tracheostomy, empyema requiring treatment, pneumonia, reintubation, initial ventilator support greater than 48 hours, ARDS, bronchopleural fistula, pulmonary embolism, air leak greater than 5 days, atelectasis requiring bronchoscopy, and respiratory failure. The two secondary outcomes include a) major morbidity - any or all of the following: respiratory complications (as above), unexpected return to the OR, atrial or ventricular dysrhythmias requiring treatment, myocardial infarction, sepsis, renal failure, central neurologic event, unexpected ICU admission, anastomotic leak and b) the composite outcome - any of the major morbidities above and/or mortality.

Exposure Variables / Covariates - MPOG

Demographic, preoperative, anesthetic and surgical data to be collected includes: age, gender, race, height, weight, BMI, ASA physical status, MPOG patient identifier, MPOG institution identifier, year of service, preoperative comorbidities (particularly pulmonary diseases which might influence choice of ventilation parameters (e.g. COPD, interstitial lung disease)), planned and performed surgical procedure(s) (STS surgical procedure codes), set tidal volume (if any) and delivered tidal volume during 2LV and 1LV, respiratory rate, PEEP, peak and plateau airway pressures, ventilator mode setting, inspired oxygen fraction (FIO_2), oxygen saturation (SpO_2), the duration of anesthesia, surgery, 2LV, and 1LV. Additional intraoperative exposures to be identified include the use or non-use of epidural analgesia, blood product transfusion, and use of vasoactive medications. Intraoperative complications to be identified include severe hypoxemia (SpO_2 < 90%), hypotension (mean arterial blood pressure <60 mm Hg for >3 minutes), and dysrhythmia requiring treatment. We anticipate that perioperative bundles of care identified in a related study [PCRC-0042] will be available to guide the definition of additional perioperative risk factors.

Driving pressure (ΔP), modified driving pressure ($m\Delta P$), static (C_s) and dynamic compliance (C_{dyn}) are defined and will be calculated as follows: $\Delta P = P_{plat} - PEEP$; $m\Delta P$= PIP – PEEP; $C_s = V_T / (P_{plat} - PEEP)$, $C_{dyn} = V_T / (PIP - PEEP)$, respectively. As above, the calculation of ΔP requires P_{plat} data, which are not currently available from all participating MPOG institutions. Consequently, it is anticipated that $m\Delta P$ will be used as the primary driving pressure covariate throughout the study.

For each case, five summary definitions of ventilator settings will be derived. For 2LV: The start of 2LV will be identified when the respiratory rate is greater than 2, and measured tidal volume is greater than 50mL. The **overall period of 2LV** will be determined from the start of 2LV immediately after induction until the start of 1LV. The **initial period of 2LV** will encompass the 10 minute epoch beginning 10 minutes before the initiation of 1LV, or for cases not utilizing 1LV, 30 minutes after the start of 2LV. The duration of 1LV will include the period from the recorded time of 1LV initiation to the first re-iniitation of 2LV. **Initial ventilator settings during 1LV** will be derived for the 10 minute epoch beginning 5 minutes after the onset of 1LV. If more than one period of is reported per case, we will examine only the first time period greater than 10 minutes in duration. Ventilator settings for the **intermediate period of 1LV** (if available) will be derived for the 10 minute epoch beginning 30 minutes after the onset of 1LV.

We will also collect data on the method of lung isolation as the use of bronchial blockers may be associated with the intentional use of lower ventilation pressures and the use of continuous positive airway pressure (CPAP) delivered to the non-ventilated lung during 1LV as this may augment oxygenation and potentially lessen inflammatory stress. Finally, data on fluid administration and fluid balance will also be collected. Predicted body weight (PBW) will be calculated as follows: PBW for males = 50kg + 2.3kg * (Height (in) - 60); PBW for females = 45.5kg + 2.3kg *(Height (in) - 60)); BMI will be calculated (weight in kg/ height in m^2); along with V_T in cc/kg of PBW.

