

Chapter 8

Anesthesia

Introduction

Battlefield anesthesia primarily describes a state of balanced anesthesia using **adequate amounts of anesthetic agents** to minimize cardiovascular instability while providing amnesia, analgesia, and a quiescent surgical field in a technologically austere environment. Adapting anesthetic techniques to battlefield conditions requires flexibility and a reliance on fundamental clinical skills. Although modern monitors provide a wealth of data, the stethoscope may be the only tool available in an austere environment. Thus, the value of crisp heart sounds and clear breath sounds when caring for an injured service member should not be underestimated.

In addition, close collaboration and communication with the surgeon are essential to assist with aggressive resuscitation and a team approach to damage control surgery (DCR) decisions.

Airway

Many methods for securing a compromised airway exist, depending on the condition of the airway, the co-morbid state of the patient, and the environment in which care is being rendered. When a definitive airway is required, it is generally best secured with direct laryngoscopy and an endotracheal tube (ETT) firmly secured in the trachea.

Indications for a Definitive Airway

- Apnea/airway obstruction/hypercarbia.
- Impending airway obstruction: facial fractures, retropharyngeal hematoma, and inhalation injury.

- Excessive work of breathing.
- Shock (blood pressure ≤ 80 mm Hg systolic).
- Glasgow Coma Scale ≤ 8 (see Appendix 2).
- Persistent hypoxia ($\text{SaO}_2 < 90\% / \text{PaO}_2 < 60$ mm Hg).

Secondary Airway Compromise Can Result From:

- Failure to recognize the need for an airway.
- Inability to establish an airway.
- **Failure to recognize an incorrectly placed airway.**
- Displacement of a previously established airway.
- Failure to recognize the need for ventilation.

Induction of General Anesthesia

- The anesthesia provider must evaluate the patient for:
 - Concurrent illness and current state of resuscitation.
 - Airway—facial trauma, dentition, hyoid-to-mandibular symphysis length, extent of mouth opening.
 - Cervical spine mobility (preexistent and trauma related).
 - Additional difficult airway indicators:
 - ◆ Immobilization.
 - ◆ Children.
 - ◆ Short neck/receding mandible.
 - ◆ Facial hair.
 - ◆ Obesity.
 - ◆ Prominent upper incisors.

Rapid Sequence Intubation (RSI) Checklist

- Equipment.
 - Laryngoscope, blades, and batteries (tested daily).
 - Suction, oxygen setup.
 - ETTs and stylet.
 - Airway adjuncts (oropharyngeal, nasopharyngeal, and LMA [laryngeal mask airway]).
 - IV access items.
 - Monitors—pulse oximeter, ECG, blood pressure, end-tidal CO_2 .
 - Positive-pressure ventilation (Ambu bag or anesthesia machine).
- Drugs.
 - Narcotics.
 - Muscle relaxants.

- Anxiolytics and amnestics.
- Induction agents and sedatives.
- Inhalation agents.
- Narcotics.
 - **Fentanyl:** 1.0–2.0 µg/kg IV bolus, then titrate to effect.
 - **Morphine:** 2–5 mg IV bolus to load, then 1–2 mg every 5 minutes to effect.
 - **Dilaudid** (Hydromorphone): 0.4–0.8 mg IV to load, then 0.2–0.4 mg every 5 minutes to effect.
 - Use caution when administering higher doses of opioids to patients with respiratory or hemodynamic compromise or head injury.
- Muscle relaxants.
 - Depolarizing.
 - ◆ **Succinylcholine.**
 - ◆ 1.0–1.5 mg/kg. (**Note:** Can double the dose to give IM if IV access is not available and it is an emergency.)
 - ◆ Onset: 30–60 seconds.
 - ◆ Duration: 5–10 minutes.
 - ◆ Can cause bradycardia, fasciculations, elevated intragastric pressure, elevated intracranial pressure, potassium release (especially in “chronic” burn or immobile patients), and prolonged duration of action possible with pseudocholinesterase deficiency.
 - ◆ Potent trigger of malignant hyperthermia.

