Title: Variation and Trends of Intraoperative Tidal Volume Habits

Proposed Authors: S. Patrick Bender MD; Lyle Gerety MD; W. Gabe Tharp PhD; Ian Black MD; Bill Paganelli MD, PhD; Amy Odefey, MD; David Adams MD Ana Fernandez-Bustamante MD; Sachin Kheterpal MD

Primary institution: Fletcher Allen Health Care / University of Vermont College of Medicine

Introduction:

Historically, physicians used higher tidal volumes to ventilate intubated patients in the operating room or intensive care unit (1), as this practice had been shown to minimize atelectasis, shunt, and hypoxia by preventing elevation of the diaphragm, airway closure, and decreased lung volumes associated with sedation in the supine position (2). Since then, further investigation characterized the concept of ventilator induced lung injury (VILI), resulting from high tidal volumes (volutrauma), airway pressures (barotrauma), repetitive recruitment and de-recruitment (atelectrauma), or the injurious release of inflammatory mediators (biotrauma) (3).

Initial experimentation with lower tidal volumes has shown this to be a safe approach for ICU patients (4). Further, data generated by the ARDSnet group has demonstrated that lung protective mechanical ventilation (LPV) with low tidal volumes (6 ml/kg of ideal body weight) along with moderate or high levels of positive end expiratory pressure (PEEP) results in reduced mortality in patients with acute lung injury (ALI) and acute respiratory distress syndrome (ARDS) (5). This remains one of the few interventions shown to reduce mortality in the ICU. In addition, there is evidence for an association between high initial tidal volumes and the eventual development of lung injury in ICU patients without pre-existing ALI (6, 7, 8). The use of LPV in ICU patients at risk for ALI/ARDS is now widely accepted.

The notion that intraoperative lung protective strategies could be beneficial for surgical patients is intuitive, and emerging data do support the use of LPV strategies intraoperatively (9). Specifically, intraoperative LPV has shown benefits for patients at risk for ALI who have undergone pneumonectomy (10), cardiac surgery (11, 12), esophagectomy (13), or major abdominal surgery (14). Despite this data, ventilation with higher tidal volumes continues to be performed, as reported by a single-center study (15). Risk factors at this center appear to include obesity, female gender, and short stature, suggesting that ventilation with higher tidal volumes may be unintentional (15).

To our knowledge, there have been no studies demonstrating current global practice with regard to intra-operative tidal volumes from large-scale, representative databases. We propose to utilize the Multicenter Perioperative Outcomes Group (MPOG) database for assessment of intraoperative tidal volume habits, temporal trends in intraoperative ventilation, and variation across centers. In addition, we will evaluate how TV may be affected by default ventilator settings, and characterize risk factors for inappropriately large TV use.

We hypothesize that despite convincing data from the anesthesia and critical care literature, and mounting evidence for the preventative benefits of low intraoperative tidal volumes in all patients, or at least those at risk for ALI, many patients continue to receive inappropriately large intraoperative tidal volumes, especially obese, short, and female patients. We also hypothesize that initial TV may be high, due to pre-set manufacturer settings, and may be subsequently changed by the anesthetic provider. We also hypothesize that TV habits may vary by institution and/or specific provider.

Methods:

Institutional Review Board approval (University of Michigan, Ann Arbor) was obtained for this retrospective, observational study of de-identified data. Since no care interventions will be performed and data collected were routine medical care, patient consent was waived.

As part of the study, each participating institution will be polled as to the default ventilator settings used in their various anesthetizing locations.

Specifically, the MPOG database will be queried for all cases from 2008 to 2013 for which general anesthesia with an endotracheal tube was used. Intubated patients will be identified and defined by use of muscle relaxant in combination with documented intubation notes. Excluded are patients with age <18, those with documented LMA placement, and those with anesthetic case duration of less than 45 minutes from anesthesia start to end. Patients with pre-existing ventilator requirements will be included.

From this data set we plan to extract the following variables: ventilator settings (Mode, actual TV, Set TV, Set RR, PIP, PEEP, FiO2), age, gender, height, weight, ASA status, type of surgery (primary surgical procedure CPT code or procedure service), MPOG patient identifier, MPOG institution identifier, provider type (Attending alone vs. supervised CRNA vs. supervised Resident), and disposition (PACU vs ICU). From these data ideal body weight (IBW) will be calculated (IBW for males = 50kg + 2.3kg * (Height (in) - 60); IBW for females = 45.5kg + 2.3kg *(Height (in) - 60)), BMI will be calculated (weight in kg/ height in m^2); along with TV in cc/kg of IBW.

