Standard Anesthetic Monitoring: Continuing Education

Kansas State University College of Veterinary Medicine

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Also big thanks to:
Sarah Keatley
Anna Harris
All the video personnel

Today's agenda:

History of and description of anesthetic monitoring practices	810 a.m.
Review the basics of:	
Pulse oximetry	910 a.m.
BREAK 1000-1020	
Electrocardiograms	1020 a.m.
Cardiovascular consequences of general anesthesia	1110 a.m.
LUNCH 1200-100	
Blood pressure	100 p.m.
Clinical Case Scenarios	200 p.m.
BREAK 300-330	
Depth assessment/management	330 p.m.
Capnography and ventilatory management	410 p.m.

Standard Anesthetic Monitoring

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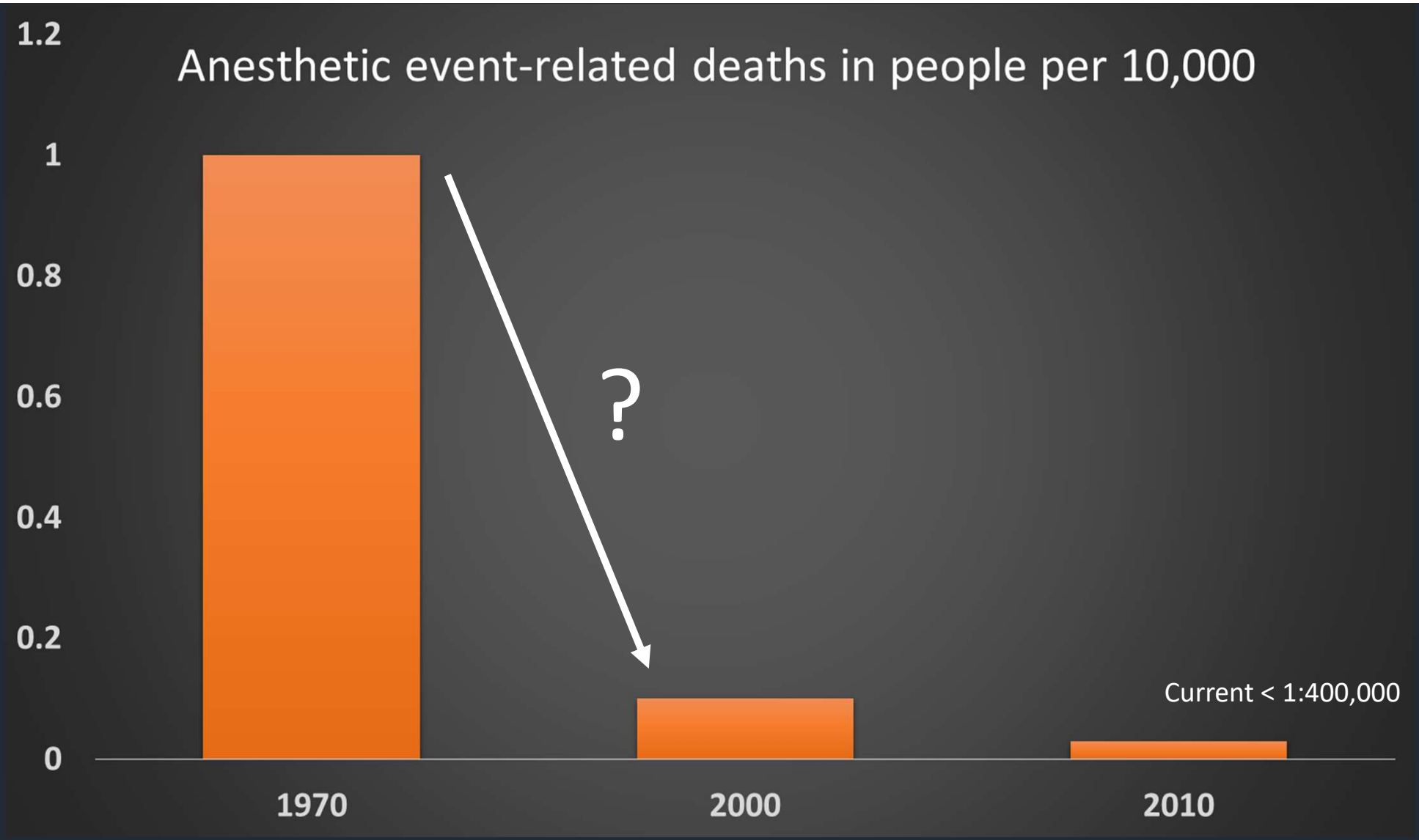
College of Veterinary Medicine

Kansas State University

Disclosures

- Owner of one of the sponsors
- Otherwise, none.


