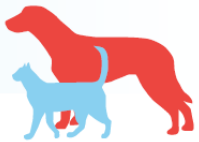
CPR Breakdown: Making Sense of Important Questions in Veterinary Resuscitation

Kenichiro Yagi, MS, RVT, VTS (ECC), (SAIM)

What does CPR look like?


RECOVER
For Them And You
Who We Are
2024 Guidelines

CPR Initial Assessment Algorithm



RECOVER

- Unresponsive
- Call for help
- Shake & Shout
  - Response → Primary Survey
  - No Response
- Breathing?
  - Yes → Primary Survey
  - No
- Number of Rescuers
  - 1
    - Airway Clear?
      - Yes → Start Single-Rescuer BLS
      - No → Clear Airway → Start Single-Rescuer BLS
  - 2+

Rescuer 1	Rescuer 2
Start Compressions Chest Compressions 100-120 / minute	Check Airway while Intubating Ventilation Every 6 seconds

CPR Algorithm for Dogs and Cats

RECOVER

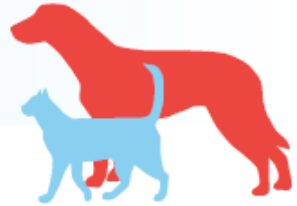
Start BLS	Start ALS
2 full minutes, no pauses 1 Chest Compressions 100-120 / minute 2 Ventilation every 6 seconds	3 Monitoring ECG $ETCO_2$ 18+ mmHg 4 IV Access 5 Reversals

Pause & Check
< 10 seconds
Rhythm Diagnosis | Pulse Palpation

- **No Pulse** — Shockable VF / Pulseless VT
  - BLS
  - Charge Defib dose x2 after 1st
  - Pause & Shock
  - **Refractory Shockable** 2 or more shocks
    - Suggest
      - Vasopressin or Epinephrine every other cycle
      - Antiarrhythmics
        - Amiodarone in cats
        - Lidocaine in dogs
      - Esmolol
- **Pulse** — ROSC
  - PCA Algorithm
- **No Pulse** — Non-Shockable Asystole / PEA
  - Epinephrine or Vasopressin every other cycle
  - Suggest
    - Atropine once, as early as possible

Prolonged CPR > 15 min
Shockable or Non-Shockable
Suggest
Bicarbonate especially if pH < 7.0

CPR ECG Algorithm



Palpable pulse?

No

Consistent, repeating complexes on ECG?

Yes

Perfusing Rhythm
= ROSC

Yes

Rate > 200/min?

No

Is the ECG a flat line?

Yes

Pulseless VT

Shockable

No

PEA

Non-Shockable

No

VF

Shockable

Yes

Asystole

Non-Shockable

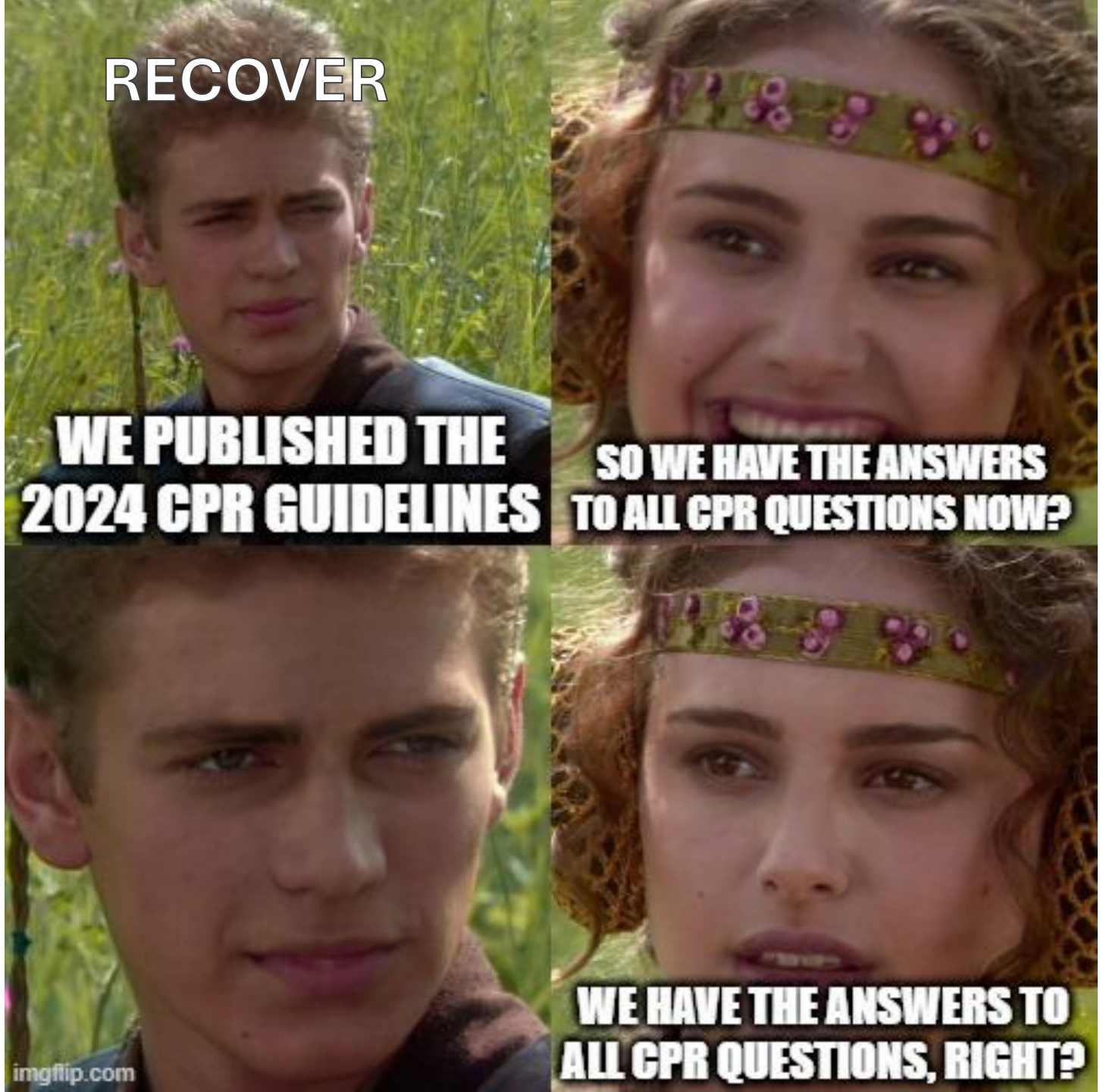
CPR Dosing Chart for Dogs and Cats

	DRUG	DOSE	Weight (kg)	2.5	5	10	15	20	25	30	35	40	45	50
				mL	mL	mL	mL	mL	mL	mL	mL	mL	mL	mL
Arrest	Epinephrine (1:1000; 1mg/mL)	0.01 mg/kg		0.03	0.05	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5
Arrest	Vasopressin (20 U/mL)	0.8 U/kg		0.1	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
Arrest	Atropine (0.4 - 0.54 mg/mL)	~ 0.05 mg/kg		0.25	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5
Anti-Arrhythmic	Amiodarone (50 mg/mL)	5 mg/kg		0.25	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5
Anti-Arrhythmic	Lidocaine (20 mg/mL)	2 mg/kg		0.25	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5
Anti-Arrhythmic	Esmolol* (10 mg/mL)	0.5 mg/kg		0.13	0.25	0.5	0.75	1	1.3	1.5	1.8	2	2.3	2.5
Reversal	Naloxone (0.4 mg/mL)	0.04 mg/kg		0.25	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5
Reversal	Flumazenil (0.1 mg/mL)	0.01 mg/kg		0.25	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5
Reversal	Atipamezole (5 mg/mL)	100 µg/kg		0.06	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Monophasic Defibrillation	External Defib (J)	4 - 6 J/kg		10 J	20 J	40 J	60 J	80 J	100 J	120 J	140 J	160 J	180 J	200 J
Monophasic Defibrillation	Internal Defib (J)	0.5 - 1 J/kg		2 J	3 J	5 J	8 J	10 J	15 J	15 J	20 J	20	20 J	25 J
			Weight (kg)	2.5	5	10	15	20	25	30	35	40	45	50

*Administer esmolol 0.5 mg/kg IV or IO over 3-5 minutes followed by a CRI at 50 mcg/kg/min

Reassessment Campaign on Veterinary Resuscitation

Simple
Easy
Know all there is to know


RECOVER
WE PUBLISHED THE 2024 CPR GUIDELINES
SO WE HAVE THE ANSWERS TO ALL CPR QUESTIONS NOW?
WE HAVE THE ANSWERS TO ALL CPR QUESTIONS, RIGHT?
imgflip.com

What are questions that you want to ask about CPR?

Nobody has responded yet.

Hang tight! Responses are coming in.

How long is too long?

Are there any differences in cat vs dog CPR?

Are interposed abdominal compression effective?

