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Prehospital tidal volume influences hospital tidal volume: A cohort study☆

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ABSTRACT

Purpose: The purposes of the study are to describe current practice of ventilation in a modern air medical system and to measure the association of ventilation strategy with subsequent ventilator care and acute respiratory distress syndrome (ARDS).
Materials and methods: Retrospective observational cohort study of intubated adult patients (n = 235) transported by a university-affiliated air medical transport service to a 711-bed tertiary academic center between July 2011 and May 2013. *Low tidal volume ventilation* was defined as tidal volumes less than or equal to 8 mL/kg predicted body weight. Multivariable regression was used to measure the association between prehospital tidal volume, hospital ventilation strategy, and ARDS.
Results: Most patients (57%) were ventilated solely with bag valve ventilation during transport. Mean tidal volume of mechanically ventilated patients was 8.6 mL/kg predicted body weight (SD, 0.2 mL/kg). Low tidal volume ventilation was used in 13% of patients. Patients receiving low tidal volume ventilation during air medical transport were more likely to receive low tidal volume ventilation in the emergency department ($P < .001$) and intensive care unit ($P = .015$). Acute respiratory distress syndrome was not associated with prehospital tidal volume ($P = .840$).
Conclusions: Low tidal volume ventilation was rare during air medical transport. Air transport ventilation strategy influenced subsequent ventilation but was not associated with ARDS.

1. Introduction

Prehospital and early hospital care has been recognized as an influential period in the evolution of critical illness [1,2]. Critically ill and injured patients being treated by air medical providers are often intubated and undergo mechanical ventilation. Mechanical ventilation is common in the prehospital and interhospital environment, but little has been reported on the details of its actual implementation in the prehospital setting.

Mechanical ventilation has been known to cause harm (ie, ventilator-induced lung injury) for decades [3], and the use of lung protective ventilation to mitigate ventilator-induced lung injury is associated with improved mortality in patients with acute respiratory distress syndrome (ARDS) [4]. Only recently, however, have investigators begun to appreciate the role of routine lower tidal volumes (6-8 mL/kg predicted body weight [PBW]) to prevent the complications of ARDS [5,6]. Randomized trials suggest that lung injury can be prevented by low tidal volume ventilation [7-9], and 2 recent systematic reviews suggest that routine use of low tidal volume ventilation may prevent ARDS development and improve patient outcomes [10,11].

Prior reports suggest that ARDS can develop within hours to days [6,12] so targeting strategies aimed at lung protection during the earliest period of mechanical ventilation have been postulated to prevent ARDS and downstream complications occurring after intensive care unit (ICU) admission [13]. Prior studies have reported poor adherence with low tidal volume ventilation in the ICU and in the emergency department (ED) [14,15].

Early medical decisions have been shown to influence subsequent care [14,16]. This association or "therapeutic momentum" has not previously been examined in the context of prehospital transport. Many important and time-sensitive interventions are begun during the transport of a critically ill patient, and the importance of these decisions could be magnified if they influence hospital-based care. Ventilator strategy is a critical component of a critically ill patient's care, and whether prehospital ventilation influences outcome is debated.

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The primary objective of this study was to describe the ventilation strategy used for intubated patients transported in a modern aeromedical transport system, with a focus on use of low tidal volume ventilation. Secondary objectives included to (1) measure the impact of prehospital ventilator tidal volume on subsequent inpatient ventilator tidal volume and (2) estimate the prevalence of ARDS in transported patients, the subsequent incidence after admission, and the association between prehospital ventilator strategy and the subsequent development of ARDS.

Our hypotheses were that low tidal volume ventilation would be uncommon in the prehospital environment, therapeutic momentum from prehospital ventilation would influence ED and inpatient tidal volume selection, and ARDS would be present in a minority of transported patients but would be influenced by patient- and treatment-related factors present in the prehospital environment.

2. Materials and methods

2.1. Study design, population, and setting

This study was a retrospective observational cohort study of intubated adult (age ≥18 years) patients transported by a university-affiliated air medical transport service to a 711-bed tertiary academic medical center between July 2011 and May 2013. The study hospital is located in a rural Midwestern state and has a 60 000-visit ED with a 2-helicopter air ambulance service with 800 annual flights. The first helicopter is based at the university, and the second is based at a community hospital approximately 85 miles from the university. Both helicopters are staffed with a nurse-paramedic flight crew, and no crew members staff both helicopters. Both helicopters carry a Crossvent 3 transport ventilator (Bio-Med Devices, Inc, Guilford, CT) and bag valve for manual ventilation. The medical flight crew ventilation protocols are detailed in Supplementary Appendix 1.