Exposure Variables / Covariates - STS

The STS database will be used on an institutional basis to obtain information for candidate risk predictors based on previously published thoracic surgery risk models[34-37] and for postoperative outcome data. Definitions of risk predictors and specific outcome events are as specified by the STS (STS GTSD Version 2.3, updated January 2015) and are available at: http://www.sts.org/sites/default/files/documents/STSThoracicDataSpecsV2_3.pdf

Covariate data from the STS database will include the following: indication for esophagectomy, cancer type, staging information, tobacco abuse, preoperative pulmonary function (if available), procedure type and duration of procedure, emergent vs. elective nature of procedure, gastric emptying interventions, surgical complications, and conduit type.

Statistical Analysis

Descriptive statistics for all relevant clinical data will be computed as frequencies and percentages for categorical variables and means and standard deviations or medians and interquartile ranges as appropriate for continuous variables. Continuous data elements will be checked for normality using the Kolmogorov-Smirnov test, and all variables deemed to be non-parametric will be reported as medians, 25^{th} and 75^{th} percentiles. If any continuous data element fails the Kolmogorov-Smirnov test then the data will be transformed as appropriate in the direction of the skew. Categorical data will be analyzed using Pearson Chi-square or Fischer's exact test as appropriate. Continuous data elements will be analyzed using a student's t test or Mann-Whitney U as appropriate.

Before any regression models are constructed, all variables under consideration for model inclusion will be checked for collinearity using the condition index. If the condition index is > 30, then a Pearson's correlation matrix will be developed. Those variables deemed to be collinear (defined as a correlation of >= 0.70) will be either combined into a single variable or selected for removal. All variables that are not considered to be collinear will be allowed to enter the models. Alternatively, if the total number of variables to be modeled is large and/or a high degree of correlation is seen between variables known or believed to represent important predictors, we will consider the use of penalized regression methods to improve predictive accuracy.

For all mixed-effects logistic regression models, the overall model's predictive capability will be reported using the area under the ROC curve c-statistic and Precision-Recall curve. Measures of effect size for model covariates will be reported as adjusted odds ratios with 95% confidence intervals. For the random effect of institution, the corresponding ICC (intra-class correlation coefficient) will be reported for all models. Any covariate found to be statistically significant following adjustment within the model will be considered an independent predictor of the outcome of interest.

A concurrently planned MPOG multicenter study examining the relationship between preoperative factors, anesthetic management factors and outcomes after esophagectomy has the potential to greatly inform our understanding of the relationships between the studied variables. As such, we anticipate the possibility of identifying, yet unknown, additional potentially important risk factors which could then be incorporated in the proposed models.

All analyses will be conducted using SAS 9.4 (SAS Institute, Cary, NC) and Stata. A p-value of 0.05 will be considered statistically significant for all analyses.

Aim 1a: The use of a putative LPV strategy conforming to expert recommendations for 1LV (defined as a $V_T \leq 5$ mL/kg PBW and PEEP ≥ 5 cm H_2O) and 2LV (defined as $V_T \leq 8$ ml/kg PBW and PEEP ≥ 5 cm H_2O) predicts improvements in postoperative respiratory complications

The aim will first be tested using a univariate chi-square or Fisher's Exact test, as appropriate, between use of LPV and the outcome of postoperative respiratory complications. If this association is statistically significant, a non-parsimonious mixed-effects logistic regression model will be constructed with the use of LPV covariate, as well as fixed effects – including variables previously associated with adverse outcomes after esophagectomy or other major thoracic surgery: age, gender, BMI, ASA status, presence of blood product transfusion, fluid balance, preoperative renal dysfunction, preoperative steroid therapy, Zubrod score, current smoking status, forced expiratory volume in 1 second (FEV_1), presence of missing FEV data, induction chemotherapy and/or radiation, major preoperative comorbidity, type of esophagectomy (e.g. Transhiatal vs. Ivor Lewis vs. Mckeown esophagectomy), incisional approach (thoracotomy vs. video-assisted thorascopic surgery (VATS)), use of 1LV vs only 2LV, and use of bronchial blocker (vs. double lumen tube). Institution will be included as a random effect. If use of LPV is found to be a statistically significant predictor of the primary outcome after adjusting for clinically relevant covariates, it will be considered an independent predictor of postoperative respiratory complications.