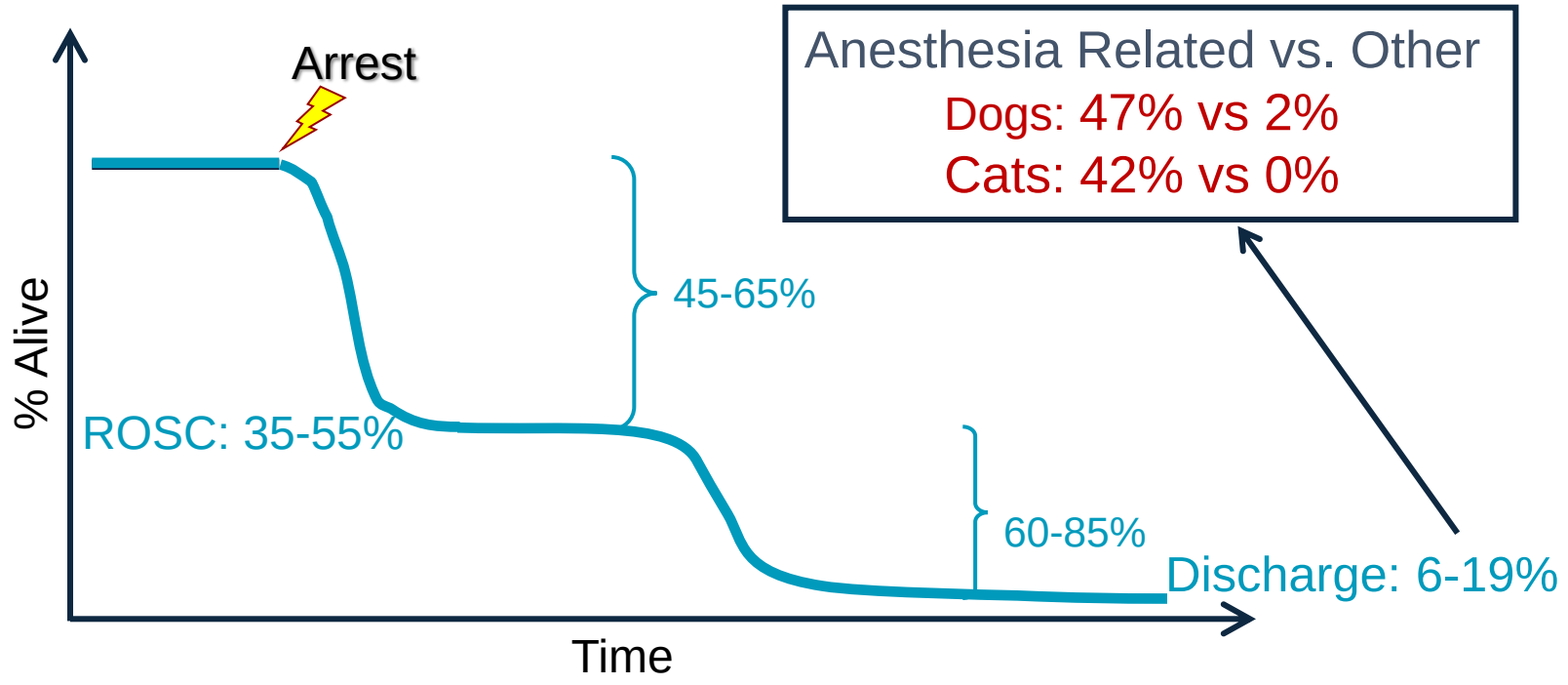
Duration of CPR:

How long is too long?

Cardiopulmonary Arrest Epidemiology

Anesthesia -> 14.82x more likely to survive
Cats -> 4.87x more likely to survive

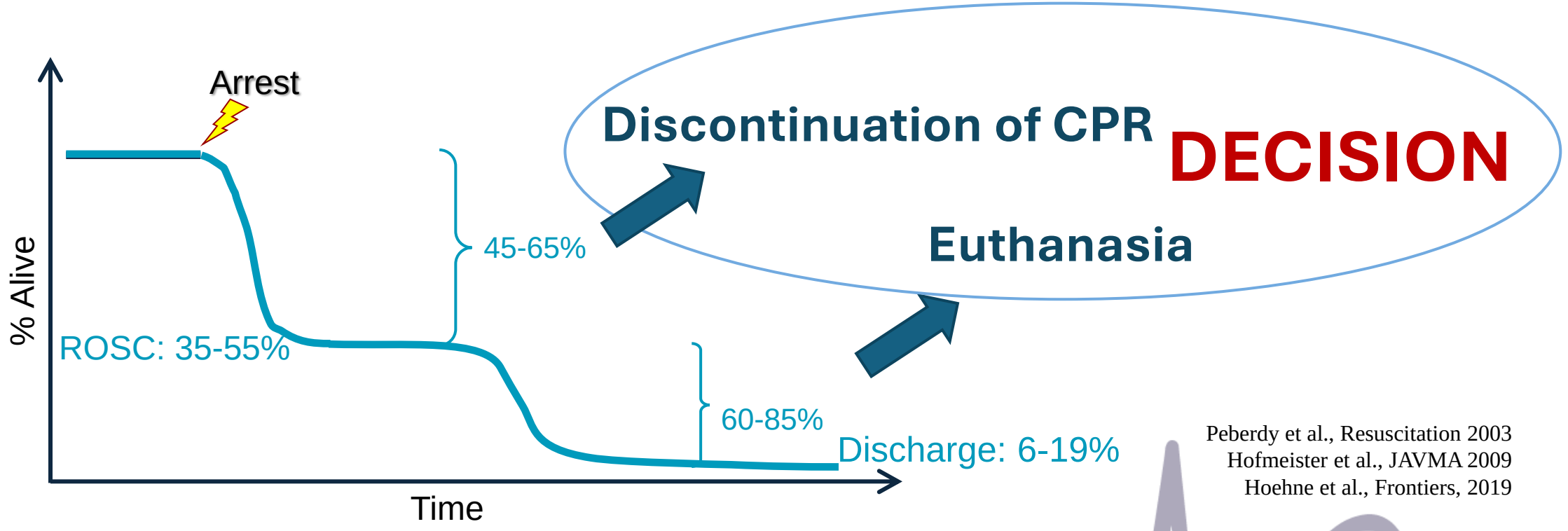
333 dogs and 90 cats with in-hospital CPA



Peberdy et al., Resuscitation 2003
Hofmeister et al., JAVMA 2009
Hoehne et al., Frontiers, 2019

Cardiopulmonary Arrest Epidemiology

333 dogs and 90 cats with in-hospital CPA



Peberdy et al., Resuscitation 2003
Hofmeister et al., JAVMA 2009
Hoehne et al., Frontiers, 2019

(Neurologic) Outcome prediction in cardiac arrest

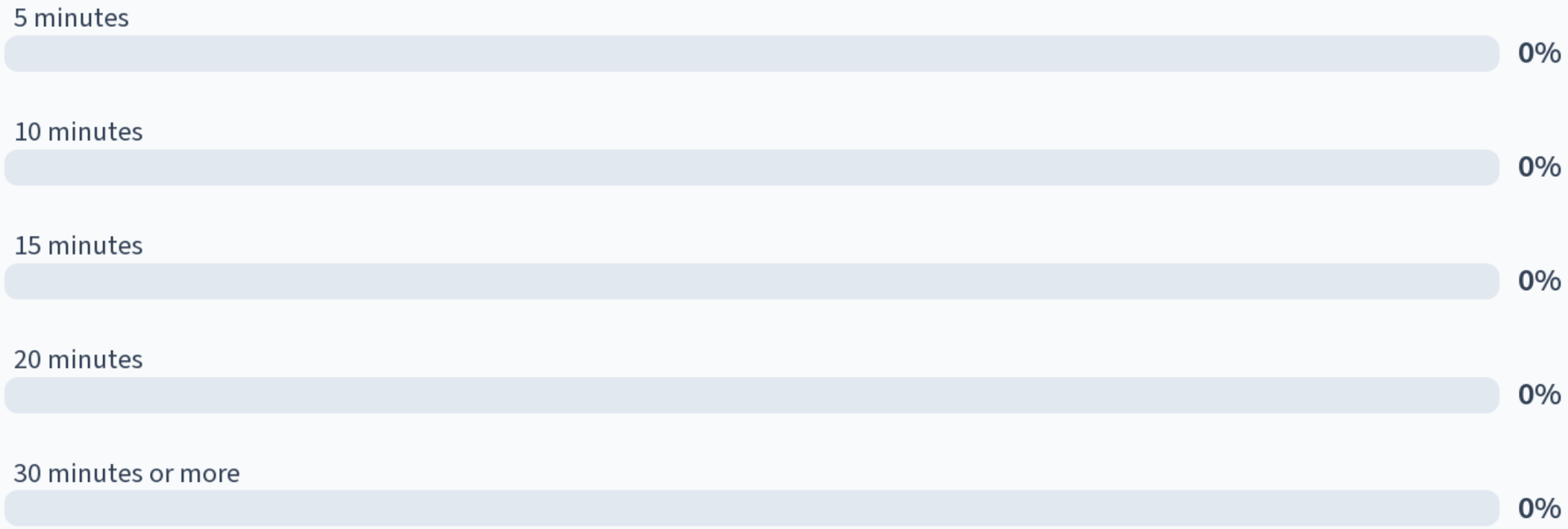
Intra-arrest

After ROSC

How long to continue?