For each case, two summary definitions of ventilator settings will be derived: initial and overall. For "overall" ventilator settings, we will derive the median tidal volume over the entire case. This overall period will be identified by the inclusion of all tidal volumes when measured respiratory rate is greater than 2, and measured tidal volume is greater than 50mL. This is necessary, as not all contributing institutions have data for Ventilator Mode, RR Set, or TV Set. Because the median tidal volume is the primary objective, short periods of manual ventilation before intubation or at case end should not influence this data. Also, periods of cardiopulmonary bypass will be excluded using these criteria.

For "initial" ventilator settings, we will acquire all ventilator settings from the onset of controlled ventilation each minute for the initial 10 minutes following the start of controlled ventilation. We will use data from only those centers that document Ventilator Mode. Otherwise, it is very difficult to identify the beginning of controlled ventilation (Time 0).

Statistical analysis:

Summary and descriptive statistics will be calculated for all clinical data. ASA status will be treated as an ordinal variable. Categorical variables will include sex, emergent surgery, and provider service. Tidal volumes (mL per kilogram) will be calculated from both ideal and actual body weight. Minute ventilation will be calculated from respiratory rates and tidal volumes.

First, we will describe trends in "overall" tidal volumes (ideal and actual) over the study period with hierarchical clustering at the institution level (Figure 1a), procedure service level (Figure 1b), and provider level by nested, repeated measures ANOVA. The provider type will be categorized as: attending alone, attending supervising resident, and attending supervising CRNA. (Figure 2) Each 3 month period will be aggregated as a single unit of analysis for trend analysis, and analyzed by repeated measures ANOVA.

Next, we will examine association of patient characteristics (e.g. age, sex, body weight, height, ASA status) and surgical characteristics (e.g. emergent, provider service) with high or low tidal volumes. We will conduct two separate multivariate logistic regression analyses first using 8 mL/kg and then 10 mL/kg as the dividing point between low and high tidal volumes. These analyses will also be subsequently examined for effects of institution and provider type by hierarchical clustering.

Last, we will assess whether tidal volumes are different between initial and overall settings and if these potential differences are associated with certain patient, surgical, provider, or institutional characteristics using nested, repeated measures ANOVA.

In all analyses, multivariate modeling will be conducted systematically using both a priori identification and step-wise inclusion of variables identified through bivariate and stratified analyses. All statistical analyses will be two-tailed and significance set at a p-value less than 0.05 with appropriate correction for multiple testing.

Variables to be collected from MPOG records

Element	**Source**
MPOG patient identifier	General_Case_Information
MPOG institution identifier	General_Case_Information
Case Date	General_Case_Information.AIMS_Scheduled_DT
age	Caseinfo.age_in_years
gender	Caseinfo.sex
Height in cm	Anthropometrics.MPOG_height_cm
Weight- kg	Anthropometrics.MPOG_weight_kg
BMI	Anthropometrics.Body_Mass_index
ASA status	ASA_Class.ASA_Class, ASA_Class_ASA_Emergent
Primary Surgical Service	General_Case_Information. MPOG_Primary_Procedural_Service_Concept_ID
Primary Surgical Service	General_Case_Information. MPOG_Primary_Procedural_Service_Concept_Desc
Procedure Code	General_Case_Information. Charge_Capture_Primary_Anesthesia_Code
Procedure Code	General_Case_Information. Charge_Capture_Primary_Surgery_Code
provider type	Case_providers_Anesthetist_first (with role_type)

provider type	Case_providers_Anesthetist_primary (with role_type)
provider type	Case_providers_Attending_First
provider type	Case_providers_Attending_primary
Disposition- PACU vs ICU	Not sure how mapped by each center, will have to review
ventilator Mode	3182 (only available from a few centers)
Set TV	3192
Actual TV	3190,
Set RR	3198
PIP	3185
PEEP – measured	3210
PEEP – set	3212
FiO2 – measured	3200
FiO2 – set	3202

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