Anesthetic event-related deaths in people per 10,000
1.2
1
0.8
0.6
0.4
0.2
0
?
Current < 1:400,000
1970
2000
2010

Instigator Of Change

- 1970-80's (people) - concern for increasing liability
- Harvard affiliated hospitals meeting – early 1980s
- Anesthesiology a "…high risk specialty"

- 1/10,000 anesthetized patients died
  - 82% identified as human error
  - 72% identified as preventable respiratory adverse events
  - < 10% attributed to equipment failure

Pandya 2020

Risk Management Committee

- **82% of deaths associated with human error**
  - 25% associated with *inadequate experience overall* or *familiarity with equipment*
  - 22% associated with:
    - Poor team communication
    - Excessive dependency on other personnel
    - Inattention and/or haste
- **'…72% of the events being adverse respiratory events (leading to mortality) would have been prevented with better monitoring.'**
  - Hypoventilation most common intra-/post-operative cause of anesthetic accidents

Pandya 2020

Risk Management Committee - 1984

- Committee formulated minimum standards, considering:
  - Cost
  - Simplicity
  - Avoidance of distractions
  - Flexible
  - Additional goal(s) of:
    - Increasing sensitivity for low frequency events
    - Target major causes of mortality events
    - Quantitative monitoring rather than qualitative

Pandya 2020

American Society of Anesthesiologists - Monitoring Standards (1986)

- Qualified anesthesia personnel shall be present in the room throughout the conduct of all general anesthetics, regional anesthetics and monitored anesthesia care.

- During all anesthetics, the patient's oxygenation, ventilation, circulation and temperature shall be continually evaluated.
  - Pulse oximetry assessing blood oxygenation during/post-all anesthetic events
  - Continuous monitoring for the presence of and quantification of end-tidal CO2
  - Continuous ECG, blood pressure measured q 5 min
  - Continuous or intermittent temperature measured to aid in keeping normothermia

Results of Implementing Standards?

Pre-Monitoring Standards
(1970-1980)

1-3 per 10,000

(1986)

American Society of Anesthesiologists adopted monitoring standards

(1995-2000)

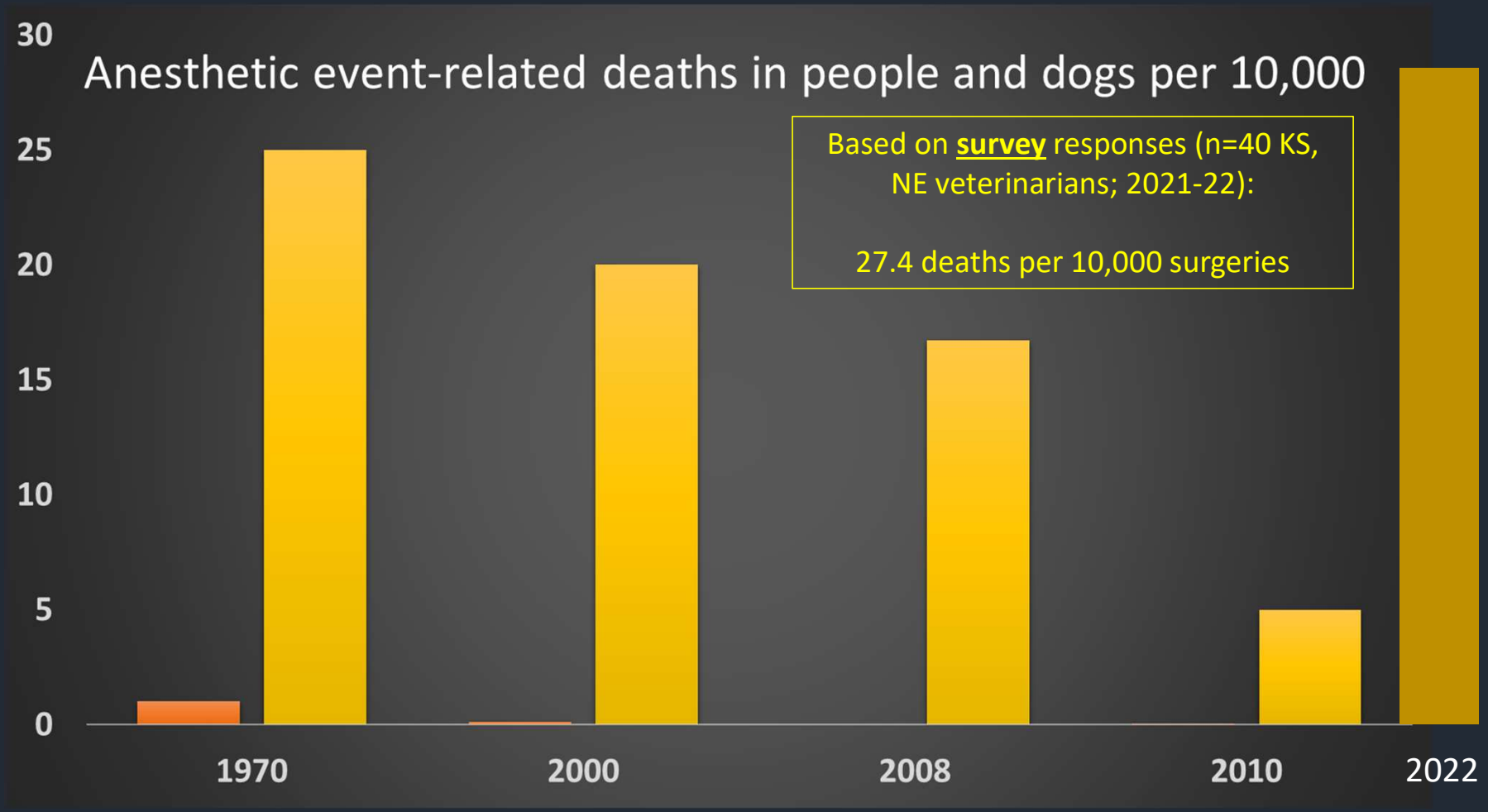
Mixed population:
1 per 300,000

Low risk ASA 1/2 patients:
< 1 per 400,000

Primary fact that allowed mortality reduction?