Aim 1b) To determine whether the use of a putative LPV strategy predicts improvements in postoperative morbidity

Aim 1b will be tested as in Aim 1a, with the outcome of major morbidity in place of postoperative respiratory complications. If use of LPV is found to be a statistically significant predictor of the outcome after adjusting for clinically relevant covariates, it will be considered an independent predictor of major morbidity.

Aim 2: To determine whether ventilatory correlates of dynamic alveolar strain – PIP and/or m∆P are predictive of postoperative complications

Three non-parsimonious mixed-effects logistic regression models will be constructed to evaluate the impact of ventilator parameters on the primary outcome of postoperative respiratory complications, adjusting for variables identified as significant risk predictors in published studies of adverse outcomes after major thoracic surgeries as sample size allows [43-45]. The following fixed effects will be included in all models: age, gender, BMI, ASA status, presence of blood product transfusion, fluid balance, preoperative renal dysfunction, preoperative steroid therapy, Zubrod score, current smoking status, FEV_1, presence of missing FEV_1 data, induction chemotherapy and/or radiation, major preoperative comorbidity, esophagectomy type, incisional approach (laparotomy vs. laparoscopy, thoracotomy vs. video-assisted thoracoscopic surgery (VATS), mixed surgical approach (laparotomy, VATS; thoracotomy, laparoscopy), robotic assisted esophagectomy), the use of 1LV versus only 2LV, and the use of a bronchial blocker versus double lumen tube. The individual institution will be included as a random effect and the corresponding ICC (intraclass correlation coefficient) will be reported for all models. In addition to the above, model 1 will contain m∆P (per 1 cm H_2O). Model 2 will contain all of the variables above and PIP. If m∆P or PIP are statistically significant after adjusting for other significant predictors, they will be considered independent predictors of postoperative respiratory complications.

A similar set of models will be constructed to determine if PIP and/or mΔP are independent predictors of the secondary outcomes of 30-day postoperative morbidity and 30-day postoperative mortality.

Aim 3a: To determine whether patients known to be at higher risk for receiving high V_T/kg PBW – patients with high BMI, short stature, and female gender - are more likely to be subjected to ventilator regimens associated with higher levels of mΔP.

To determine whether patients known to be at higher risk for receiving high V_T/kg PBW are more likely to be subjected to ventilator regimens associated with higher levels of mΔP, three non-parsimonious mixed-effects linear regression model will be constructed for the dependent variable (mΔP) and random effect of institution. The first model will contain the fixed effect of BMI, the second model will contain the fixed effect of height, and the third model will contain the fixed effect of gender.

Aim 3b: To determine whether, after adjustment for other risk predictors, patients at higher risk for receiving high V_T/kg PBW (high BMI, short stature, female gender) are also at higher risk for postoperative complications.

Three non-parsimonious mixed-effects logistic regression models will be constructed to evaluate whether patients known to be at higher risk for receiving high V_T are at higher risk of the primary outcome of postoperative respiratory complications, adjusting for variables identified as significant risk predictors in published studies of adverse outcomes after major thoracic surgeries as sample size allows [43-45]. The following fixed effects will be included in the model: age, gender, BMI, ASA status, presence of blood product transfusion, fluid balance, preoperative renal dysfunction, preoperative steroid therapy, Zubrod score, current smoking status, forced expiratory volume in 1 second (FEV_1), presence of missing FEV data, induction