.....there are NO guidelines

In a patient without irreversible disease, how long do you continue CPR until you consider it futile?

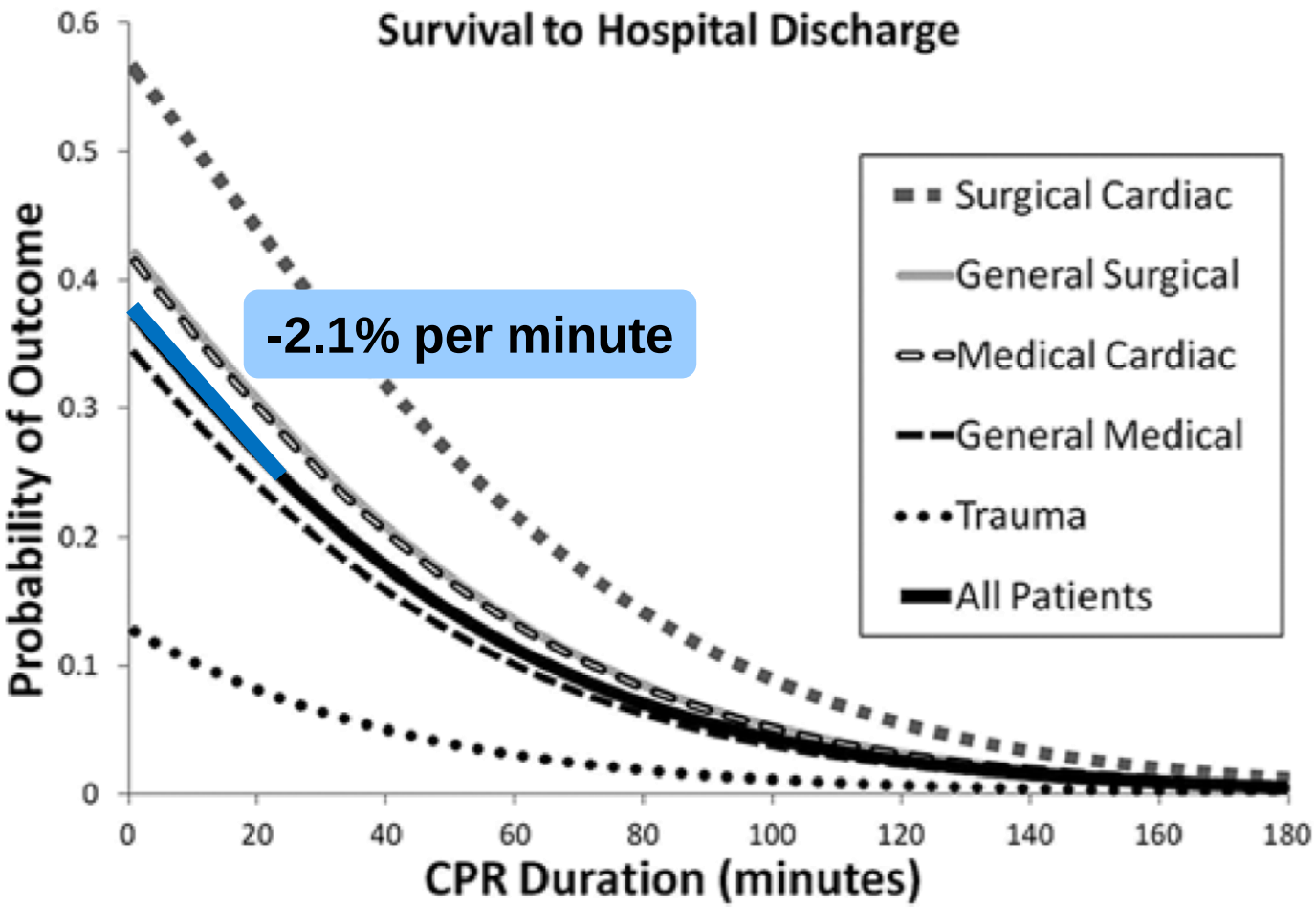


What factors do you consider when deciding to stop CPR?

Nobody has responded yet.

Hang tight! Responses are coming in.

How is duration of CPR associated with survival?



Duration of CPR and survival:

- **3419** children
- pediatric critical care unit

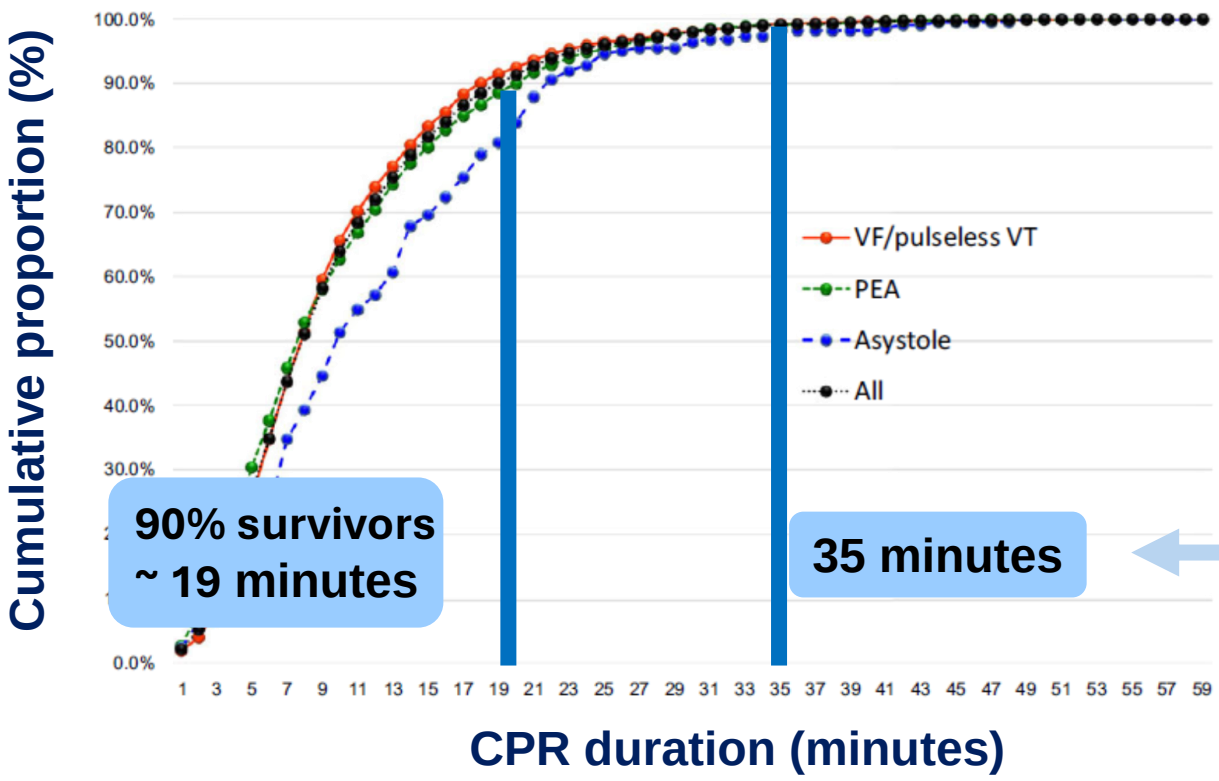
Survival to discharge:

- 1-15 minutes of CPR: 41%
- **>35 minutes: 12%**
- Overall: 27.9%

Matos, R. I., et al. (2013). Circulation **127**(4): 442-451.

How is duration of CPR associated with survival?