Identification that 70% of anesthetic ‘accidents’ occurring were preventable with appropriate monitoring (pulse oximetry/capnography)

How Do We Compare?



Anesthetic-Related Death in Veterinary Medicine

- Improving but mortality remains discordantly high

- Factors implicated:
  - Increased level of training involved in human anesthesiology
    - **CRNA** – B.A./S., Master's of Nursing → nurse anesthesia program **(7-10 years)**
    - **Anesthesiologist** – B.A./S., MD/DO → Intern./Residency +/- fellowship **(12-14 years)**
    - (general practice) **Veterinarian** – B.A./S., DVM → +/-Intern. **(7-9 years/*4-8 wks)**
    - **Veterinary Nurse/tech** – B.A., +/- internship (uncommon) **(2-3 years)**

  - National requirements for monitoring under sedation/general anesthesia (GA)
    - ASA Standards for Basic Anesthetic Monitoring

Anesthetic-Related Death in Veterinary Medicine

- Some real species' differences exist:
  - Obvious anatomic differences, often in our favor (e.g., airway control)
  - Patient inability to report pre-existing illness
  - Reliance on pet owner recognition of illness prior to progression
  - Infrastructure, equipment availability/utilization

- Mammalian physiology is very similar
  - Response to physiologic perturbations similar between dogs, cats, humans etc.
  - Response to general anesthetics similar between dogs, cats, humans etc.

Anesthetic-Related Death in Veterinary Medicine

- Published evidence suggests ‘average’ veterinary anesthetic practice is perhaps like pre-1980 practice of human anesthesiology

- Consider a clinic anesthetizing 15-20 patients each week (780-1040/yr)
  - Pre-1980 (human): 1 mortality event every 5+ years
  - Current VetMed estimation: 1 per 2 years – to – 2.7/year

- Standardized monitoring practices are majority of solution to improving veterinary anesthetic-related morbidity and mortality.

American College of Veterinary Anesthesia & Analgesia

- Position statement: (2009)
  - Minimize mortality and morbidity by **objective** monitoring for hypotension, hypoxemia, and hypercapnia
  - Anesthetic providers should provide frequent and continuous monitoring of patients through observation and various monitors while creating record of parameters

- Monitoring anesthetized animal patients
  - Ensure adequate circulation
  - Ensure oxygenation
  - Ensure adequate ventilation
  - Maintain normothermia
  - Maintain *legible anesthetic record capturing entire event*
  - Monitor/ensure *safe and comfortable recovery* period

ACVAA.org

ANESTHESIA RECORD

DATE: 06-28-2021
PROCEDURE: CT scan + Sternotomy + Lung lobectomy

SURG./CLINICIAN: [redacted] SURG. STUDENT: [redacted]
ANESTHESIOLOGIST: [redacted] ANES. STUDENT: [redacted]

[redacted]

Canine Black
Labrador Retriever

DR.

33

WT	TEMP	HR	RR	PULSE QUAL	M.M. COLOR	CRT	BUN/CREAT	PCV	TSP	PHYSICAL STATUS
26 Kg	100°F	88 bpm	60 bpm	str	pink	1-2 s	19/0.8	45%	7g/dL	1 2 (3) 4 5 E

PRE-ANESTHESIA DRUGS

DRUG	DOSE (mg)	ROUTE	TIME
Fentanyl	78mcg	IV	12:44pm
Ketamine	26mg	IV	12:44p
Lidocaine	52mg	IV	12:44p

ANESTHETIC INDUCTION

DRUG	DOSE (mg)	ROUTE	TIME
Propofol	79mg	IV	12:47p

EPIDURAL TIME ______
DRUG (mg) ______
DRUG (mg) ______

ENDOTRACHEAL TUBE
SIZE MM 12mm

TIME	12:00p	12:30	1:00p	1:30	2:00p	2:30	3:00pm	3:30	TOTAL FLUIDS
78mL/hr FLUIDS TYPE Fent/Ket/Lidoc					6, 11/17	19/36, 20/56	18/74, 20/94	20/114, 13/127	20/147 mL
5mL/kg/hr FLUIDS TYPE LRS							15/15, 20/35	35/70, 30/100	20/120 mL

O2 Flow L/min: air (medical) — 0.45 L/min, 0.6 L/min; 0.8 L/min O/C
Isoflurane / Sevoflurane (scale 0–5)

SYSTEM: CIRCLE ☒ NON REBREATH ☐

Blood Press: v syst, – mean, ʌ diast; Heart Rate ● ●; Vent. Rate ○ ○; ETCO₂ X X (scale 2–180)

Time
Start Proc. 1 CT 1:02pm
Start Proc. 2 Sx 2:50pm
End Surg. 4:10p
Arrive Recovery 4:20p
Extubation 4:33p
Standing