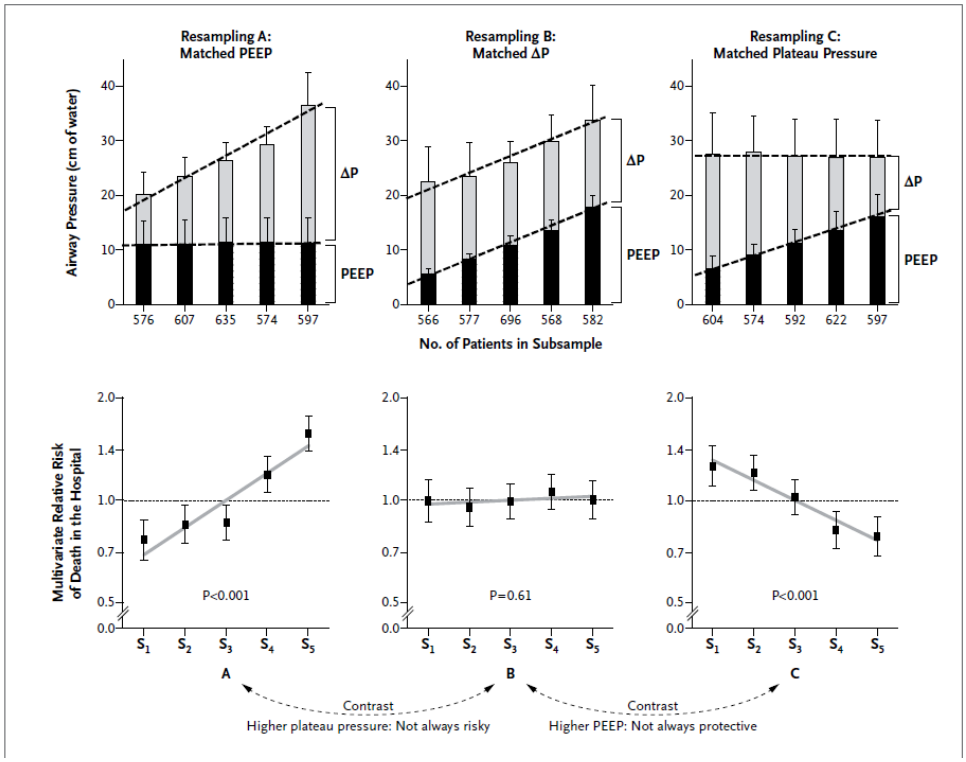
chemotherapy and/or radiation, major preoperative comorbidity, type of esophagectomy (e.g. Ivor Lewis vs. McKewin esophagectomy), incisional approach (thoracotomy vs. video-assisted thorascopic surgery (VATS)), use of 1LV vs only 2LV, and use of bronchial blocker (vs. double lumen tube). The individual institution will be included as a random effect and the corresponding ICC (intraclass correlation coefficient) will be reported for all models. In addition to the above, the first model will contain the fixed effect of BMI, the second model will contain the fixed effect of height, and the third model will contain the fixed effect of gender.

A similar set of models will be constructed for all secondary outcomes.
If the additional fixed effect for each model is found to be statistically significant, that characteristic will be considered an independent predictor of the outcome of interest. If all three are independent predictors, then those at high risk for receiving high V_T will be said to be at higher risk for postoperative complications.

Aim 4: To assess the role of ventilation pressures during 1LV on outcomes after thoracic surgery

To determine if the putative effects of ventilation pressures on outcomes after thoracic surgery are related to PIP versus mΔP we will use a double stratification procedure as described previously by Amato et al[29]. Briefly, we will match one variable - PEEP, mΔP, or PIP - while varying another to create three models: 1) matched PEEP with increasing mΔP, 2) increasing PEEP with matched mΔP, and 3) matched PIP with increasing PEEP. We anticipate creating at least five distinct subsamples and calculating the relative risk for each subsample compared to the total sample. As in the figure below (from Amato et al.[29]), the first set is matched on the basis of PEEP to investigate the relative risk increase with the change in driving pressure. The second set is matched on the basis of driving pressure to investigate the relative risk with

increasing PEEP and airway pressure. The third set is matched on the basis of airway pressure to investigate the relative risk associated with increasing PEEP and decreasing ΔP.



Questions for Group

1. Are we focusing on the correct LPV variables? Is there a hypothesis/specific aim that should be primary?
2. Are there other surgical variables which might affect the risk of pulmonary complications and should thus be considered in the analysis?
3. As perioperative aspiration is a frequent and significant risk factor for pulmonary complications in this patient population, are there management strategies (identifiable in the databases) potentially affecting aspiration risk which should also be considered in this study? Pyloric interventions, nasogastric tube practices, swallowing studies?
4. The proposal includes use of the modified driving pressure (mΔP) variable which incorporates the peak inspiratory pressure and PEEP level. The rationale for this is that ΔP calculation requires P_{plat}, a ventilator variable not captured at all MPOG sites. Although mΔP has been shown to predict complications, much more data is available to support the use of ΔP as a predictor. Should we additionally consider calculating ΔP and performing analysis with this predictor in a subset of data from sites submitting P_{plat}?

