**Bradycardia**

1. Communicate with surgeon & team
   - Stop surgical manipulation
   - Consider requesting addl help

2. Check the patient:
   - Pulse quality, capillary refill time
   - If no pulse/hr, go to *cardiac arrest flow sheet*
   - Assess ECG - verify sinus bradycardia
   - (vs 3rd degree AV block, idioventricular rhythm)
   - Verify adequate oxygenation & ventilation

3. Decrease or discontinue inhalant delivery
   - Consider reversal of alpha-2 agonists +/- opioids

4. Administer atropine:
   - Start with 0.05 mg/kg if bradycardia is severe & affecting perfusion

5. If atropine ineffective:
   - Consider epinephrine, dobutamine, or isoproterenol infusion
   - Consider possibility of hyperkalemia
   - Consider cardiology consult
   - Consider transcutaneous pacing

**Bradycardia:**

Large dog: HR <60 bpm with hypotension or HR <50 bpm
Small dog/cat: HR <80 bpm with hypotension or HR <60 bpm

**Drug doses:**
- Atipamazole 90 - 400 mcg/kg IM or IV
- Atropine 0.015 - 0.05 mg/kg IV
- Epinephrine bolus 0.005 mg/kg IV
- Epinephrine 0.01 - 0.2 mcg/kg/min IV
- Dobutamine 10 - 20 mcg/kg/min IV
- Isoproterenol 0.04 - 0.09 mcg/kg/min IV
- Naloxone 0.01 - 0.05 mg/kg IV
Caricard Arrest

1 Call for help
   Check airway and IV access

2 Start compressions 100 – 120 bpm
   Allow full recoil between compressions
   Continue uninterrupted for 2 minutes following drugs/defib
   Consider open chest compressions through diaphragm (surgeon)

3 Discontinue inhalant delivery, flush circuit with O₂
   Consider reversal of alpha-2 agonists, opioids, and benzodiazepines

4 Ventilate 8 -12 bpm with 100% O₂
   Do not overventilate

5 Give low dose epinephrine and atropine IV

6 If shockable rhythm (VT/VF), defibrillate @ 3-5 J/kg

7 Monitor ETCO₂
   If < 10 mmHg, re-assess CPR technique
   If >30 mmHg, may indicate ROSC

8 Assess every 2 minutes
   Switch personnel providing compressions
   Check rhythm
   If rhythm acceptable, check pulse
   If arrest rhythm continues, go to step 2

9 Repeat drug administration every 3-5 minutes
   Give high dose epinephrine on 3rd round of drug delivery

Drug doses:
Atipamazole 200 mcg/kg IV
Atropine 0.05 mg/kg IV
Epinephrine (Low Dose ) 0.01 mg/kg IV
Epinephrine (High Dose ) 0.1 mg/kg IV
Flumazenil 0.01 mg/kg IV
Naloxone 0.01 - 0.05 mg/kg IV

Reversible Causes (H’s & Ts):
Hypovolemia                               Toxins (including anesthetic overdose)
Hypoxia                                    Tamponade
Hydrogen ion (acidosis)                    Tension pneumothorax
Hyper/hypokalemia                          Thrombosis (pulmonary)
Hypo/hyperthermia                          Trauma (including surgical)
Hypoglycemia
Delayed Emergence

1 Check the patient
   Heart rate and rhythm, pulse quality, respiratory rate and character, mm color and CRT.
   Is the airway adequately protected?
   Ensure all inhalant and injectable anesthetics are discontinued
   Stimulate the patient (rubbing vigorously, flipping recumbency)

2 Check for hypothermia, hypotension, hypoxemia, hypercarbia

3 Review anesthetic record
   Check for medication error (dose or wrong drug)
   Profound physiologic disturbance during anesthesia?

