INCIDENCE OF FAILED VENTILATION AMONGST CRITICAL CARE PATIENTS GOING FOR URGENT SURGERY

Urooj Siddiqui PGY3 Anesthesia
Andrew Syrett PGY3 Anesthesia
McMaster University
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Case

- **ID:** 51yo M with 70% TBSA
- **HPI:**
  - Enclosed space propane tank explosion resulting in 70% TBSA to face, neck, B/L hands, arms, legs and feet
  - Tracheostomy for prolonged ventilation
  - Development of Staph. aureus bacteremia
  - AKI requiring dialysis
- **PMHx:** Nil previous to admission
  - Since admissions: ARDS (+Trach), R phrenic n. palsy, AKI requiring dialysis, sepsis, anemia
- **Meds:** Fentanyl, PPF, Voriconazole, Tylenol, Ondansetron, CaCO₃, Hydralazine, Clonazepam, Hydromorphone
Case

• Dx: 70% TBSA burns + inhalational injury
• Procedure: Debridement and STSG face + R hand
• Duration: 4h
• Blood loss: 1200ml
• Fluids in: 3L crystalloid, 4U PRBCs
Case

- **Pre-op Ventilator settings + ABG:**
  - PCV 22/10, FiO$_2$ 0.4, rr16
  - ABG: 7.45/33/97/23

- **Intra-op Ventilator settings + ABG:**
  - PCV 30/24, FiO$_2$ 0.6, rr15
  - ABG: 7.17/46/197/17

- **Post-op Ventilator settings + ABG (next –am):**
  - FiO$_2$ 1.0
  - ABG: 7.23/48/376/20
How can this have been avoided?
Could this have been predicted?
Outline

• History of Mechanical Ventilation
• Characteristics of ICU vs. OR ventilators
• Our Study
  • Objective
  • Study Design
  • Patient Selection
  • Data Collection
  • Outcomes
  • Analysis
• Impact
History of mechanical ventilation

• 2nd century AD: Galen proposes that breathing was required to maintain the circulation
• 1543: Vesalius makes first known reference to PPV:

“But that life may be restored to the animal, an opening must be attempted in the trunk of the trachea, into which a tube of reed or cane should be put; you will then blow into this, so that the lung may rise again and take air”

History of mechanical ventilation

• 1667: Robert Hook confirms Galen’s hypothesis, showing that cessation of respiration would cause:

“the Lungs to fall and lye still, [and] the Dog would immediately fall into Dying convulsive fits; but be as soon reviv’d again by renewing the fullness of his lungs…”

History of mechanical ventilation

- It was believed that people were unconscious because of lack of stimulation, so “resuscitation” aimed to stimulate patients:
  - Rolling over barrels
  - Strapping them to the back of a trotting horse
  - Flagellation
  - Hanging them upside down
  - Cooling them on ice
  - Blowing smoke up the patients rectum (fumigation)
History of mechanical ventilation

• Better knowledge of respiratory physiology sparked the advent of negative pressure ventilation

History of mechanical ventilation

History of mechanical ventilation

- 1952: Danish poliomyelitis epidemic. Despite negative pressure ventilation, patients found to be dying of “renal failure” – diaphoresis, hypertension, and high CO2. Bjorn Ibsen proposes tracheostomy and positive pressure ventilation, and mortality dropped from 87% to 40%.
- All patients brought to same unit and hand ventilated by a total 1500 students over the course of the epidemic.

Bellows or Piston?

**Bellows**
- Visual cue of bellows rising and falling
- Audible feedback of ventilator cycling
- Intrinsic PEEP of 2-3 cmH$_2$O

**Piston**
- Less OR noise
- No intrinsic PEEP
- Better precision of delivered tidal volume in both volume and pressure control modes
- No driving gas
Our ventilators

GE Datex Ohmeda Aisys
Datex Ohmeda S/5 ADU
Maquet Servo-i
Study Question

In critically ill, ventilated ICU patients requiring transfer to the Operating Room for surgical intervention, are OR ventilators able to adequately maintain oxygenation and ventilation compared to more sophisticated ICU ventilators as determined by incidence of failed ventilation in patients previously well-ventilated in the ICU
Study Question

- **P** = Adults (>18y) admitted to ICU being mechanically ventilated prior to surgery requiring transfer to the operating room for surgical intervention between January 1\(^{st}\) 2014 and December 31\(^{st}\) 2015.

- **I** = Transfer of ventilation from ICU to OR ventilator, with subsequent ventilation monitoring for adequacy

- **C** = Assessment of ventilation using ICU ventilators prior to use of OR ventilator

- **Q** = Incidence of failed/difficult ventilation using OR ventilators in patients previously adequately ventilated using ICU ventilators
Study Objectives

• Compare adequacy of ventilation of critically ill patients using ICU vs OR ventilators
• Determine the incidence of failed/difficult ventilation either before or after a trip to the operating room
• Identify factors which may predispose to inadequate ventilation in the ICU or OR
Study Design

- Retrospective case series
- Hamilton General Hospital
- Juravinski Hospital
Patient Selection

- **Inclusion Criteria**
  - Adult patients (>18y)
  - Admitted to ICU and requiring mechanical ventilation
  - Transfer to operating room from ICU for a surgical procedure with continued mechanical ventilation

- **Exclusion Criteria**
  - No pre- or post-operative ABG
  - Hypoxemia or respiratory acidosis in ICU prior to surgery
  - Patients extubated in operating room
Data Collection

- Data will be extracted from hospital EMR systems
  - One reviewer will extract data with confirmation by a second reviewer
- Patient demographics (age, gender, Ht, Wt, BMI, Dx)
- PMH_x
- Medications
- Vital signs
- Surgery
- Operative urgency (ASA, priority)
- Ventilator type
- Ventilator Settings (mode, V_t, peak/mean A/W pressures, PEEP)
  - were ventilator settings changed throughout the case to maintain normocapnia?
- Laboratory Results (ABG, troponins,)
- Primary and Secondary Outcomes data
  - Blood gas analyses
  - In hospital mortality
  - LOS in hospital
Outcomes

• Primary
  • Failed mechanical ventilation defined as:
    • Respiratory acidosis: post operative finding of pH<7.35, pCO$_2$>45mmHg, or ETCO$_2$ >40mmHg
    • Hypoxemia or hypoxia: Pa$_0$$_2$<80mmHg on intra- or post-op ABG, or Sp$_0$$_2$<90% intra-operatively
    • Difficult Ventilation
  • Secondary
    • In-hospital mortality, post-op MI
    • LOS in ICU
    • Total hospital LOS
    • Disposition at discharge
Analysis

• Incidence of failed/difficult ventilation and secondary outcomes reported as percentages with 95% confidence intervals (CI)
• Interval data reported as a mean with 95% CI
• Comparison analysis of patients successful vs. failed mechanical intra-operative ventilation
  • LOS, MI, mortality, disposition
• Univariate analysis to identify significant differences between successful vs. failed ventilation groups
  • Candidate variables will be identified (p<0.2) to determine risk factors for failed/difficult ventilation
Impact

• >300 ICU patients from JH and HGH taken to OR in 2015
  • For >650 procedures
• Examination of these cases is necessary to determine clinical end-points which may predict which patients are best served by which ventilator
• Goals:
  1. prevent further deterioration of already critically-ill patients
  2. identify risk factors for difficult OR ventilation
  3. predict patients that would benefit from use of ICU ventilators in the OR