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Demographic data	Standardized View/Table	View/ Concept	MPOG Concept ID
Case ID	General Case Information -> MPOG_Case_ID	V	
Institution ID	** Institution ID **	T	
Age	Patient Demographics -> AIMS_Patient_Age_Years	V	
Sex	Patient Demographics -> AIMS_Sex	V	
Race	Patient Demographics -> MPOG_Race_Concept_ID		
ASA status	ASA Class -> ASA_Class	V	
Height	Patient Anthropometrics -> MPOG_Height_cm	V	
Weight	Patient Anthropometrics -> MPOG_Weight_kg	V	
BMI	Patient Anthropometrics -> MPOG_Body_Mass_Index		
Comorbidites	*** From ICD9 Billing Data ***	C	
Zubrod score			
Induction chemotherapy and/or radiation			
Renal Dysfunction			
Forced expiratory volume (FEV_1)			
Steroid Therapy			
Procedure Data			
Surgery CPT codes	Charge_Capture -> Primary_Surgery_Code	V	
Anesthesia CPT Codes	Charge_Capture -> Primary_Anesthesia_Code	V	
Bronchial blocker use			

	Year of Service	Derived from Case Times -> Anesthesia_Start_DT	V	
	Planned Surgical Procedure	General Case Information -> AIMS_Scheduled_Procedure_Text	V	
	Performed Surgical Procedure	General Case Information -> AIMS_Actual_Procedure_Text	V	
	Duration of Anesthesia	Case Times -> Case_Duration_Anesthesia_min	V	
	Duration of Surgery	Case Times -> Case_Duration_Surgery_min	V	

Intraop Data				
	Set Tidal Volume	Physiologic Observations	T	3192
	Measured Tidal Volume	Physiologic Observations	T	3190
	Respiratory Rate – Gas Analyzer	Physiologic Observations	T	3230
	Respiratory Rate – Ventilator - Set	Physiologic Observations	T	3198
	PEEP – Set	Physiologic Observations	T	3212
	PEEP – Measured	Physiologic Observations	T	3210
	Peak Inspiratory Pressure	Physiologic Observations	T	3185
	Plateau Airway Pressure	Physiologic Observations	T	3186
	Ventilator Mode Setting (if available)	Physiologic Observations	T	3182
	Inspired O2 Fraction – Gas Analyzer	Physiologic Observations	T	3240
	Inspired O2 Fraction – Ventilator	Physiologic Observations	T	3200
	Thoracic - Single lung ventilation (1LV Start)	Intraoperative Events, Interventions, and Observations	T	50501
	Thoracic - Single lung ventilation side detail (Alternative 1LV Start)	Intraoperative Events, Interventions, and Observations	T	50502

	Thoracic - bronchial cuff inflation detail	Intraoperative Events, Interventions, and Observations	T	50641
	Thoracic - bronchial cuff inflated or deflated (Alternative 1LV Start)	Intraoperative Events, Interventions, and Observations	T	50640
	Thoracic - Two lung ventilation (TLV Start/Restart)	Intraoperative Events, Interventions, and Observations	T	50500
	Blood product use	Intraoperative Blood Products In		10490/10492/10493/10494/10495/10496
Postoperative				

	Post Operative Destination	** Unknown ***	T	
	Mortality			
	Anastomotic leak			
	Unexpected ICU admission			
	Central Neurologic event			
	Renal failure			
	Sepsis			
	Myocardial Infarction			
	Atrial or ventricular dysrhythmias requiring treatment			
	Unexpected return to OR			
	Respiratory failure			
	Atelectasiss requiring bronchoscopy			
	Air leak > 5 days			
	Pulmonary embolism			
	Bronchopleural fistula			
	ARDS			

	Tracheostomy			
	Empyema requiring treatment			
	Pneumonia			
	Reintubation			
	Initial ventilator support > 48 hours			