Recovery Quality: Good ☒ Fair ☐ Poor ☐

COMPLICATIONS: None ☐; Hypotension ☐; Arrhythmias ☐; Blood loss ☐; Low PCV ☐; Low TSP ☐; Transfusion ☐; Airway problem ☐; Hypercapnea ☐; Hypoxia ☒; Epidural: CSF ☐, Blood ☐; Resuscitation: PR ☐, CPR ☐; Death: Intraanes. ☐, Recovery ☐, 24-hrs post ☐, Euthanesia ☐

COMMENT #: ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩ ⑪ ⑫

Temperature: 99, 98.5, 98, 97.6, 98, 97, 96.7, 96.2, 96, 95, 93.7, 93.3, 93.5 — Post-Op Temp
SpO_2: 99, 98, 99, 99, 98, 98, 99, 99, 98, 99, 83, 97, 98, 99
F_iO_2: 41, 41, 39, 45, 44, 45, 40, 40, 41, 39, 93, 90, 90

COMMENTS: ① Spontan. vent TV = 190mL (sternal) ② positive pressure breath hold 10cmH2O (PIP) ③ Iohexol (contrast) 15g IV ④ end CT, relubricate eyes ⑤ move into dorsal prep for sternotomy TV = 210mL ⑥ Fent 10mcg/kg/hr, Ket 600mcg/kg/hr, Lidoc 40mcg/kg/min CRI started, Unasyn IV 786mg ⑦ LRS started 5mL/kg/hr ⑧ started mech. IPPV PIP 11cmH2O, TV = 350mL, relubricated eyes ⑨ chest open EtCO2 = 34 ↓ PIP TV from 420mL to 260mL (PIP = 5cmH2O) EtCO2 = 42mmHg ⑩ SpO2 ↓ 83% immed. recruitment maneuver 25cmH2O 30secs x 3 SpO2 ↑ 97%. Sensor happened again, added PEEP 3cmH2O SpO2 ↓ 90% ↑ PEEP 5cmH2O, O/C medical air SpO2 = 98% ⑪ closing chest started ⑩ lung lobectomy (R) dorsal lobe) ⑪ Unasyn IV 786mg, TV ↓ 260mL EtCO2 = 47mmHg ∴ ↑ TV to 330mL, EtCO2 = 40mmHg (PIP = 10cmH2O) ⑫ chest closed

[redacted] 09/13

Oxygen Flow- O
Vaporizer Setting - X

Symbols:
SPO2 △
Temp ○
Pulse +
Respiration ●
ET CO2 □
Blood pressure
Systolic ▽
Mean x
Diastolic △

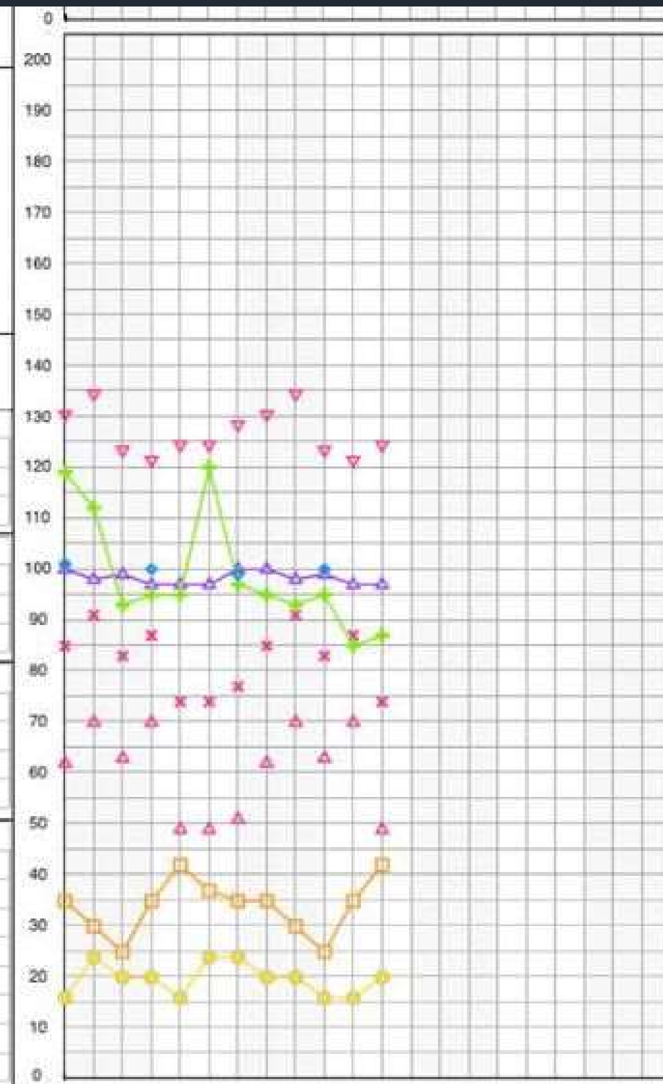
Anesthetic Maintenance:
Isoflurane

Airway Maintenance:
☐ Mask
☐ Trach
☒ ET Tube — Size: 10.5

System:
☒ Circle
☐ Bain
☒ Bag Size — 2.0 L

Airway Maintenance:
☐ Right Lateral
☐ Left Lateral
☐ Sternal
☒ Dorsal

Complications:
☒ None
☐ Difficult Intubation
☐ Apnea/Resp.Distress
☐ Hypothermia (< 99 F)
☐ Hypotension (MAP <60)
☐ Shock
☐ Arrhythmia
☐ Prolonged Recovery



The Anesthetic Record

- Impossible to prospectively know how a patient will respond to anesthetic medications, surgical interventions etc.

