I. Introduction
   a. Definitions
      i. General anesthesia
      ii. Sedation
      iii. Tranquilization
      iv. Analgesia
         1. Local analgesia
         2. Regional analgesia

II. Objectives
   a. Balanced anesthesia
   b. Preemptive analgesia

III. Anatomy and physiology
   a. Poikilothermic species
   b. Cardiopulmonary system
   c. Renal-portal system

IV. Signs of pain
   a. Change in normal behavior
      i. Aggression in passive animal
         ii. Passive behavior in normally aggressive animals
   b. Reluctance to move
   c. Abnormal ambulation
   d. Dull, closed eyes
   e. Anorexia
   f. Hunched posture
   g. Elevated, extended head
   h. Lameness
      i. Decreased tendency to coil (snakes)
   j. Aerophagia
   k. Color changes (darker or paler)

V. Analgesia
   a. Pure mu agonist
      i. Morphine
1. Increased tolerance to thermal stimulus in red-eared sliders (RES), bearded dragons (BD), tegu, crocodiles and anole lizards, and electrical in iguanas and BD
2. Decreased duration of limb retraction in formalin test in Speke’s hinged tortoise
3. Associated with severe (up to 80%) respiratory depression in RES
4. Dosage: 1.5-5 mg/kg q24h; 10-20 mg/kg in BD

ii. Hydromorphone
1. Increased tolerance to thermal stimulus in RES
2. Plasma levels in BD
3. Dosage: 0.5 -1 mg/kg
   a. Sedation at higher doses

iii. Fentanyl
1. Plasma concentrations detectable in ball pythons and prehensile-tailed skinks with fentanyl patch
2. No evidence of efficacy in snakes using patches
3. Dosage
   a. 0.05 mg/kg in RES and black-bellied slider
   b. 2.5-12.5 mcg/h

b. Weak mu agonist
   i. Tramadol
      1. inhibits reuptake of serotonin and norepinephrine
      2. Increased tolerance to thermal stimulus in RES, and to electrical stimulus in BD
      3. Plasma concentrations determined in sea turtles, bearded dragons
      4. Respiratory depression in RES was less than with morphine
      5. Falling out of favor with anesthesiologists due to lower clinical effects in practice
      6. Dosages in RES 5-10 mg/kg q 72 h PO

c. Nonsteroidal anti-inflammatory drug, cycloxygenase (COX)-2 specific inhibitor
   i. Meloxicam
      1. Increased the tolerance to electrical stimulus in BD at 0.4 mg/kg IM
      2. Did not change physiologic parameters in ball pythons at 0.3 mg/kg, or hematological and biochemical parameters in iguanas at 0.2 mg/kg
      3. Plasma concentrations determined in RES and iguanas
      4. Dosage 0.5 mg/kg q 24 h

d. Regional analgesia/anesthesia
   i. Intrathecal spinal analgesia in RES
      1. Lidocaine – 1h
      2. Bupivacaine – 2h
      3. Morphine – 48h
4. Preservative free formulations

VI. Indications for Tranquilization
   a. Restraint of fractious animals
   b. Ultrasound
   c. Radiographs
   d. Transport
   e. Venipuncture
   f. Fine-needle aspirates (FNA)

VII. Indications for Sedation
   a. Restraint of fractious animals
   b. Ultrasound
   c. Radiographs
   d. Transport
   e. Venipuncture
   f. FNA
   g. (Minimally invasive procedures combined with local analgesia)

VIII. Indications for Anesthesia
   a. Surgery
   b. Endoscopy
   c. Invasive procedures
   d. Injectable Agents
      i. Ketamine
      ii. Dexmedetomidine
      iii. Midazolam
      iv. Propofol
      v. Alfaxalone
         1. Neuroactive steroid agent
         2. Rapid induction and recovery
         3. IV and IM routes
         4. Induction (5-10mg/kg), maintenance CRI and bolus
         5. Minimal cardiorespiratory depression
   e. Inhalational Agents
      i. Isoflurane
         1. Minimal metabolism, eliminated by lungs
         2. Right-to-left cardiac shunting might result in mismatch
            concen. gas and anesthetic depth
         3. Dose-dependent cardiovascular depression
         4. Minimum anesthetic concentration (MAC) 1.8-2.1% iguana,
            1.37-1.71% monitors, 1.31-2.49 % rat snake
         5. Induction variable %, maintenance 2-3%
      ii. Sevoflurane
         1. Faster induction and recovery than isoflurane in iguana, but
            similar recovery in monitors
2. No significant cardiopulmonary differences with isoflurane in iguanas
3. Less irritant to airways than isoflurane
4. MAC 3.0-3.2% iguana, 2.05-2.97% monitors, 1.85-2.99% rat snakes
5. Induction variable %, maintenance 3.5-4.5%