Succinylcholine should NOT be used in patients with burns or crush injuries >24 hours old or chronic neuromuscular disorders due to risk for hyperkalemia.

Rocuronium is the next best choice.

- Nondepolarizing.
 - ◆ **Vecuronium:** Induction dose of 0.1 mg/kg, with an onset of 2–3 minutes and a duration of action of 30–40 minutes.
 - ◆ **Rocuronium:** Induction dose of 0.6 mg/kg, with an onset of 1.5–2.5 minutes and a duration of action of 35–50 minutes. At 1.2 mg/kg, onset is similar to succinylcholine, with a duration of action that can exceed 60–90 minutes.

- ◆ **Pancuronium:** Induction dose of 0.1–0.15 mg/kg (it will cause or exacerbate tachycardia), with an onset of 3.5–6 minutes and a duration of action of 70–120 minutes.
- ◆ **Cisatracurium:** Induction dose of 0.15–0.20 mg/kg, with an onset of 2–3 minutes and a duration of action of 30–40 minutes. (Drug of choice for renal or hepatic disease.)

Table 8-1. Induction Agents and Sedatives

Agent	Routine Dose*	Characteristics	Concerns
Ketamine	1.0–2.0 mg/kg IV	Dissociative anesthetic and amnestic Sympathomimetic effects (useful in hypovolemia) Potent bronchodilator	Varying degrees of purposeful skeletal movement despite intense analgesia and amnesia
	4.0–10.0 mg/kg IM	Onset within 30–60 seconds Emergence delirium avoided with concomitant benzodiazepine use	Increased salivation; consider an antisialagogue
Propofol	1.0–2.5 mg/kg IV	Mixed in lipid, strict sterility must be ensured Rapid onset and rapidly metabolized Onset within 30–60 seconds	Contraindicated in acute hypovolemic shock patients
Etomidate	0.2–0.4 mg/kg IV	Onset within 30–60 seconds Duration: 3–10 minutes Minimal cardiac effects Minimal effects on peripheral and pulmonary circulation Maintains cerebral perfusion	May cause clonus May cause adrenal suppression

*All induction agents can be used for induction of severely injured patients if reduced dosages are used (eg, $\frac{1}{2}$ of the lower recommended dose). However, the recommended choice for hypovolemic patients would be ketamine \geq etomidate \gg propofol.

- Anxiolytics and amnestics.
 - **Versed** (midazolam; 0.5–2 mg IV bolus).
 - **Scopolamine**: 0.4 mg IV. (For use in hemodynamically unstable patients.)
- Induction agents and sedatives (Table 8-1).

Rapid Sequence Intubation—5 Steps

1. Preoxygenate with 100% oxygen by mask.
 2. Ketamine 2 mg/kg IV/IO (alternate: propofol 2 mg/kg, .5–1.0 mg/kg if hypotensive)
 3. Muscle relaxant: succinylcholine 1.0–1.5 mg/kg IV push.
 4. Laryngoscopy and orotracheal intubation (after 1 minute or seeing fasciculation).
 5. Verify tube placement.
- Consider nasogastric or orogastric tube placement after securing airway.

Note: For children, see Table 31-4.

- Endotracheal intubation.
 - Orotracheal.
 - ◆ Direct laryngoscopy 60–90 seconds after administration of induction agents and neuromuscular blockade.
 - ◆ First attempt is the best chance for success, but have a backup plan:
 - ◇ Optimize positioning of patient and anesthesia provider.
 - ◇ Have adjuncts readily available (stylet, smaller diameter tubes, alternative laryngoscope blades, suction, LMA, lighted stylet).
 - Nasotracheal intubation should generally not be performed.
 - Other considerations.
 - ◆ Hypertension can be managed with short-acting medications, such as beta blockers (labetalol, esmolol).
 - ◆ May treat induction-related (transient) hypotension initially with a small dose of ephedrine (5–10 mg), Neo-Synephrine (50 µg), or epinephrine (5–10 µg). But if hypotension persists after induction agents are metabolized, use damage control resuscitation DCR

principles to treat the persistent hypovolemia. The anesthesiologist must convey this situation to the surgeon, because the need to control bleeding becomes urgent.