4 Check for hypoglycemia, anemia, electrolyte, or acid-base abnormality

5 Consider reversal of alpha-2 agonists, opioids, and benzodiazepines
   Consider reversal of neuromuscular blockers

6 Consider pre-existing disease (severe liver disease, Addison’s, intracranial disease) or new neurologic disorder (ischemia/↑ICP)

Delayed Emergence:
Most patients can be extubated within **15 to 20 minutes**

Following long procedures, stable patients should be extubated within **45 minutes**

Drug doses:
Atipamezole 90 – 300 mcg/kg IM
Edrophonium 0.2 mg/kg IV & atropine 0.02 mg/kg
Flumazenil 0.01 – 0.02 mg/kg IV
Naloxone 0.01 - 0.05 mg/kg IV (start low, dilute dose, and administer ¼ of the final volume every few minutes)
Hemorrhage

1 Communicate with surgeon & team; get help.

2 Check the patient, including color, CRT, pulse quality and BP
   Consider decreasing inhalant delivery; keep patient warm

3 Estimate blood loss
   Check floor and table
   Weigh sponges (1 mL blood = 1 gram)
   Measure volume of blood in suction canister

4 Bolus crystalloid fluids (balanced isotonic or hypertonic), +/- artificial colloids

5 Consider transfusion with >20% loss of blood volume & signs of systemic perfusion
   deficit (persistent hypotension, incr BE, lactate), PCV/TS approaching 20/4.0, or if
   estimated blood loss exceeds calculated maximum allowable blood loss.
   Consider pretx with diphenhydramine
   Blood typing recommended for cats
   Universal donor blood can be administered to dogs if first transfusion

6 Submit CBC, PT/PTT, arterial blood gas with eleys, lactate

7 Consider administration of aminocaproic acid

8 Monitor for development of hypocalcemia and hyperkalemia
   Transfusion reaction may be masked during general anesthesia

10 Massive transfusion
   > 50% of blood volume in 3h, full blood volume in 24h
   Administer 1:1 ratio FFP:unit of pRBCs

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**Estimated blood volume (EBV):**

- Dogs ~ 90 mL/kg
- Cats ~ 50 mL/kg

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**Drug Doses:**

- Balanced crystalloids
  - 3:1 vol:vol with estimated blood loss
- Hypertonic crystalloids 4 mL/kg/15 minutes
- Artificial colloids
  - 1:1 vol:vol with estimated blood loss
- Aminocaproic acid 50 – 100 mg/kg for 1 hour,
  then 15 mg/kg/hr for 6 - 8 hours
- Diphenhydramine 2 mg/kg IM

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**Volume to transfuse:**

- Whole blood mL = 
  - $BW_{kg} \times \text{blood volume} \times ([\text{desired PCV} - \text{recipient PCV}] / \text{Donor PCV})$
- Or Whole blood ~ 20 mL/kg

- PRBC (mL) = 1.5 x desired rise in PCV x $BW_{kg}$ (dogs)
- Or PRBCs ~ 10 mL/kg

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**Allowable Blood Loss (ABL):**

- $\text{ABL} = \text{EBV} \times (\text{HCT}_i - \text{HCT}_f / \text{HCT}_{avg})$
  - $\text{HCT}_i =$ initial HCT
  - $\text{HCT}_f =$ lowest allowable HCT
  - $\text{HCT}_{avg} =$ average of initial and final HCT
Hyperkalemia

1 Check the patient:
   Heart rate/rhythm, pulse quality, capillary refill time,
   & anesthetic depth
   If no pulse/hr, go to cardiac arrest flow sheet

2 Stop IV solutions containing potassium, including blood products

3 Hyperventilate patient to 30 mmHg ETCO₂ to induce alkalosis

4 Administer calcium gluconate to restore membrane potential difference

5 Administer regular insulin with dextrose to drive K⁺ into cells

6 Consider sodium bicarbonate and β₂ agonists

7 Correct underlying cause

Hyperkalemia: K⁺ > 5.5 mEq/L
Do not anesthetize a patient with K⁺ > 6 mEq/L
Associated ECG changes:
   tall peaked T waves
   bradycardia
   loss of P waves
   wide QRS complexes
   Possible: tachyarrhythmias
   ventricular rhythms
   asystole

Drug Doses:
   Calcium gluconate 50 – 100 mg/kg (0.5 – 1.0 mL/kg)
   Regular insulin 0.25 – 0.5 U/kg IV with
      dextrose 1 mL/kg
   Sodium bicarbonate 1 - 2 mEq/kg (1 – 2 mL/kg)
   Inhaled albuterol 20 – 100 mcg/kg
   Terbutaline 0.01 mg/kg