- Informs managing anesthetist of:
  - Trends in physiologic processes (e.g., progressive hypotension, tachycardia)
  - Response to anesthetic medications, considering comorbidities
  - Management of future of anesthetic events; when I see referred patients

- Documents appropriate patient care during anesthetic event
- Protects veterinarian/clinic of record

Schwartz 2016

The Anesthetic Record

- Dedicated anesthetist
  - To administer/titrate general anesthesia
  - Monitor/manage patient-specific response
  - Make anesthetic record

  Protective when dedicated personnel present throughout (Dyson et al 1998):
  - Dogs – 0.26 Odds Ratio of dying under anesthesia
  - Cats – 0.19 OR

Schwartz 2016

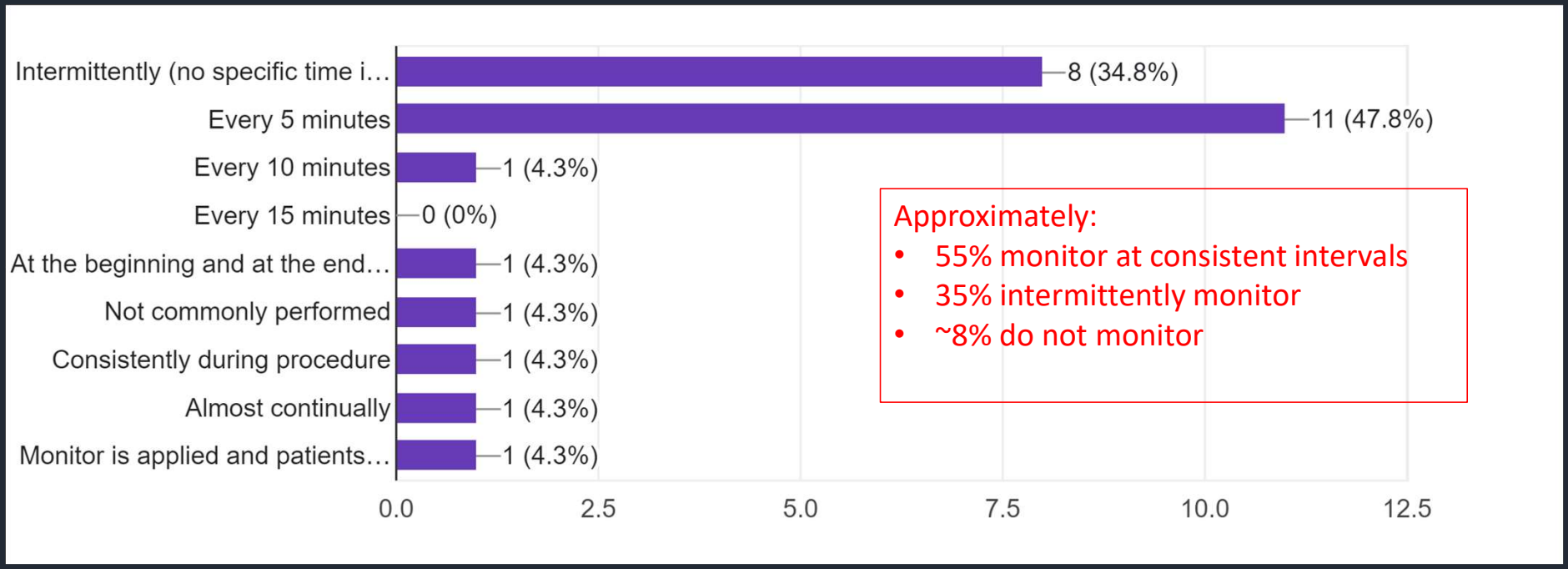
The Anesthetic Record

"(D) a complete record of the physical examination findings and treatment or services rendered."
"Manner of maintenance. Each veterinarian shall maintain records in a manner that will permit any authorized veterinarian to proceed with the care and treatment of the animal, if required, by reading the medical record of that particular patient." Kan. Admin. Regs. § 70-7-1

- Each state has equivocal language pertaining to record keeping
- Anesthetic-related deaths resulting in professional liability claim
  - Most common claims per AVMA-PLIT:
    - 'sudden death' **in recovery**
    - Intra-op sudden death due to **closed pop-off valve**
  - Primary reason for lost claim:
    - Inadequate or no record of anesthetic event and recovery
    - Influenced by reasonable standards of practice for an area