Critical duration of CPR



Duration of CPR and survivors:

- 17,238 adults w/ ROSC
- OHCA

Critical duration of CPR:

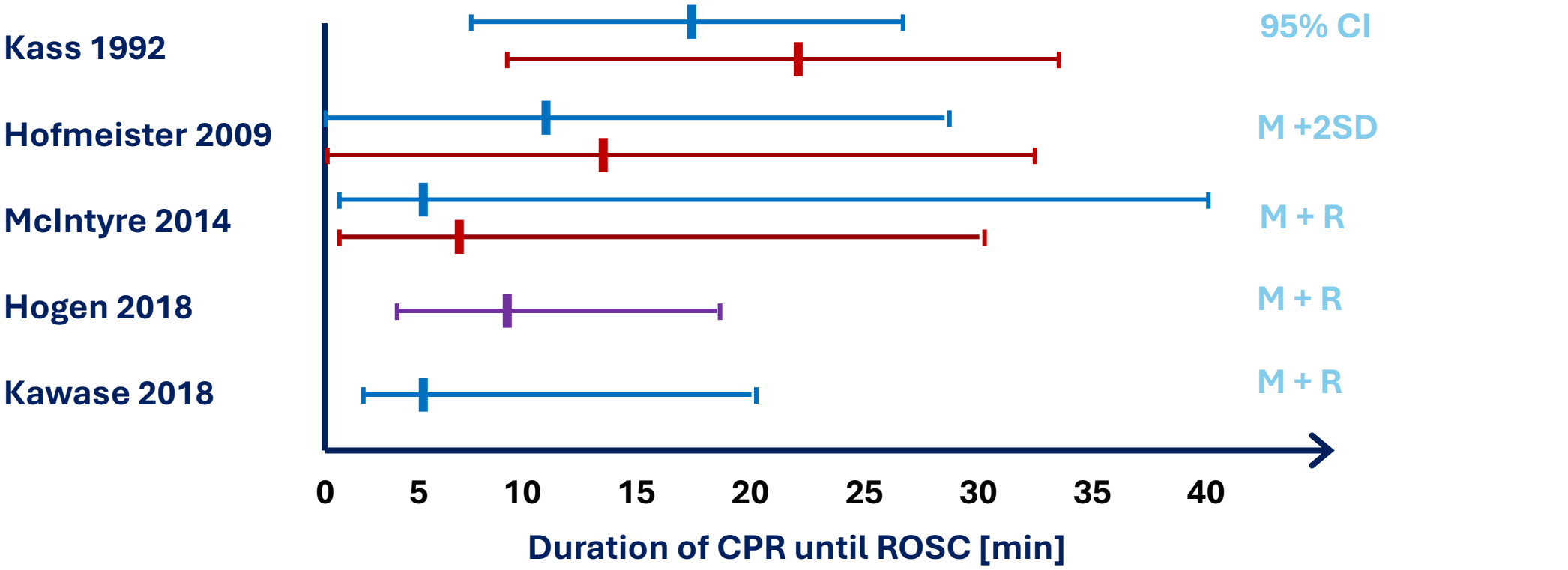
- 99% of survivors (30 days)
- CPC 1-2

Goto, Y., et al. (2015) JAHA **5**(3).

How about dogs and cats?

6 studies report ROSC data
- Dogs: 206 dogs
- Cats: 63 cats

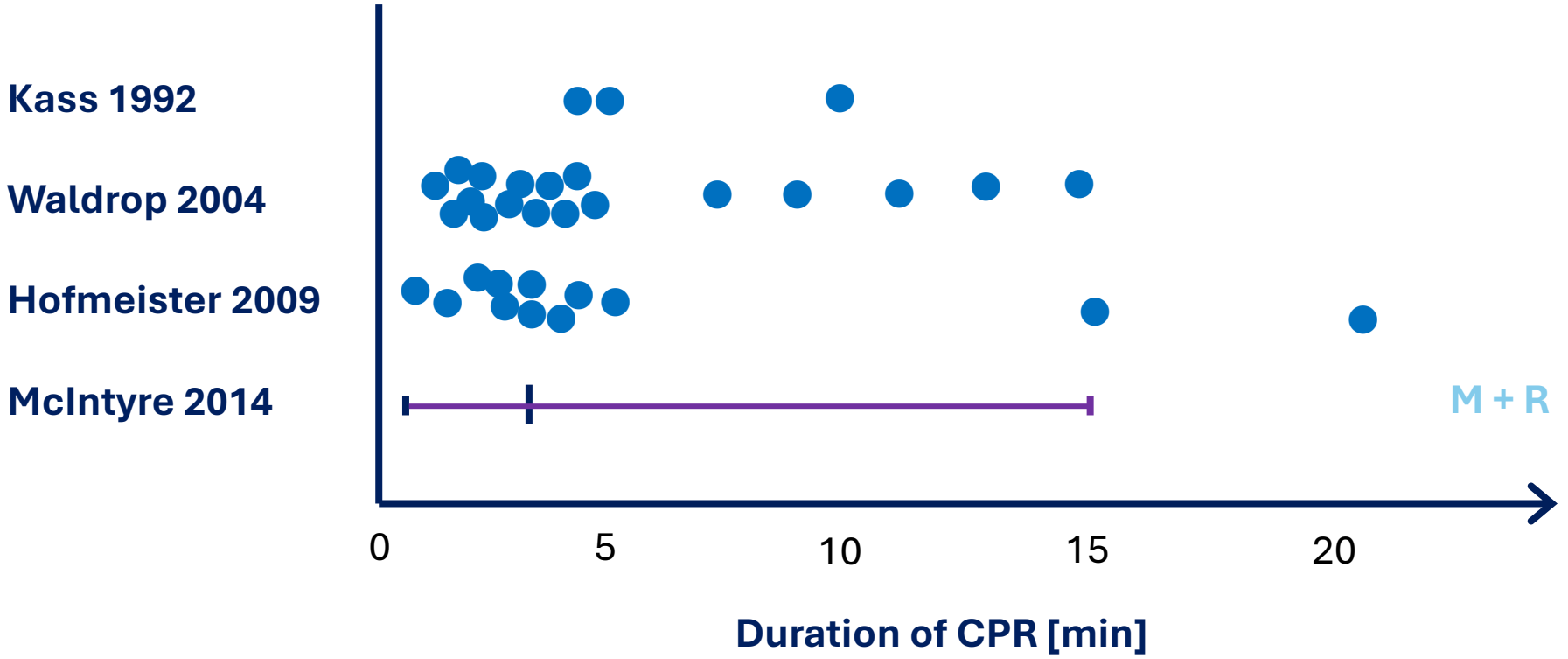
5 studies report CPR durations
- Dogs: 184 dogs
- Cats: 55 cats



How about dogs and cats?

7 studies report survivors
- Dogs: 44 dogs
- Cats: 13 cats

4 studies report CPR durations
- Dogs: 29 dogs
- Cats: 8 cats

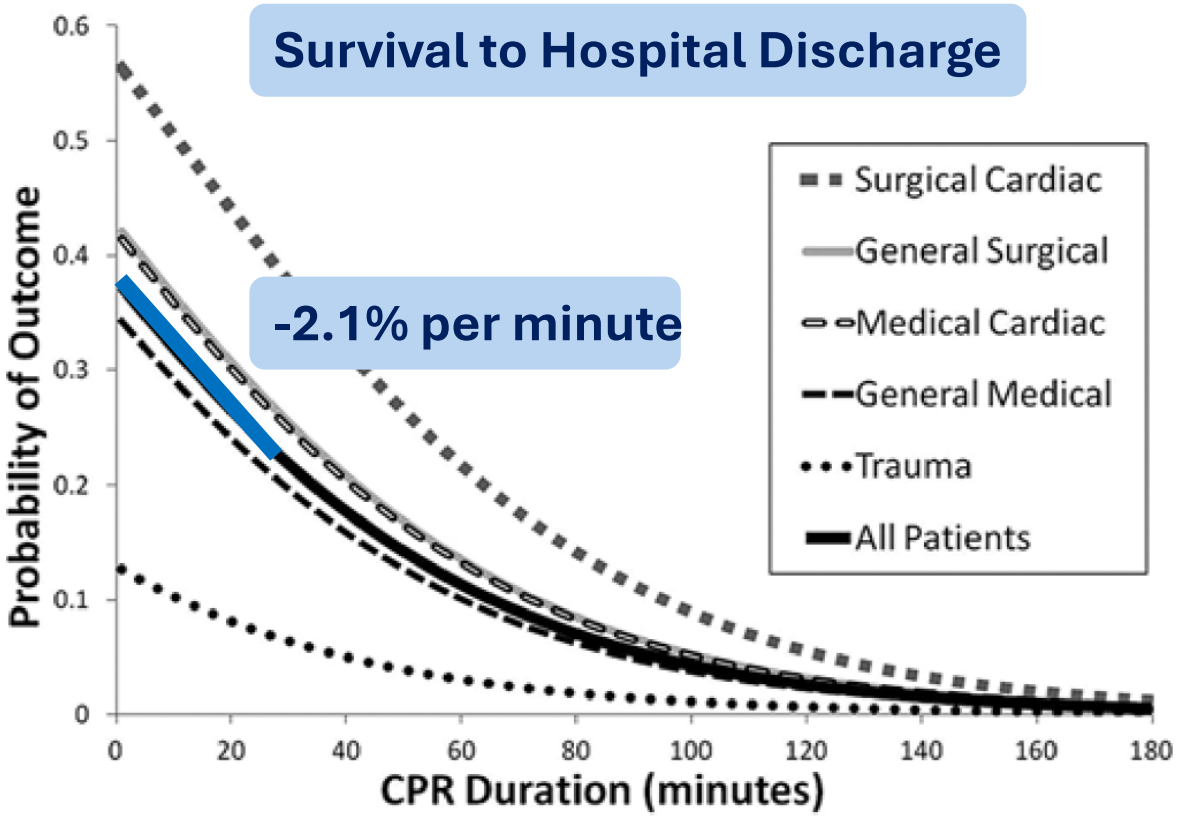


Discontinue CPR

- Economics
- Severity of illness
- Futility

Functional Capacity
Quality of Life

How is duration of CPR associated with functional outcome?

