

Kittitas County Prehospital EMS Protocols

SUBJECT: PORTABLE VENTILATOR

1) Indications

- a. Inter-facility transport of an intubated patient
- b. Mechanical ventilation of a patient intubated in the field

2) Contraindications

- a. Intubated patient with a known pneumothorax without a chest tube in place.
- b. Patients less than 20 kg **except** for inter-facility transfers with physician orders.

3) Adverse Effects/Complications

- a. Increased intra-thoracic pressure
- b. Decreased venous return to the heart and decrease cardiac output (hypotension, tachycardia)
- c. Increased V/Q ratio (ventilation/perfusion ratio)
- d. Decreased blood flow to the kidneys with resultant fluid retention (edema)
- e. Air trapping and intrinsic PEEP (Auto PEEP)
- f. Barotrauma
- g. Nosocomial infections of the lungs and sinuses
- h. Respiratory alkalosis
- i. Agitation and increased respiratory distress
- j. Increased work of breathing

4) Procedure

- a. If the patient is an interfacility transfer, use the ventilator settings recommended by Respiratory Therapy or the Attending Physician
- b. If there are no instructions on ventilator settings or if the ventilator is established in the field, Lung Protection Strategy Settings will be utilized unless Obstructive Strategy is indicated by the patient's physiologic status
- c. The ventilator settings in this procedure are intended to be guidelines; settings should be appropriately adjusted based on the patient's physiologic presentation and the attending paramedic's, training, clinical experience, and best judgement
- d. **Lung Protection Strategy (all patients except COPD/Emphysema/Asthma/Anaphylaxis)**
 - Assemble per manufacturer's recommendations and if available set PEEP to 5 cm H₂O
 - A Heat and Moisture Exchange Filter should be used to heat inspired air, add moisture, and filter out debris and pathogens
 - Select a volume control mode (Synchronized Intermittent Mandatory Ventilation (SIMV) or Assist Control A/C)) SIMV, SIMV may be better in the prehospital setting at preventing

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patient/ventilator asynchrony. If the patient is fully paralyzed and sedated, there is no functional difference between SIMV and A/C

- Determine patient’s height and IBW using chart and select appropriate tidal volume starting at 6 mL/kg
- Set initial respiratory rate to 18 breaths/minute (this RR will equal an I:E ratio of 1:2 and allows for complete exhalation)
- Initially set FiO₂ to 1.0 (100%)
- Set inspiratory time (0.5-2 seconds for adults, 0.5-1 second for pediatrics)
- Set pressure support to 10-15 cm/H₂O if available
- a. Once the patient is intubated and tube placement is confirmed attach the ventilator circuit and begin ventilation.
- b. Allow the ventilator to operate for two minutes then assess for the following:
 - i. Plateau Pressure: maintain at less than 30 cmH₂O. If Plateau Pressure exceeds 30 cmH₂O, decrease Tidal Volume by 10% every two minutes until the target pressure is achieved. If the ventilator alarms “Low Minute Volume” and the Plateau Pressure is less than 30 cmH₂O, Tidal Volume may be increased by 10% every two minutes until the alarm is satisfied provided the Plateau Pressure remains below 30 cmH₂O
 - ii. EtCO₂: Maintain between 35-45 mmHg. If EtCO₂ is high, increase respiratory rate every 2 minutes until target is achieved. If EtCO₂ is low, decrease respiratory rate every 2 minutes until target is achieved. Use caution in metabolic acidosis and closed head injury patients (see Special Considerations below)
 - iii. SpO₂: After 2 minutes reduce FiO₂ to 0.3 (30%) and monitor. SpO₂ target should be 90-98%. If SpO₂ falls below 90% increase FiO₂ and PEEP stepwise using the ARDSNET chart below, FiO₂ and PEEP should increase and decrease in tandem to achieve target SpO₂

FiO₂	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.7
PEEP	5	5	8	8	10	10	10	12

FiO₂	0.7	0.8	0.9	0.9	0.9	1.0
PEEP	14	14	14	16	18	18-24

e. Obstruction Patients (COPD, Emphysema, Asthma)

- Assemble per manufacturer’s recommendations and if available set PEEP to 0-3 cm H₂O
- A Heat and Moisture Exchange Filter should be used to heat inspired air, add moisture, and filter out debris and pathogens.