f. Premedication via combination of:
   i. Ketamine
   ii. Dexmedetomidine
   iii. Midazolam
   iv. Propofol
   v. Alfaxalone
   vi. Hydromorphone/morphine

g. Induction
   i. Propofol
   ii. Alfaxalone

h. Maintenance
   i. Isoflurane
   ii. Sevoflurane

IX. Examples
   a. Example 1: Tranquilization to sedation
      i. Sulcata for exam and venipuncture
      ii. Option A: Midazolam, ketamine +/- dexmed. IM or IV
      iii. Option B: Alfaxalone IM

   b. Example 2: Esophagostomy tube placement
      i. Midazolam IV or IM for sedation
      ii. Hydromorphone or morphine IM
      iii. Meloxicam
      iv. Local lidocaine block

   c. Example 3: Rads, gastroscopy +/- celioscopy of alligator snapping turtle
      i. Premed/induction
         1. Hydromorphone 1mg/kg
         2. Ketamine 2-5 mg/kg
         3. Dexmedetomidine 0.25-0.5 mg/kg
         4. Midazolam 0.5-1 mg/kg
         5. IV injection
      ii. Maintenance
         1. Isoflurane

   d. Example 4: Rads, gastroscopy +/- celioscopy of alligator snapping turtle
      i. Premed/induction
         1. Hydromorphone 0.5 - 1mg/kg
         2. Propofol 10mg/kg or Alfaxalone 10-20 mg/kg
      ii. Maintenance
         1. Isoflurane

   e. Example 5: green iguana coelomic surgery
i. Premed/induction
   1. Hydromorphone 1mg/kg
   2. Ketamine 2-5 mg/kg
   3. Dexmedetomidine 0.25-0.5 mg/kg
   4. Midazolam 0.5-1 mg/kg
   5. IV injection

ii. Maintenance
   1. Isoflurane

X. Injection sites

XI. Intubation
   a. Chelonians
   b. Snakes
   c. Lizards
   d. Crocodilians

XII. Patient Monitoring
   a. Same principles as other species
   b. Corneal reflex is good indicator of depth and death
   c. Heart rate
      i. Doppler
      ii. ECG
   d. Respiratory rate: often need IPPV
      i. DO NOT EXCEED 15 – 20mmHg
      ii. POP-OFF valve MUST REMAIN OPEN after breathing
      iii. 2 – 4 breaths/min
   e. Temperature
      i. KEY for successful anesthesia
      ii. Aim for 32-35°C (90-95°F) during anesthesia

XIII. Cardiovascular Support
   a. IV Access
      i. Jugular vein
      ii. Ventral coccygeal vein
      iii. Ventral abdominal vein
      iv. Subcarapacial
   b. IO Access
      i. Femur
      ii. Tibia
      iii. Carapace/plastron
      iv. IO access can be used the same as IV but with slower volume of infusion
      v. IO Catheter

XIV. Temperature support
   a. Forced air warmer
b. Heat blankets
c. Heat lamps
d. Warm fluids
e. Rice/bean bags
f. Hypothermia
   i. Heat loss
      1. Convection
         a. Air exchange at body surface
      2. Radiation
         a. Heat loss to surfaces and environment
      3. Conduction
         a. Heat loss from contact (i.e. cold table)
      4. Evaporation
         a. Heat loss from lungs, skin, exposed tissues
   ii. Preventing Hypothermia
      1. Forced-air warmers
         a. Can reduce convection, conduction, and radiation losses depending on the blanket type
      2. Heating pads
         a. Reduce conduction losses
      3. Heat lamps
         a. Reduce radiation losses
      4. Water bath
         a. Reduce conduction, radiation losses
      5. Bean/rice stockings
         a. Reduce radiation losses

XV. Recovery
   a. Wean off gas before the end of procedure
   b. Maintain O\textsubscript{2} at low flow rate
   c. KEEP WARM!!!!!!!!!!!!!!!!!!!
   d. Breathing stimulus in reptiles: O\textsubscript{2}

XVI. Key to success
   1. Keep patients warm
   2. Keep patients hydrated
   3. Use balanced anesthesia and analgesia
   4. Discontinue O\textsubscript{2} before end of surgery

XVII. Not every patient needs drugs
   a. Radiography
   b. Computed tomography
References mentioned in the presentation