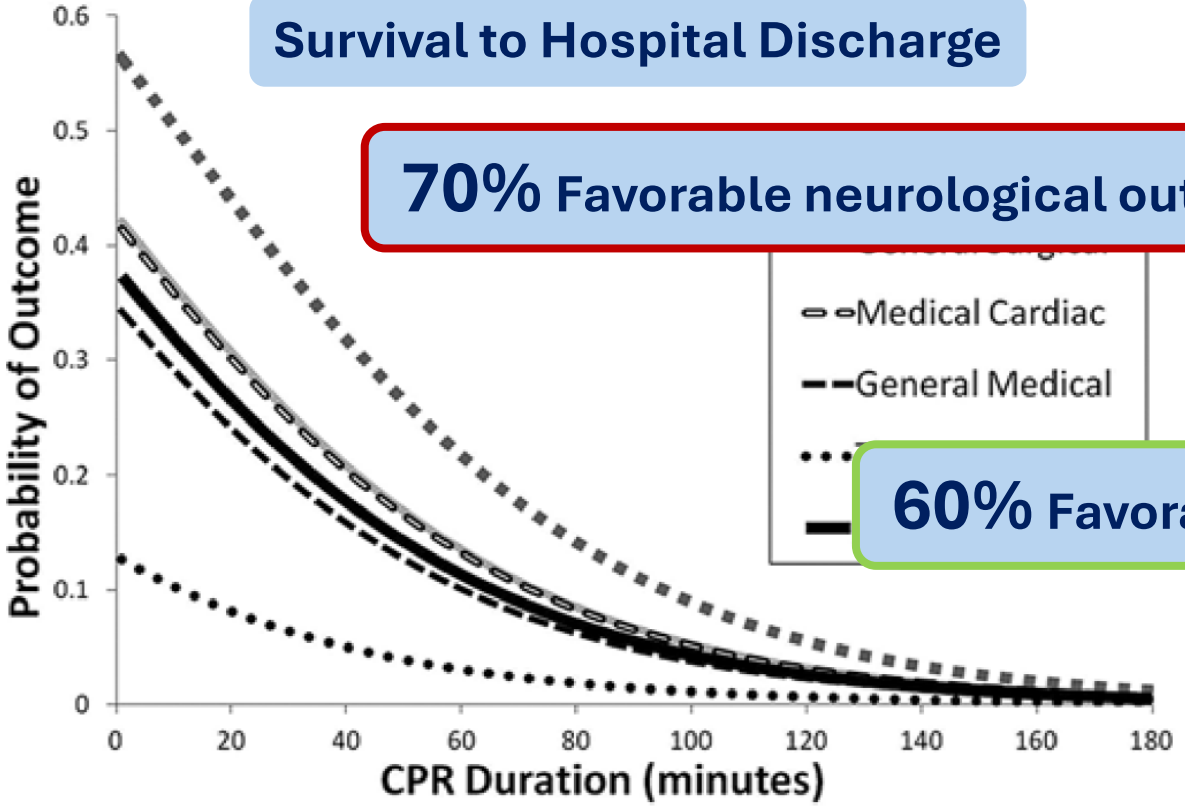


Matos, R. I., et al. (2013). Circulation **127**(4): 442-451.

How is duration of CPR associated with functional outcome?

Survival to Hospital Discharge

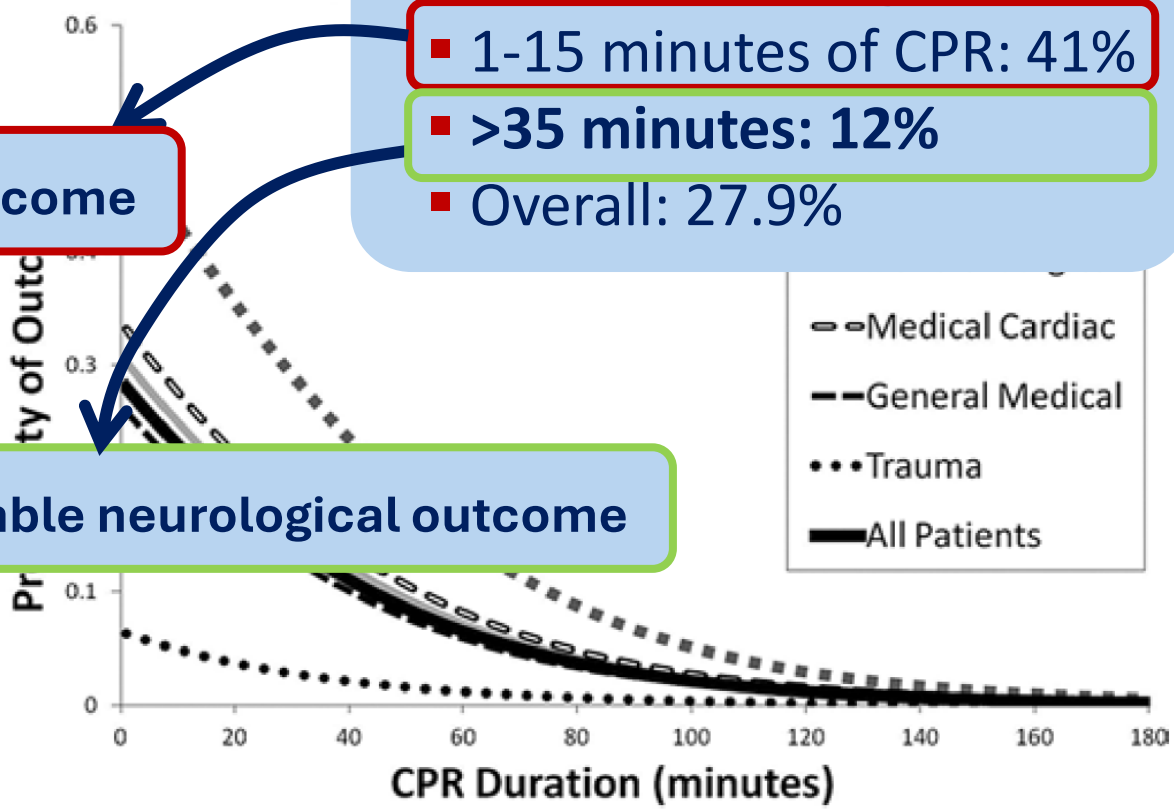
70% Favorable neurological outcome



Survival to discharge:

- 1-15 minutes of CPR: 41%
- **>35 minutes: 12%**
- Overall: 27.9%

60% Favorable neurological outcome



Matos, R. I., et al. (2013). Circulation **127**(4): 442-451.

Understanding the RECOVER CPR Registry

Gathering Data From Around the Globe

A registry is a health-related database containing demographic and clinical information of individual animals and serving a specific health-related purpose. Registries are used for long-term data collection, while observational research projects focus on short-term data gathering.

The RECOVER initiative developed a CPR registry to collect epidemiological information on CPR in small animals. Epidemiological CPR data in dogs and cats is currently only based on observational studies conducted in single veterinary hospitals. Due to the heterogeneity of the veterinary cardiopulmonary arrest (CPA) population, data from a large number of animals are needed to determine the effects of specific variables (e.g., age) on the outcome. Important questions can be answered with registries. For example, determining the frequency of return of spontaneous circulation (ROSC) and survival rates after CPR may provide practitioners with more evidence on how long to continue the resuscitation effort. In short, the RECOVER CPR registry is a central instrument to create new knowledge of small animal CPR. The RECOVER CPR registry-based its content on the Utstein-style reporting guidelines. Accordingly, data elements are divided into those absolutely required for the data to make any sense (aka, core variables) such as animal species and survival to discharge information, and into those that cannot reliably be collected or are primarily useful as hypothesis-generating data (aka, supplemental variables), rather than essential. Examples of supplemental variables include EtCO2 values or time until the first epinephrine administration. The RECOVER case report form is designed to facilitate data collection required for the registry by using the same data elements and synchronized terminology.

The RECOVER CPR registry is implemented using an electronic research data capture system developed by the NIH and data can be entered via a computer terminal or tablet by everyone that has a RECOVER CPR registry account. Registry data will be made available to any registry contributor to answer specific hypotheses, provided a respective application was submitted and approved.

So when to stop?

Proposal for termination of resuscitation

1. Irreversible cause of CPA

Irreversible Causes

Severe Neurologic Damage – Brain death, cerebral herniation, non-survivable traumatic brain injury

Catastrophic Trauma – Severe spinal cord transection, ruptured major vessels, non-survivable injury (blunt/penetrating)

Severe Cardiac Disease – Advanced dilated cardiomyopathy, cardiac rupture

End-Stage Disease – Terminal cancer, organ failure, refractory sepsis

Extreme metabolic derangements – refractory metablic/electrolyte disturbances, lethal toxic ingestions (cyanide, irreversible neurotoxins, massive barbiturates)

H’s (Primary Reversible Causes)

Hypoxia – Ensure adequate oxygenation and ventilation.