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- Determine patient's height and IBW using chart and select appropriate tidal volume starting at 6 mL/kg
- Set initial respiratory rate to 10 breaths/minute (this RR will equal an I:E ratio of 1:6 and allows for complete exhalation)
- Initially set FiO₂ to 1.0 (100%)
- Set inspiratory time (0.5-1 second for adults, 0.5-1 second for pediatrics)
- Set pressure support to 10-15 cm/H₂O if available
- Once the patient is intubated and tube placement is confirmed attach the ventilator circuit and begin ventilation.
- Allow the ventilator to operate for two minutes then assess for the following:
 - i. Plateau Pressure: maintain at less than 30 cmH₂O. If Plateau Pressure exceeds 30 cmH₂O, decrease Tidal Volume by 10% every two minutes until the target pressure is achieved.
 - ii. EtCO₂: Air trapping is the primary problem with COPD/Emphysema/Asthma patients. Allowing for complete exhalation is essential. These patients may have elevated ETCO₂. Hypercarbia up to 80 mmHg is acceptable for short term transport. Increasing the respiratory rate to adjust the EtCO₂ is ineffective as this will interfere with exhalation and potentially cause barotrauma.
 - iii. SpO₂: After 2 minutes reduce FiO₂ to 0.3 (30%) and monitor. SpO₂ target should be 90-98%. If SpO₂ falls below 90% increase FiO₂ by 0.1-0.2 (10-20%) every 1-2 minutes to achieve target SpO₂ PEEP should not need to be adjusted above physiologic normal (5 cmH₂O)
 - iv. If the patient continues to show signs of Auto PEEP (increasing Plateau Pressure, inspiratory volume exceeds expiratory volume, chest wall distention), pause ventilations, disconnect ventilator to allow complete exhalation, resume ventilations at a lower respiratory rate
 - v. A respiratory rate of 6-10 per minute with elevated EtCO₂ is acceptable during transport as long as the patient has adequate oxygenation/SpO₂
- c. Monitoring ventilator patients during transport
 - Continuously monitor Plateau Pressure (or Peak Pressure if Plateau Pressure is not available), EtCO₂, SpO₂, lung sounds, chest rise and adequacy of sedation
 - Verify respiratory rate by checking the ventilatory frequency (f) as displayed by the ventilator
 - If pressure-limit alarm sounds, immediately reassess equipment and patient for kinked tubing, airway obstruction, Auto PEEP, tension pneumothorax, etc.
 - Always have BVM device with PEEP valve in place available for use in the event of ventilator failure.

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5) Considerations:

- All ventilated patients must be monitored for waveform capnography, pulse oximetry, and ECG monitoring
- For patients where adequate oxygenation with acceptable P-Plat is not achievable, Pressure Control modes may be used per Kittitas County Ventilator Training Course.
- Ensure adequate sedation and analgesia throughout the transport
- Patients with suspected metabolic acidosis (diabetic ketoacidosis, sepsis, ASA, or TCA poisonings, etc.) that present with EtCO₂ less than 32 mmHg should be maintained at their initial EtCO₂ value as the patient is compensating for acidosis through increased ventilatory rate
- Maintain SpO₂ level of 90 to 98%. Asthma patients may be permissively allowed to stay in the range of 88-92% to prevent excessive pressures.
- If the high-pressure alarm alerts or if the patient is unable to maintain SpO₂ values above 90%, remove the ventilator, resume ventilations with BVM with 5 cmH₂O PEEP, and 100% O₂, and evaluate for the following:
 - Displaced tube,
 - Tension pneumothorax
 - Post intubation hemodynamic collapse
 - Air trapping in the lungs (Auto PEEP)
 - ET tube cuff leak
 - Obstruction of the ET tube
 - Obstruction of the ventilation circuit
 - Failure of the oxygen source,
 - Equipment failure.
- If patient has sudden decrease in SpO₂, BP, increase in P-Plat, and/or increase/decrease in HR evaluate for developing Tension Pneumothorax.
- EtCO₂ is notoriously inaccurate in patients with hypovolemia, chest/pulmonary trauma, and closed head injuries. EtCO₂ should not be used as a target value in these patients. A ventilatory rate of 10-18 breaths per minute to maintain an SpO₂ of 90-98% and maintaining a SBP > 90 mmHg should be the target goal.

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MALES				Patient Height	FEMALES			
IBW	6ml	7ml	8ml		IBW	6ml	7ml	8ml
22.4	134	157	179	4'0"	17.9	107	125	143
24.7	148	173	198	4'1"	20.2	121	141	162
27	162	189	216	4'2"	22.5	135	158	180
29.3	176	205	234	4'3"	24.8	149	174	198
31.6	190	221	253	4'4"	27.1	163	190	217
33.9	203	237	271	4'5"	29.4	176	206	235
36.2	217	253	290	4'6"	31.7	190	222	254
38.5	231	270	308	4'7"	34	204	238	272
40.8	245	286	326	4'8"	36.3	218	254	290
43.1	259	302	345	4'9"	38.6	232	270	309
45.4	272	318	363	4'10"	40.9	245	286	327
47.7	286	334	382	4'11"	43.2	259	302	346
50	300	350	400	5'0"	45.5	273	319	364
52.3	314	366	418	5'1"	47.8	287	335	382
54.6	328	382	437	5'2"	50.1	301	351	401
56.9	341	398	455	5'3"	52.4	314	367	419
59.2	355	414	474	5'4"	54.7	328	383	438
61.5	369	431	492	5'5"	57	342	399	456
63.8	383	447	510	5'6"	59.3	356	415	474
66.1	397	463	529	5'7"	61.6	370	431	493
68.4	410	479	547	5'8"	63.9	383	447	511
70.7	424	495	566	5'9"	66.2	397	463	530
73	438	511	584	5'10"	68.5	411	480	548
75.3	452	527	602	5'11"	70.8	425	496	566
77.6	466	543	621	6'0"	73.1	439	512	585
79.9	479	559	639	6'1"	75.4	452	528	603
82.2	493	575	658	6'2"	77.7	466	544	622
84.5	507	592	676	6'3"	80	480	560	640
86.8	521	608	694	6'4"	82.3	494	576	658
89.1	535	624	713	6'5"	84.6	508	592	677
91.4	548	640	731	6'6"	86.9	521	608	695
93.7	562	656	750	6'7"	89.2	535	624	714
96	576	672	768	6'8"	91.5	549	641	732