Possible Causes:
   Acute renal insufficiency
   Addisonian crisis
   Iatrogenic
   Malignant hyperthermia
   Severe burns and crushing injuries
   Transfusion of “old” blood, massive transfusion
   Tumor lysis syndrome
   Urethral obstruction
   Uroabdomen

Greyhounds & large exotic cats?
**Hypotension**

1 **Communicate** with surgeon & team
   - Surgical hemorrhage? Vascular compression?
   - Consider requesting addl help

2 **Check the patient:**
   - Heart rate/rhythm, pulse quality, capillary refill time, oxygenation, ventilation, & anesthetic depth
   - If bradycardia, go to *bradycardia flow sheet*
   - If no pulse/hr, go to *cardiac arrest flow sheet*

3 **Decrease inhalant** delivery
   - Consider partial injectable technique

4 **Consider equipment error**
   - Assess integrity of anesthetic circuit
   - Check BP cuff placement
   - Obtain BP reading with another machine

5 **Administer IV fluid bolus**
   - Balanced crystalloids
   - Hypertonic saline
   - +/- artificial colloids

6 **Administer pressors and/or inotropes**
   - Ephedrine bolus to temporize
   - Dopamine or dobutamine infusion
   - Norepinephrine infusion
   - Severe refractory hypotension: epinephrine bolus or infusion

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**Drug doses:**

- Balanced crystalloids
  - 5–10 mL/kg over 5-10 minutes
  - (~20-30 mL/kg total volume)

- Hypertonic saline
  - 4 mL/kg over 15 minutes

- Artificial colloids
  - 3-5 mL/kg over 10 minutes

- Ephedrine bolus 0.03 – 0.1 mg/kg IV
- Dopamine infusion 2-20 mcg/kg/min
- Dobutamine infusion 2-20 mcg/kg/min
- Norepinephrine infusion 0.1–2 mcg/kg/min
- Epinephrine bolus 0.005 mg/kg
- Epinephrine infusion 0.005-0.2 mcg/kg/min
- Vasopressin 0.5 – 5 mU/kg/min

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*Systolic Arterial Pressure <80 mmHg*

*Mean Arterial Pressure <60 mmHg*

*Diastolic Arterial Pressure <40 mmHg*

*<30% reduction from awake baseline*
**Hypoxemia**

1. **Call for additional help**

2. **Check the patient:**
   - Heart rate/rhythm, pulse quality, capillary refill time, & anesthetic depth
   - Consider decreasing anesthetic depth
   - If no pulse/hr, go to cardiac arrest flow sheet

3. **Assess oxygen supply**
   - Check supply pressure and flow meter
   - Assess integrity of the anesthetic machine, anesthesia circuit, and connection to the ETT
   - Check FiO₂ (gas analyzer), increase to 100%

4. **Confirm presence of ETCO₂ & assess waveform**

5. **Ventilate** by hand
   - Assess compliance
   - Confirm presence of ETCO₂ & assess waveform
   - Listen to breath sounds on both sides of chest

6. **Consider:**
   - suctioning airway
   - discontinuing anesthetic event
   - obtaining thoracic radiographs
   - performing an alveolar recruitment maneuver/PEEP
   - submitting an arterial blood gas

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**Think: Equipment or Patient?**

**Equipment:**
- Oxygen supply failure
- Mis- or disconnection of circuit
- Airway obstruction
- Endobronchial
- Intubation
- Extubation

**Patient**

**Respiratory:**
- Apnea, anaphylaxis, aspiration, asthma/bronchospasm,
- diaphragmatic hernia, hypoventilation, obesity,
- pleural fluid, pneumothorax, pneumonia, pulmonary edema

**Cardiovascular:**
- Anatomical shunt, congestive heart failure, pulmonary embolus, reduced pulmonary perfusion/low cardiac output

{Abnormal hemoglobin – low SpO₂, normal PaO₂}
Local Anesthetic Systemic Toxicity

1 **Call for additional help**
   Stop local anesthetic injection, if possible

2 **Check the patient**
   If no pulse/hr, go to *Cardiac Arrest Checklist*
   Verify adequate **oxygenation & ventilation**