Kapaldo, personal correspondence 5-2022

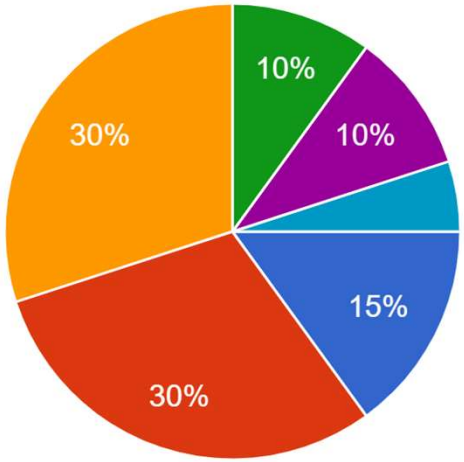
Monitoring practices



Approximately:

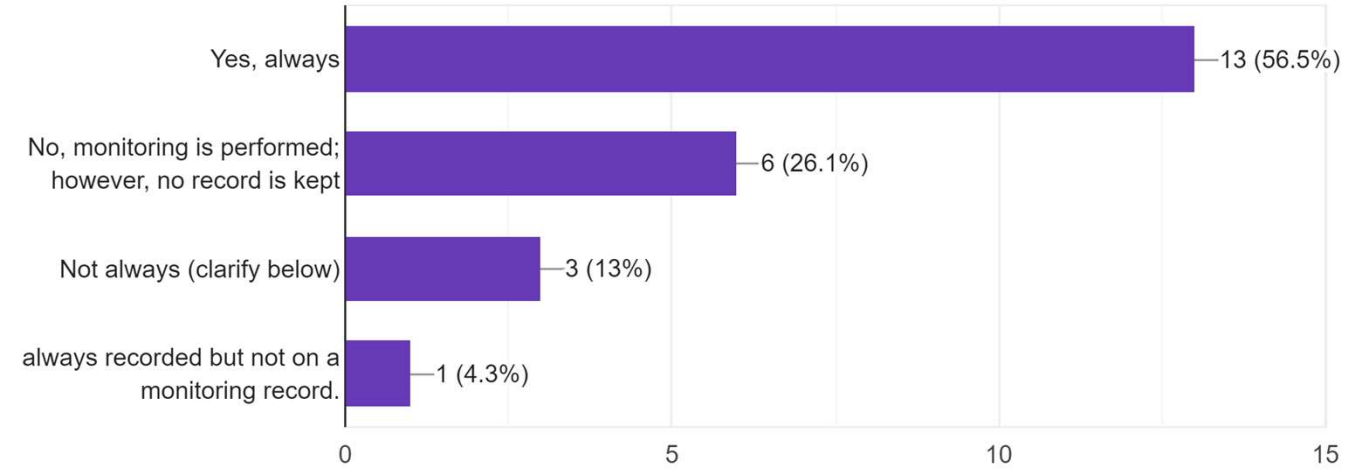
- 55% monitor at consistent intervals
- 35% intermittently monitor
- ~8% do not monitor

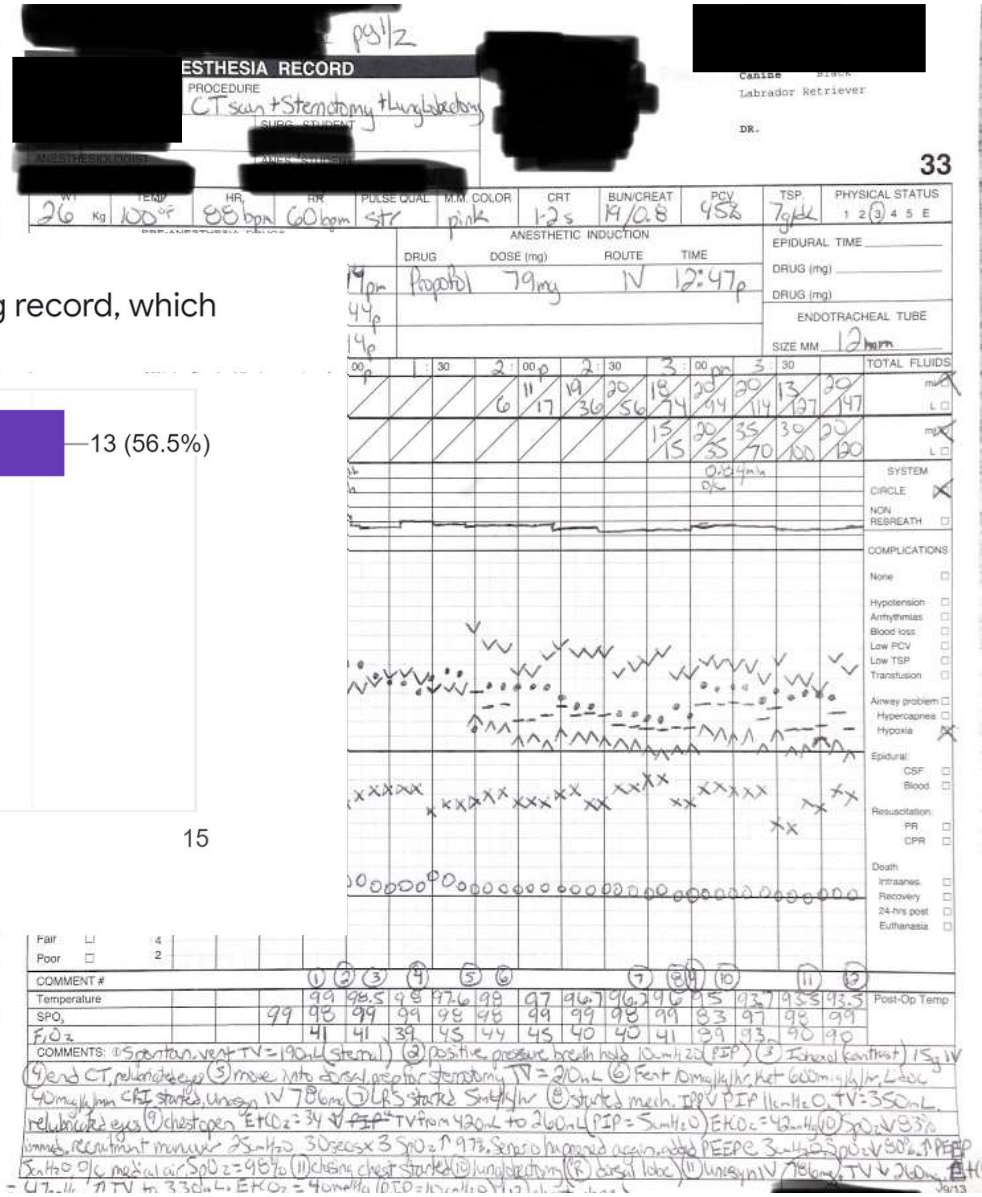
You monitor the patient while also performing a given surgery/procedure