- ◆ A sensitive airway can be topically anesthetized with lidocaine 1.5 mg/kg 1–2 minutes before laryngoscopy.
- Verify ETT placement.
 - Auscultate the lungs.
 - Measure the end-tidal CO₂.
 - Ensure that the SaO₂ remains high.
 - Palpate cuff of ETT in sternal notch.
 - Place the chemical CO₂ sensors in the airway circuit.

Verification of tube placement is VITAL. Any difficulty with oxygenation/ventilation following RSI should prompt evaluation for immediate reintubation.

The Difficult Airway

(See Chapter 5, Airway/Breathing)

Initially provide airway management with jaw thrust and face mask oxygenation. Assess the situation. Failed RSI may be due to inadequate time for induction agents to work; inadequate time for muscle relaxation to occur; anatomically difficult airway; or obstruction due to secretions, blood, trauma, or foreign material.

- Resume oxygenation; consider placing a temporary oral and/or nasal airway.
- Reposition patient.
- Call for help.
- Consider alternatives to RSI.
 - Awake intubation.
 - LMA.
 - Regional anesthesia (RA) or local anesthesia.
 - Surgical airway.

Maintenance of General Anesthesia

General anesthesia is maintained after intubation with:

- Oxygen. Titrate to maintain SaO₂ >92%.
- Maintain body temperature >36 C.

- Resuscitation according to DCR principles.
 - Consider TXA: 1 g over 10 minutes followed by infusion of 1 g over 3 h.
 - Re-administer antibiotics at decreased intervals with large volume replacement.
 - Consider hydrocortisone: 100 mg in critically ill patients.
- Ventilation.
 - Tidal volume: 6 mL/kg (low lung volume ventilation).
 - Respiratory rate: 12–14/min.
 - Positive end-expiratory pressure: if desired at 5 cm H₂O, titrate as necessary.
- Minimal alveolar concentration (MAC).
 - 0.6 MAC: awareness reliably abolished, although 50% of patients respond to verbal commands.
 - 1 MAC: 50% of patients do not move to surgical stimulus.
 - 1.3 MAC: 95% of patients do not move to surgical stimulus.
 - Common inhalation agent MACs:
 - ◆ Halothane: 0.75%.
 - ◆ Sevoflurane: 1.8%.
 - ◆ Isoflurane: 1.17%.
 - ◆ Desflurane: 6.00%.
 - ◆ Enflurane: 1.63%.
 - ◆ Nitrous oxide: 104%.
 - ◆ Additive effects (eg, 60% nitrous oxide mixed with 0.8% sevoflurane yields 1 MAC).
- Total intravenous anesthesia.
 - Mix midazolam 5 mg, vecuronium 10 mg, ketamine 200 mg in 50 mL normal saline and infuse at 0.5 mL/kg/h (stop 10–15 minutes before end of surgery).
 - Mix 50–100 mg of ketamine with 500 mg of propofol (50 mL of 10% propofol) and 250 µg of fentanyl, and administer at 50–100 µg/kg/min of propofol (21–42 mL/h for a 70-kg patient).
- Balanced anesthesia (titration of drugs and gases) combine:
 - 0.4 MAC of inhaled agents.
 - Versed: 1–2 mg/h.
 - Ketamine: 0.5–1 mg/kg/h.
 - Fentanyl: 2–4 µg/kg/h.