3 **Discontinue inhalant** delivery
   Consider reversal of alpha-2 agonists and opioids

4 **If severe hypotension, administer low dose epinephrine**

5 **Administer Intralipid**

6 **Treat seizures with diazepam**

7 **Avoid local anesthetics, β blockers, & Ca++ channel blockers**

**Clinical Signs:**
Seizures (when conscious), hypotension, bradycardia, ventricular arrhythmias, cardiovascular collapse

**Drug doses:**
- Atipamezole 300 mcg/kg IV slowly
- Diazepam 0.5 mg/kg IV
- Epinephrine 0.01 mg/kg IV
- Naloxone 0.01 - 0.05 mg/kg IV

**Intralipid Dosing:**
- **Bolus 1.5 mL/kg** over 1-5 minutes
- Follow with **continuous infusion 0.25 mL/kg/min**
- **Repeat bolus** once or twice for persistent cardiovascular collapse
- **Double the infusion rate** to 0.5 mL/kg/min if hypotension persists
- **Continue infusion at least 10 minutes** beyond attaining cardiovascular stability
Reflux (Witnessed)

1. Check the endotracheal tube seal
   - Minimum no-leak volume to 25 cmH₂O
   - Assess with cuff manometer

2. Check pH of reflux

3. Flush esophagus with warm tap water
   - Red rubber urinary catheter
   - Catheter tip 35 – 60 mL syringe
   - Source of active suction
   - Do not cross LES with catheter (9th rib)
   - Flush until suctioned water is clear

4. Consider:
   - Systemic H₂ blocker or proton pump inhibitor
   - Localized bicarbonate infusion
   - Oral sucralfate once awake

5. Monitor for cough, increased respiratory rate, & regurgitation

Reflux:
Passive movement of stomach contents across the lower esophageal sphincter (LES)

Possible Sequelae:
- Aspiration pneumonia
- Esophageal stricture
- Rhinitis

Drug doses:
- Bicarbonate 10 – 30 mL of 4.2% soln
- Famotidine 0.5 – 1 mg/kg IV q12h
- Sucralfate 0.5 - 1 gram PO q8h
**Supraventricular Tachycardia**

1. **Check the patient**
   - Auscult chest, palpate pulse
   - If no pulse, go to Cardiac Arrest Checklist
   - Assess hemodynamic results – poor perfusion/hypotension?

2. **Decrease** or discontinue inhalant delivery
   - Confirm adequate oxygenation and ventilation

3. Consider carotid sinus massage

4. **Control rate**
   - Diltiazem slowly IV
   - OR
   - Esmolol slowly IV

5. **Primary differential is** sinus tachycardia (d/t sympathetic stimulation)
   - More likely SVT if rate > 250 bpm, irregular, sudden onset/offset

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**Drug doses:**

**Diltiazem** 0.05 mg/kg IV administered in increments over 2 – 5 minutes, can repeat cautiously up to 0.25 mg/kg

**Esmolol** 0.25 mg/kg IV administered in increments over 2 – 5 minutes followed by 10 – 200 mcg/kg/min
Ventricular Tachycardia

1 Check the patient
   Auscult chest, palpate pulse
   If no pulse, go to Cardiac Arrest Checklist
   Assess hemodynamic results – poor perfusion/hypotension?

2 Decrease or discontinue inhalant delivery
   Confirm adequate oxygenation and ventilation

3 Administer lidocaine

4 Consider procainamide or esmolol

5 Primary differential is an SVT with a bundle branch block (consider diltiazem – go to SVT checklist)

Ventricular Tachycardia:
Wide complex tachycardia, HR > 200

Drug doses:
Esmolol 0.25 mg/kg IV administered in increments over 2 – 5 minutes followed by 10 – 200 mcg/kg/min

Lidocaine (dogs) 2 mg/kg IV, can repeat once or twice. Follow with 50 – 100 mcg/kg/min

Procainamide 2 – 4 mg/kg slowly over 2 minutes. Follow with 10 – 40 mcg/kg/min