- Yes
- No, there is a dedicated RVT to monitor the patient
- No, there is a dedicated staff/assistant to monitor the patient
- No, there is a dedicated unregistered technical staff to monitor the patient
- Someone intermittently comes in the room to check on the patient
- Dedicated RVT or unreg Tech

Anesthetic monitoring is performed/recorded on a standardized monitoring record, which becomes part of the patient's record.





Goals of General Anesthesia

Unconsciousness

Amnesia (loss of memory)

Analgesia (loss of pain *perception*)

Akinesia (loss of movement)

Cardiopulmonary, thermoregulatory, and autonomic stability

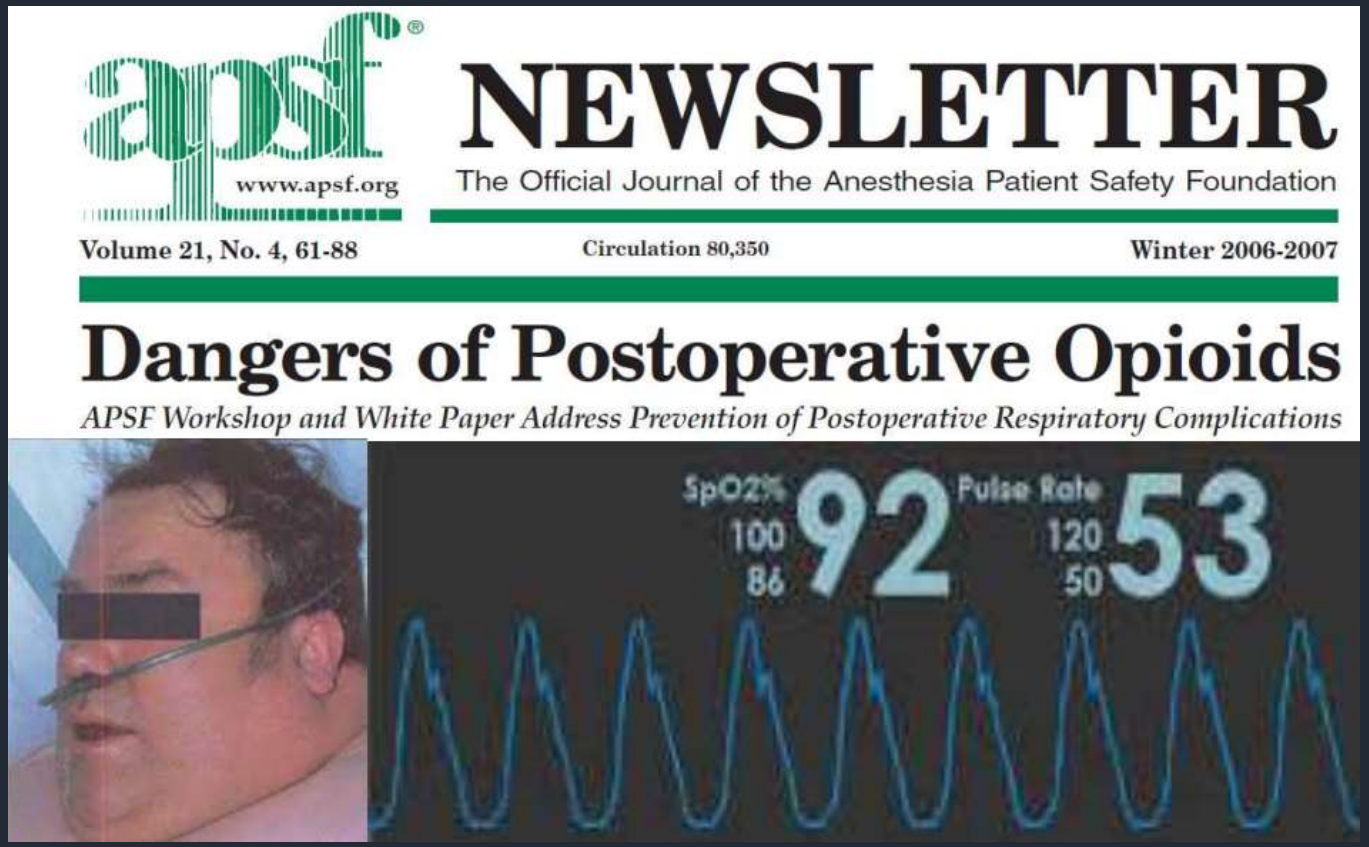
Effects of Degrees of Unconsciousness

Factor	Minimal Sedation (Anxiolysis)	Moderate Sedation/ Analgesia (Conscious Sedation)	Deep Sedation/Analgesia	General Anesthesia
Responsiveness	Normal response to verbal stimulation	Purposeful response to verbal or tactile stimulation	Purposeful response following repeated or painful stimulation	Unarousable even with painful stimulation
Airway	Unaffected	No intervention required	Intervention may be required	Intervention often required
Spontaneous ventilation	Unaffected	Adequate	May be inadequate	Frequently inadequate
Cardiovascular function	Unaffected	Usually maintained	Usually maintained	May be impaired