Conclusion of General Anesthesia

- If the patient is to **remain intubated**, anesthetics may be terminated, but sedatives and possibly muscle relaxants should be continued.
- If the patient is to be **extubated**, controlled ventilation is decreased to allow the patient to spontaneously breathe.
 - Anesthetic agents are titrated to allow for rapid recovery.
 - Muscle relaxation reversal is accomplished with Neostigmine (0.04–0.08 mg/kg IV over 3–5 minutes and can be mixed in the same syringe as Glycopyrrolate [Robinul 0.01–0.02 mg/kg IV over 3–5 minutes]).
- Extubation criteria include reversal of muscle relaxation, spontaneous ventilation, response to commands, eye opening, and head lifting for 5 seconds. **When in doubt, keep the patient intubated.**
- Amnestic therapy with midazolam and analgesic therapy with a narcotic are appropriate in small amounts so as not to eliminate the spontaneous respiratory drive.

Regional Anesthesia

RA is a “field-friendly” anesthetic requiring minimal logistical support while providing quality anesthesia and analgesia on the battlefield. Advantages of RA on the modern battlefield include the following:

- Excellent operating conditions.
- Profound perioperative analgesia.
- Stable hemodynamics.
- Limb-specific anesthesia.
- Reduced need for other anesthetics.
- Improved postoperative alertness.
- Minimal side effects.
- Rapid recovery from anesthesia.
- Simple, easily transported equipment needed.

Recent conflicts have revealed that the majority of casualties will have superficial wounds or wounds of the extremities. RA is well suited for the management of these injuries either as an adjunct to general anesthesia or as the primary anesthetic. The use of basic RA blocks (listed below) is encouraged when time and resources are available.

- Superficial cervical plexus block.
- Axillary brachial plexus block.
- Intravenous RA.
- Wrist block.
- Digital nerve block.
- Intercostobrachial nerve block.
- Saphenous nerve block.
- Ankle block.
- Spinal anesthesia.
- Lumbar epidural anesthesia.
- Combined spinal-epidural anesthesia.
- Femoral nerve block.

Prior training in basic block techniques is implied, and use of a nerve stimulator or ultrasound, when appropriate, is encouraged to enhance block success. More advanced blocks and continuous peripheral nerve blocks are typically not available until the patient arrives at a Role 3 or higher level healthcare facility where personnel trained in these techniques are available. A long-acting local anesthetic, such as 0.5% ropivacaine, is used for most single-injection peripheral nerve blocks. Peripheral nerve blocks can often be used to treat pain (without the respiratory depression of narcotics) while patients are waiting for surgery. Do not perform a peripheral nerve block for an injured extremity without consulting an orthopedic or general surgeon regarding the risk of compartment syndrome and the potential to obscure its diagnosis.

- **Neuraxial anesthesia.**
 - Subarachnoid block.
 - Epidural block.

When the patient's physical condition allows the use of spinal or epidural anesthesia, those techniques are encouraged. The sympathectomy that results is often poorly tolerated in a trauma patient, and this must be factored into any decision to use those techniques. Peripheral nerve blocks do not have this limitation.

Local Anesthesia

When local anesthesia would suffice, such as in certain wound debridements and wound closures, it should be the technique of choice.

Field Anesthesia Equipment

There are two anesthesia apparatuses currently fielded in the forward surgical environment: (1) the drawover vaporizer and (2) a conventional portable ventilator machine. A schematic of the drawover system is shown in Fig. 8-1.

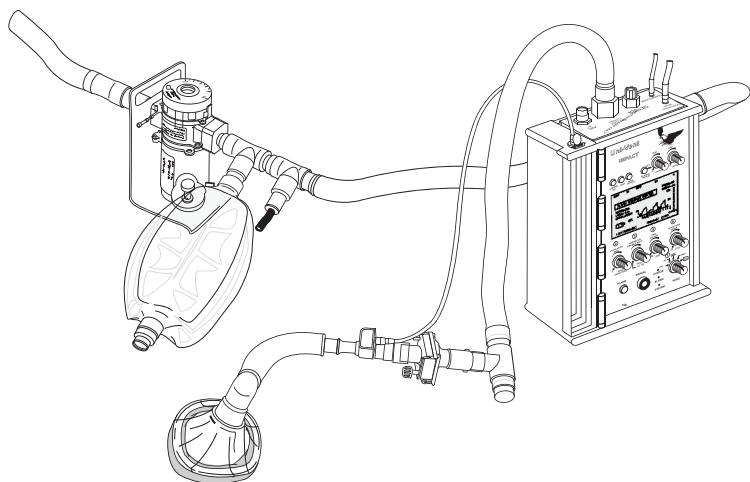


Fig. 8-1. Drawover apparatus in combination with the ventilator.