Hypovolemia – Rapid IV fluid therapy, blood transfusion if severe hemorrhage.

Hydrogen ion (Acidosis) – Treat metabolic acidosis (sodium bicarbonate if indicated).

Hyperkalemia / Hypokalemia – Correct electrolyte imbalances (calcium, insulin-dextrose for hyperkalemia).

Hypoglycemia – Administer dextrose if blood glucose is low.

Hypothermia – Rewarm strategically in cold-related arrests.

T’s (Secondary Reversible Causes)

Tension Pneumothorax – Decompress with thoracocentesis.

Tamponade (Cardiac) – Pericardiocentesis.

Toxins (Drug Overdose, Poisoning) – Identify and administer antidotes if available (e.g., naloxone for opioids).

Thrombosis (Pulmonary Embolism, MI) – Consider thrombolysis or advanced interventions.

Trauma – Address underlying injuries (internal bleeding, pneumothorax, etc.).

Proposal for termination of resuscitation

1. Irreversible cause of CPA
2. Continued (>20 min?) poor efficacy of CPR

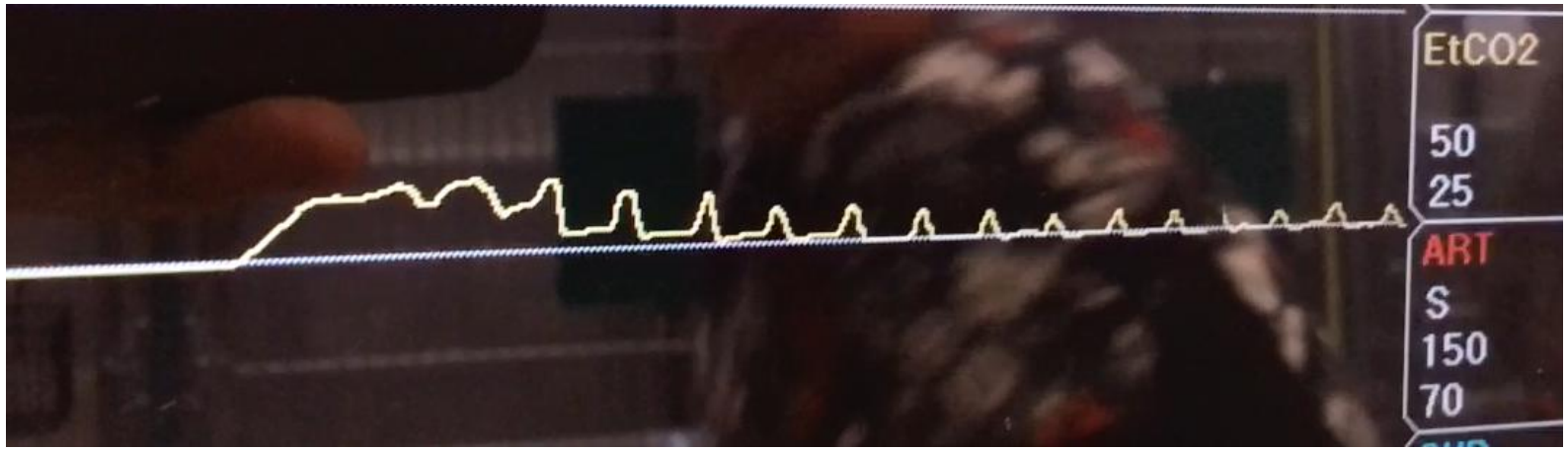
How do you know if CPR is going well?

Nobody has responded yet.

Hang tight! Responses are coming in.