Adapted from the American Society of Anesthesiologists definitions. Available from URL: http://www.asahq.org/quality-and-practice-management/standardsguidelines-and-related-resources/continuum-of-depth-of-sedation-definition-of-general-anesthesia-and-levels-of-sedation-analgesia (accessed 2022)

End of procedure ≠ Done

- Majority of anesthetic-related deaths in people before monitoring standards occurred post-operatively/in recovery unit



End of procedure ≠ Done

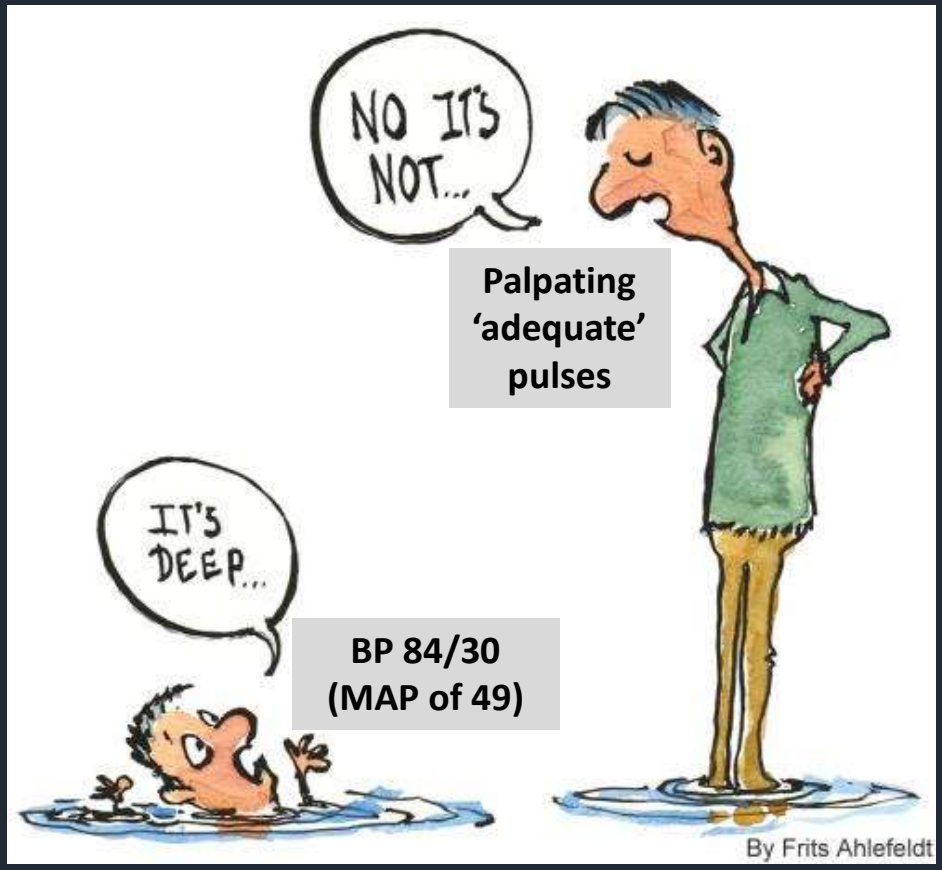
- Majority of anesthetic-related deaths in people before monitoring standards occurred post-operatively/in recovery unit

- Majority of anesthetic deaths in dogs and cats occur post-operatively / in recovery
  - 62% - Matthews et a. 2017
  - 57% - Brodbelt et al. 2009

- Hypoventilation associated hypoxia, hypoxemia
  - Reason pulse oximeters *required* in all recovering patients

Perspective

- Each monitoring tool tells part of the picture
- Monitors do not know about patients
- Diligent anesthetists required



Review / Questions

- *Standard* monitoring practices/protocols provide primary path to reducing mortality
- The majority of anesthetic-related deaths are preventable
- Anesthetic monitoring records make up a portion of a patient's medical record and influence the ability to defend against liability claims