● Drawover vaporizer.

- Currently fielded model: Ohmeda Universal Portable Anesthesia Complete (UPAC).
- Demand-type system (unlike the plenum systems in hospital-based ORs).
 - ◆ When the patient does not initiate a breath or the self-inflating bag is not squeezed, there is **no flow of gas**. No demand equals no flow.
- Temperature-compensated, flow-over inline vaporizer.
- Optimal oxygen conservation requires a larger reservoir (oxygen economizer tube) than is described in the operator's manual—a 3.5-foot oxygen economizer tube optimizes Fio_2 .
- May be used with spontaneous or controlled ventilations.
- Bolted-on performance chart outlines dial positions for some commonly used anesthetics (eg, halothane and isoflurane).

Ohmeda UPAC Drawover Apparatus in Combination With the Impact Uni-Vent Eagle Model 754 Portable Ventilator

- Currently, there is no mechanical ventilator specifically designed for use with the UPAC drawover apparatus, but use with various portable ventilators has been studied in both the drawover and pushover configurations.
 - Adding the ventilator frees the anesthesia provider's hands while providing more uniform ventilation and more consistent concentrations of the inhalational anesthetic agent.
 - The **drawover** configuration places the ventilator distal to the vaporizer, entraining ambient air and vapor across the vaporizer in the same manner as the spontaneously breathing patient. Do not attach a compressed source of air to the Impact Uni-Vent Eagle Model 754 in this configuration because it will preferentially deliver the compressed gases and will not entrain air/ anesthetic gases from the UPAC drawover.
 - The **pushover** configuration places the ventilator proximal to the vaporizer, effectively pushing entrained ambient air across the vaporizer and then to the patient.
- The Impact Uni-Vent Eagle Model 754 portable ventilator (Fig. 8-1) is not part of the UPAC apparatus, but is standard equipment for the US military. It has been used in combination with the Ohmeda UPAC drawover apparatus.
 - The air entrainment (side intake) port is used to create the drawover/ventilator combination.
 - ◆ The side intake port of the ventilator contains a nonreturn valve, preventing back pressure on the vaporizer that could result in erratic and inconsistent anesthetic agent concentrations.
 - The patient air-outlet port on the ventilator also contains a nonreturn valve, preventing backflow into the ventilator from the patient side.
 - Scavenging of waste gases can be accomplished by attaching corrugated anesthesia tubing to either the outlet port of the Ambu E-valve (induction circuit) or the exhalation port of the ventilator tubing (ventilator circuit) venting to the outside atmosphere.

- The following items are added to the circuit to improve this UPAC/Impact Uni-Vent Eagle Model 754 ventilator combination:
 - ◆ Small and large circuit adapters to aid in attachment of various pieces.
 - ◆ Pall Heat and Moisture Exchange Filter to conserve heat and limit patient contact with the circuit.
 - ◆ Accordion circuit extender to move the weight of the circuit away from the patient connection.
 - ◆ Oxygen extension tubing to attach supplemental oxygen.
- Two separate circuits should be constructed for use with the UPAC/Uni-Vent Eagle Model 754 combination: for induction and spontaneous ventilation and for controlled ventilation using the portable ventilator.
 - ◆ This process can be complicated because switching circuit components requires several disconnections and reconnections, creating the potential for error. (Practice.)
- **Conventional plenum anesthesia machine.**
 - Currently fielded models: Drager Narkomed and Fabius Tiro M.
 - Compact version of standard OR machines, with comparable capabilities.

**For Clinical Practice Guidelines, go to
http://jts.amedd.army.mil/index.cfm/PI_CPGs/cpgs**