Upon hospital arrival, patients were admitted to the ED, operating room, or directly to an ICU. Patients were ventilated in the ED and during intrahospital transport using a Respironics Trilogy 202 (Philips Healthcare, Andover, MA) and in the ICU with the Maquet Servo-i (Maquet Getinge Group, Rastatt, Germany). In all patient care areas, ventilation settings are determined by the treating physician.

Patients who (1) died within 72 hours of hospital arrival, (2) were younger than 18 years at time of transfer, or (3) were admitted to a transferring hospital before definitive transfer were excluded from the study. The reason for excluding patients who died within 72 hours is that (1) it is impossible to assess clinical outcomes (such as ARDS) with a short period of observation and (2) patients who die early are a heterogeneous group that includes patients who are both very ill and patients who are being transported for palliative care and expectant management. Because of the variability in this group, it is challenging to interpret appropriateness of ventilator settings in this cohort. This study is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology Statement [17] and was approved by the institutional review board (IRB no. 201305726) of the principal investigator's institution under waiver of informed consent.

2.2. Study protocol

2.2.1. Data collection

Two data abstractors were trained in data abstraction techniques and extracted data from the electronic medical record (AJS and TSW). Variables for collection were defined a priori, and a standardized form was used to ensure uniform data collection. Intubated patients were identified using flights logs from the air ambulance service. Ventilation parameters were abstracted from the flight medical record and were

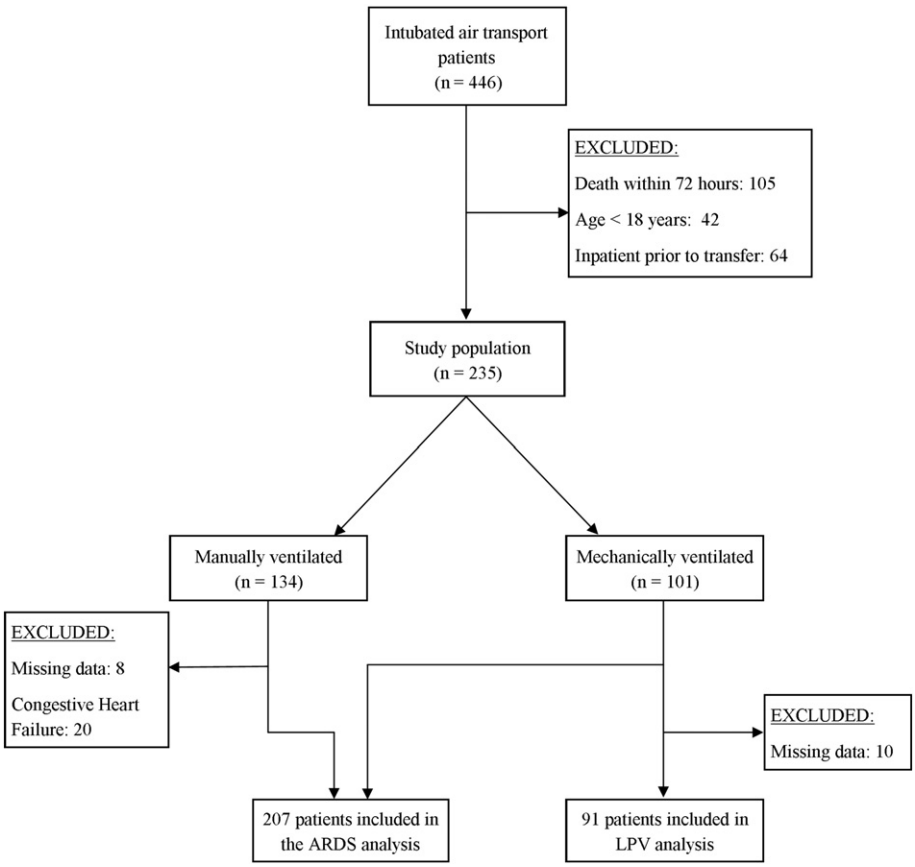

Fig. 1. Study patient flow diagram.