Useful Monitors

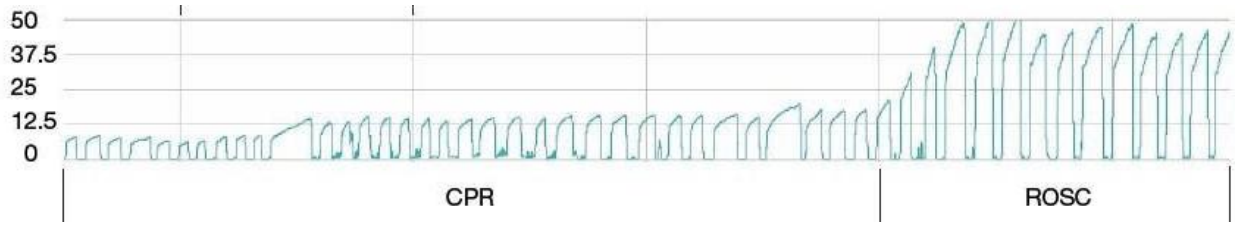
- ETCO2



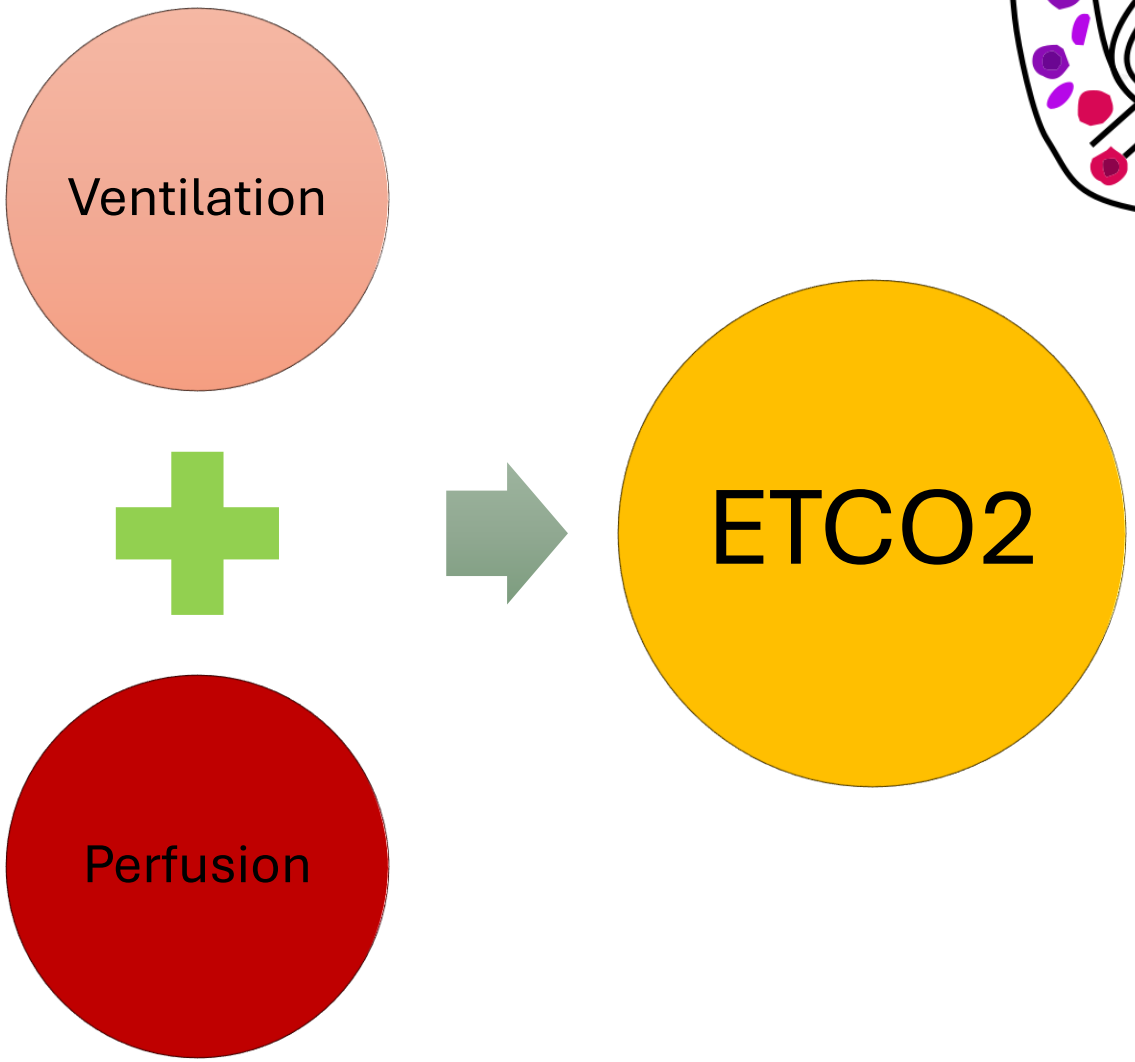
- ECG

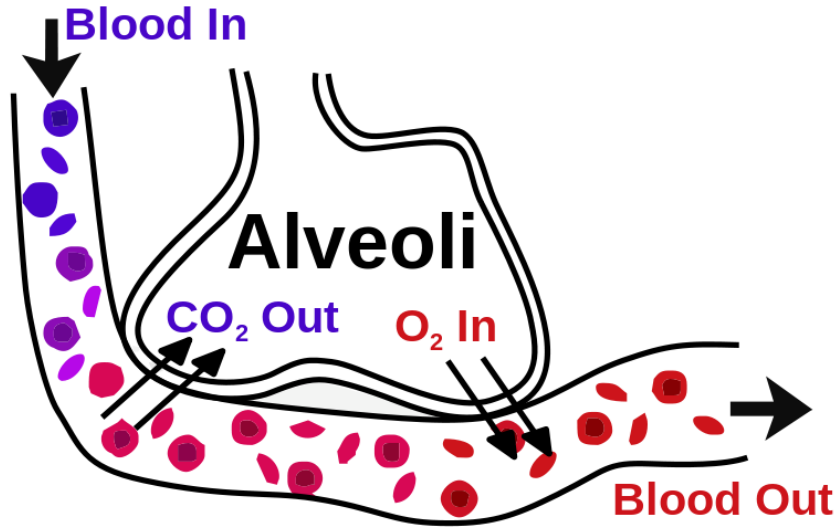
$ETCO_2$ Guidelines

- **Helps confirm endotracheal intubation (>12 mmHg)**
  - Visually confirm endotracheal intubation if <5 mmHg
- **Assess Compression Quality**
  - **Goal: $ETCO_2$ > 18 mmHg. If lower…**
    - Evaluate compression quality: Rate, depth, recoil / leaning, location, posture, etc.
    - Confirm correct ventilation: RR = 10 / min (6 seconds between breaths)
  - Especially feasible in cats where compressions are more likely to be effective
- **Indication of ROSC**
  - If $ETCO_2$ increases suddenly by ≥ 15 mmHg or value ≥ 35 mmHg
  - Don't stop compressions until you confirm the pulse!



Capnography

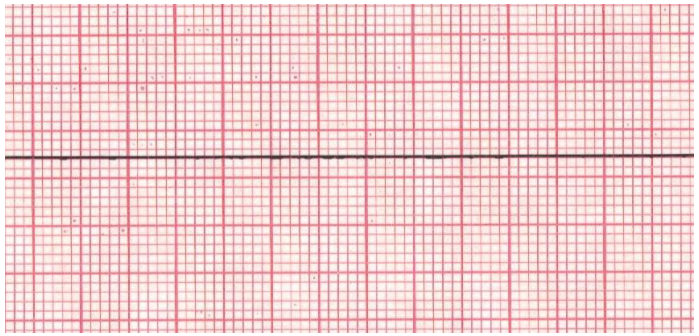




Yes

Asystole

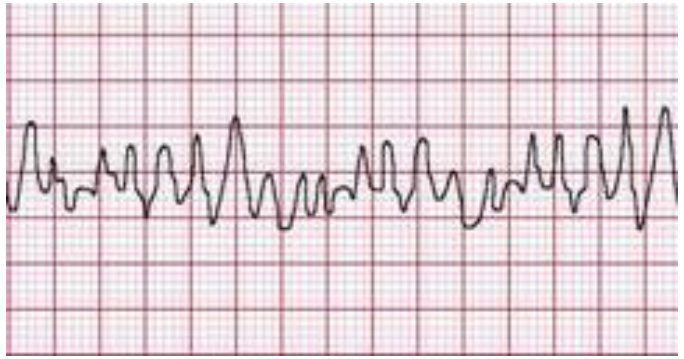
Non-Shockable



No

VF

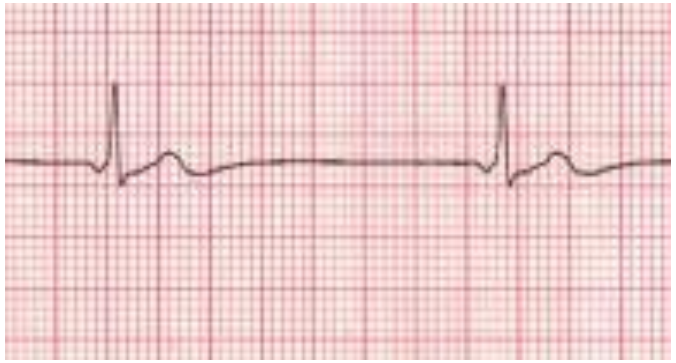
Shockable



No

PEA

Non-Shockable

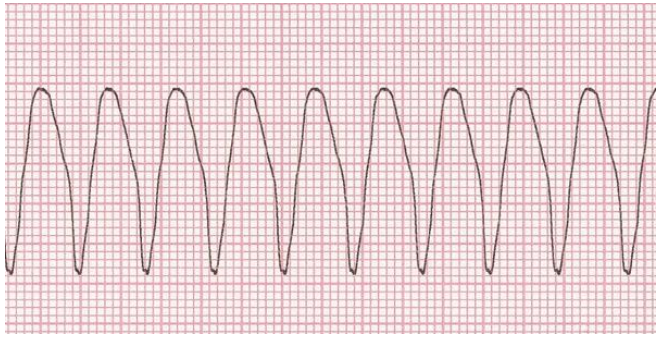


Rate = 40/min

Yes

Pulseless VT

Shockable

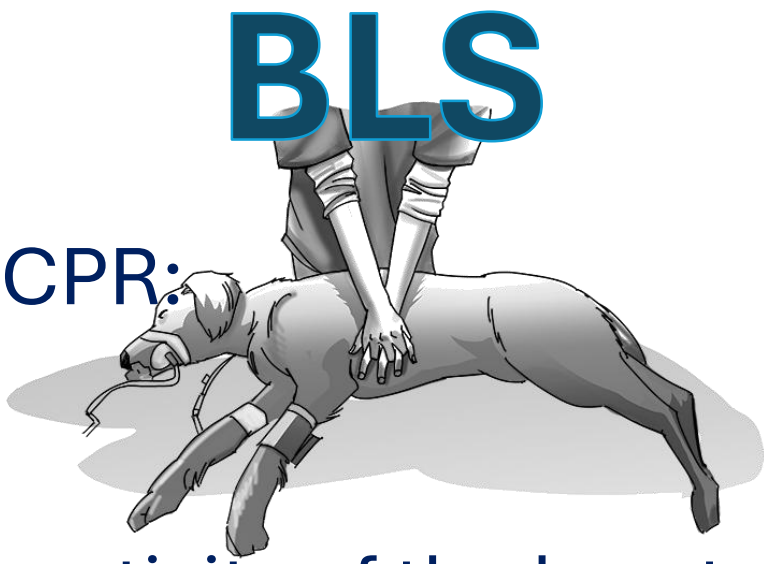


Rate = 216/min

Proposal for termination of resuscitation

1. Irreversible cause of CPA
2. Continued (>20 min?) poor efficacy of CPR:

   $EtCO_2$ < 10 mm Hg
3. Prolonged (>20 min?) lack of electrical activity of the heart
4. Never any, even intermittent signs of ROSC
5. Long (> 10 min?) no-flow time



How do the pet owners/family members affect CPR?

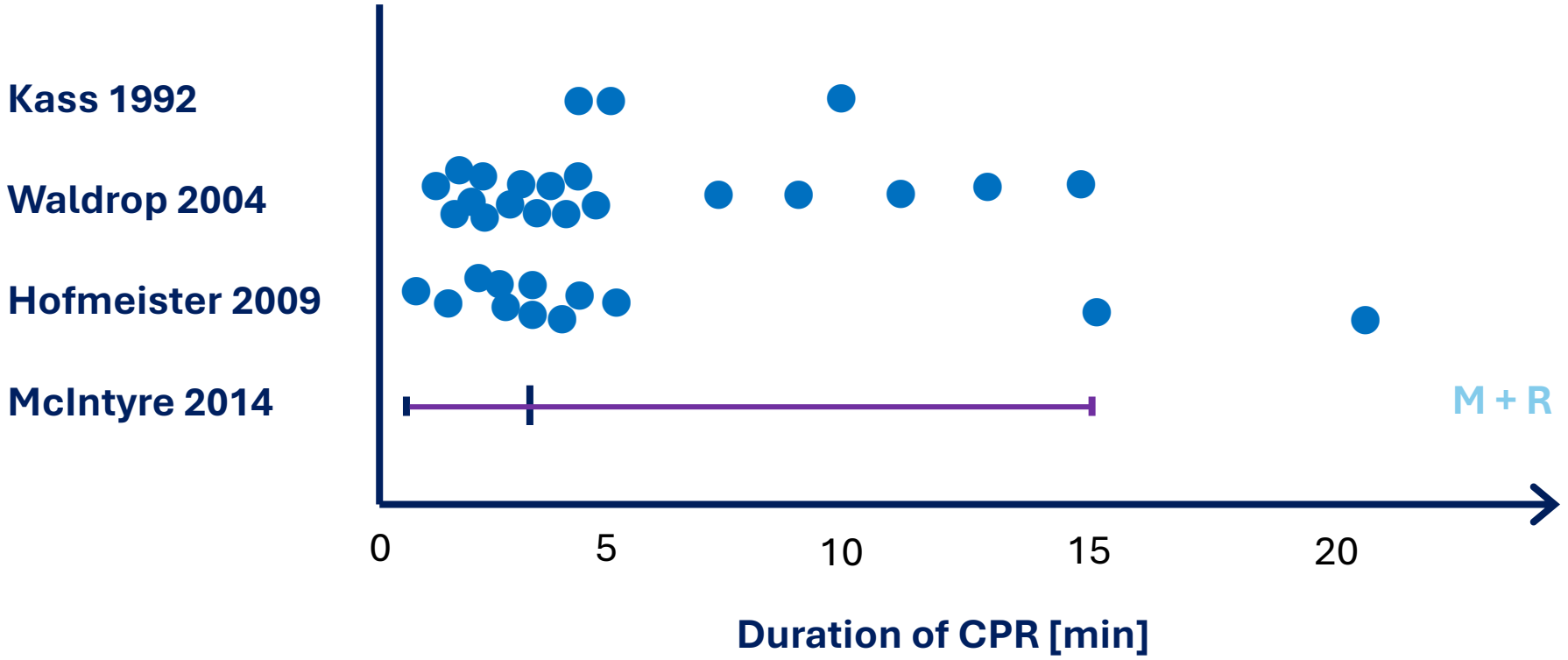
Nobody has responded yet.

