

Negative Pressure Pulmonary Edema

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Abstract

Negative pressure pulmonary edema (NPPE) is a rare but dangerous complication of general anesthesia potentially causing anoxic brain injury and a 5% mortality, if not promptly recognized and treated. This case report reviews an 18-year-old male who developed NPPE after a pilonidal cyst removal under general anesthesia. The purpose of this poster is to educate professionals on the etiology, signs, symptoms, treatments, risk factors, and preventions of NPPE to aid in the early recognition and treatment of its occurrence.

About the Author: Christine Nagel, is a graduate student pursuing a Doctorate of Nurse Anesthesia Practice from Texas Christian University School of Nurse Anesthesia.



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Background of NPPE

- PICOT:** In surgical patients, how is negative pressure pulmonary edema (NPPE) best prevented and treated compared to the traditional methods of intubation and mechanical ventilation to provide safer anesthesia care during the perioperative period?
- NPPE is a rare, life-threatening complication of general anesthesia
 - Incidence: 0.01-0.1% of all general anesthetics
- Etiology:** non-cardiogenic
 - Large negative intrathoracic pressure produced by forceful inspiration against a closed glottis
 - Increased pulmonary capillary permeability and enhanced venous return to the heart leads to fluid accumulation in the alveoli from the intravascular system
- Type 1 NPPE: occurs immediately due to obstruction
- Type 2 NPPE: delayed appearance; due to relief of a chronically obstructed airway
- Characterizations of NPPE:** acute hypoxemia, upper airway obstruction after removal of endotracheal tube (ETT) or laryngeal mask airway (LMA), radiographic evidence of pulmonary infiltrates, productive cough of pink frothy sputum
- Common causes:** laryngospasm (50%), upper airway occlusion (11%), residual neuromuscular blockade (NMB)
 - Laryngospasm incidence: 1% of adult general anesthetics, 2% of pediatric cases, 3% in neonates, and up to 10% in the presence of upper respiratory infection or asthma
 - Percent of laryngospasms that result in NPPE: 4%
- NPPE mortality: 5%

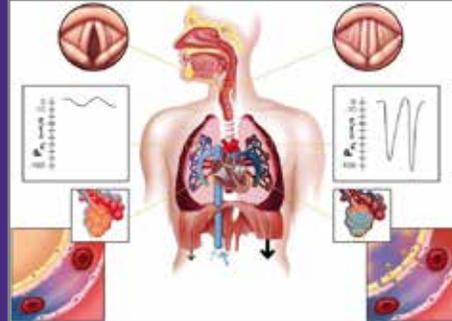


Figure 1: Pathophysiology of NPPE¹

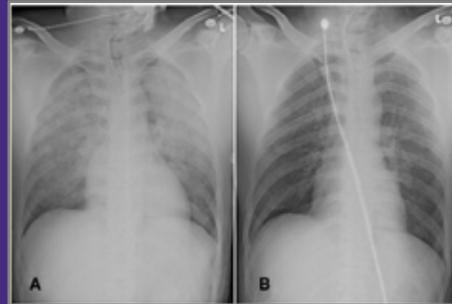


Figure 2: Chest x-ray of bilateral pulmonary infiltrates immediately after NPPE occurrence versus follow-up x-ray 24 hours after²

Case Report

Pre-anesthetic:

- 18 y/o male, 102 kg, pilonidal cyst removal
- ASA II – active marijuana smoking
- Preop VS: 97.6 F, HR 85 bpm, NSR, RR 20 bpm, BP 142/70

Intraoperative:

- Induction: midazolam 2 mg IV, fentanyl 100 mcg IV, lidocaine 50 mg IV, propofol 200 mg IV
- Muscle relaxation: rocuronium 50 mg IV
- ETT size 7.5 placed at 21 cm at the teeth
- Prone position
- Sevoflurane 2% at 2 L/min used throughout case
- Neuromuscular reversal: 3/4 twitches, sugammadex 200 mg IV given, 4/4 twitches after reversal

Postoperative:

- Patient experienced a laryngospasm upon ETT removal
- Oxygen desaturation to 50%
- Positive pressure ventilation (PPV) and propofol 100 mg IV given with no improvement
- Succinylcholine 200 mg IV given and patient re-intubated with presence of red, frothy sputum in ETT
- Mechanical ventilation with 100% oxygen given for 20 minutes
- Furosemide 10 mg IV given for pulmonary edema
- Patient extubated awake 30 minutes later – placed on 100% oxygen via facemask at 15 L/min
- Monitored for 24 hours in the PACU
- Discharged after all symptoms had resolved and pulmonary infiltrates had cleared on the chest x-ray

NPPE Prevention/Treatment Algorithm

Risk Factors of Laryngospasm:
Age, lower BMI, male, ASA I-II, reactive airway, smoke exposure, ETT, emergency operation, multiple DL attempts

Prevention Strategies:

- LMA versus ETT
- Magnesium sulfate 15-30 mg/kg IV infusion
- Lidocaine topical or 1-2 mg/kg IV before extubation
- Sub-hypnotic propofol 0.5 mg/kg IV prior to extubation
 - Thorough suctioning
 - Deep extubation + oral airway

IF LARYNGOSPASM OCCURS:

Treatments:

1. 100% oxygen, PPV, oral airway
2. Larson's maneuver/jaw thrust
3. Ensure NMB reversal
4. Gentle chest compression (pediatrics)
 - If no ventilation:**
 1. Propofol 0.5 mg/kg IV
 2. Midazolam 0.03 mg/kg IV
3. Succinylcholine 1-2 mg/kg IV or 4 mg/kg IM
4. Re-intubation + mechanical ventilation

IF NPPE OCCURS:

Symptoms:

Acute respiratory failure, hypoxemia, productive cough of pink/red frothy sputum, auscultation abnormalities, tachycardia, paradoxical breathing

Treatments:

1. Positive pressure (BIPAP, CPAP) + 100% oxygen
 - a. If re-intubated, give PEEP
2. Beta-2 agonists (albuterol)
3. If no improvement in symptoms, give diuretics

Differential Diagnoses:

- Anaphylactic reaction
- Cardiogenic pulmonary edema
- Myocardial infarction
- Volume overload
- Pneumonia
- Pulmonary embolism
- Aspiration
- Covid-19 complications

Results/Synthesis of Evidence

- **Risk factors:** age (<35 years), male, ASA I-II classification, reactive airway, active smoking, environmental smoke exposure, lower BMI (<27), ETT, and emergency operation
- **Prevention:** limited direct laryngoscopy attempts, LMA, magnesium sulfate IV for muscle relaxation, adequate and gentle suctioning, deep extubation, oral airway, lidocaine topical or IV, and propofol IV
- **Most common findings:** acute and isolated respiratory failure, hypoxemia, productive cough of pink/red frothy sputum, auscultation abnormalities (rales, rhonchi), tachypnea, tachycardia, and paradoxical breathing
- **Diagnostic measures:** chest x-ray, arterial blood gas, physical presentation, auscultation abnormalities, bloody bronchoscopy and bronchoalveolar lavage
- **Management:**
 - **Treating the cause (obstruction)** – PPV via facemask, 100% oxygen, adequate NMB reversal, gentle chest compressions (pediatrics), intubation and mechanical ventilation, propofol IV, midazolam IV, succinylcholine IV/IM
 - **Treating NPPE** – PPV (BIPAP, CPAP), 100% oxygen, albuterol, diuretic (if no improvement in symptoms), intubation and mechanical ventilation with PEEP
- Close monitoring in ICU/PACU recommended for 24 hours
- Average time to full resolution: 30 hours
- **Gaps in the literature:** diuretics as treatment, associated surgeries, the use of desflurane and/or sugammadex as a possible cause

Recommendations and Suggestions

- Careful assessment of risk factors for upper airway obstruction
- Prevention and treatment preparation in high-risk patients
- Prevention with gentle suctioning, LMA if applicable, oral airway, and proper medications prior to extubation
- Treatment sequence: 100% + PPV → Larson's maneuver → propofol → succinylcholine → intubation (if unable to ventilate) → PEEP/PPV → beta-2 agonist → ICU/PACU monitoring + 100% oxygen + PPV
- Non-invasive treatment of NPPE was shown to be a safe alternative to intubation and mechanical ventilation
- More data and experience with NPPE needed to further improve outcomes and patient safety

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