Hang tight! Responses are coming in.

Duration of CPR and Survival Chance

7 studies report survivors
- Dogs: 44 dogs
- Cats: 13 cats

4 studies report CPR durations
- Dogs: 29 dogs
- Cats: 8 cats



If we never continue CPR longer than 15 minutes, we will never have data for greater than 15 mins

Go longer for the right patients

How long is too long?

Are there any differences in cat vs dog CPR?

Are interposed abdominal compression effective?


MEOWTROPOLITAN

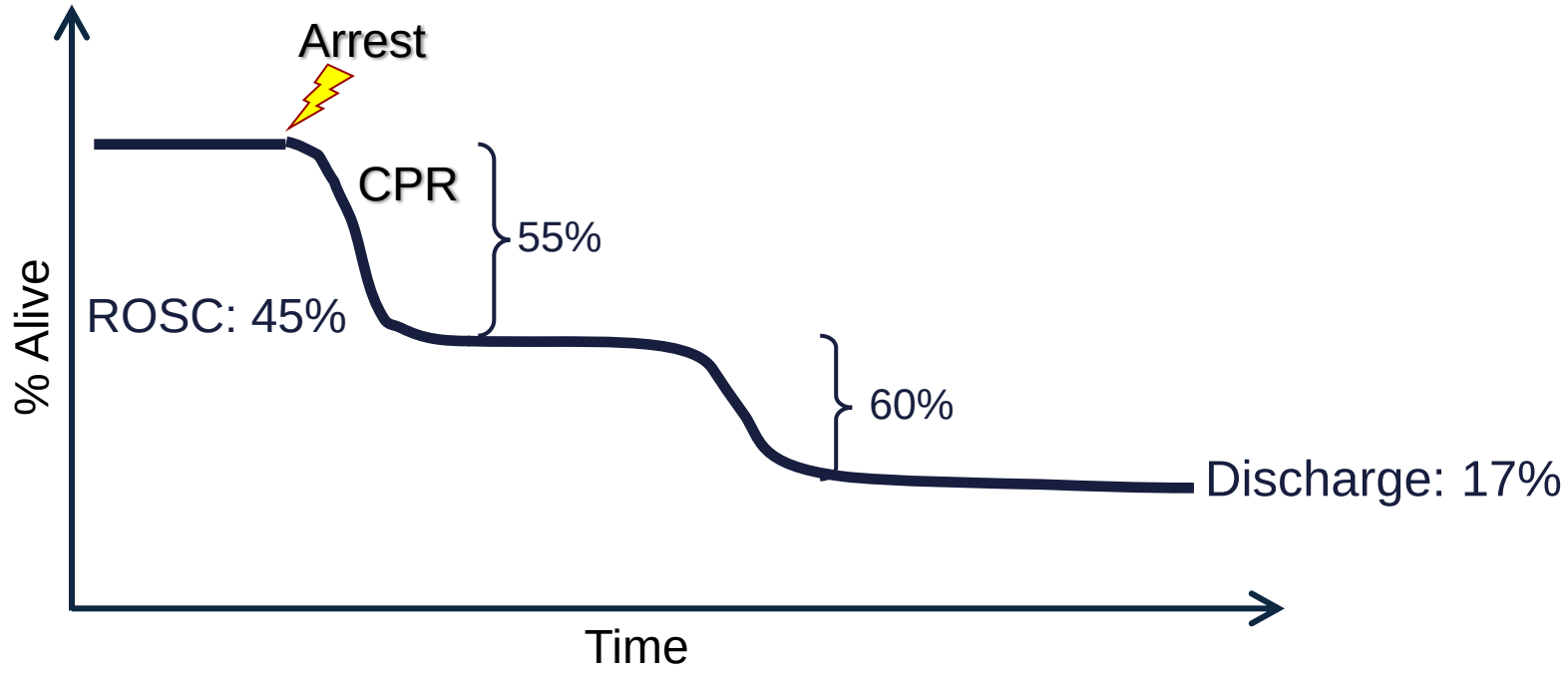
How is CPR different in cats when compared to dogs?

Nobody has responded yet.

Hang tight! Responses are coming in.

Cardiopulmonary Arrest Epidemiology

14,720 people with in-hospital CPA

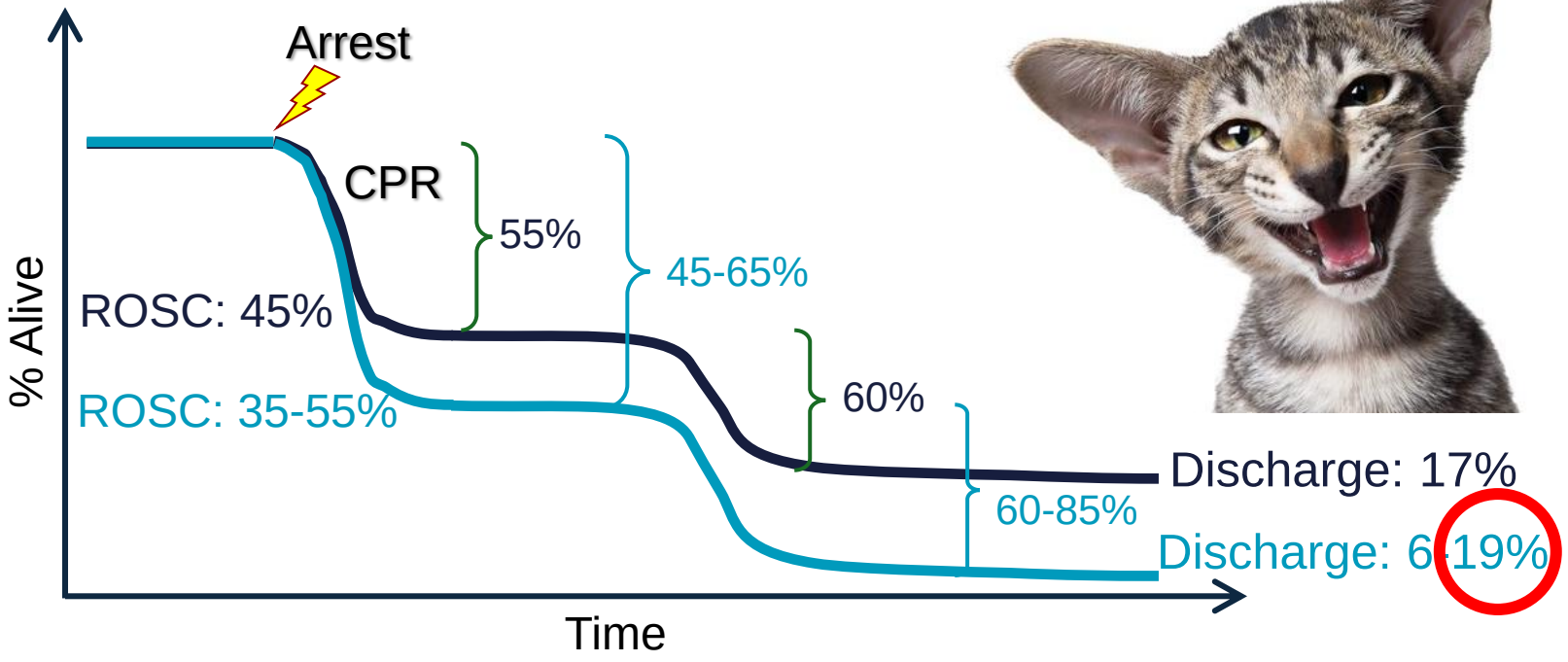


Peberdy et al., Resuscitation 2003
Hofmeister et al., JAVMA 2009
Hoehne et al., Frontiers, 2019

Cardiopulmonary Arrest Epidemiology

14,720 people with in-hospital CPA

333 dogs and 90 cats with in-hospital CPA

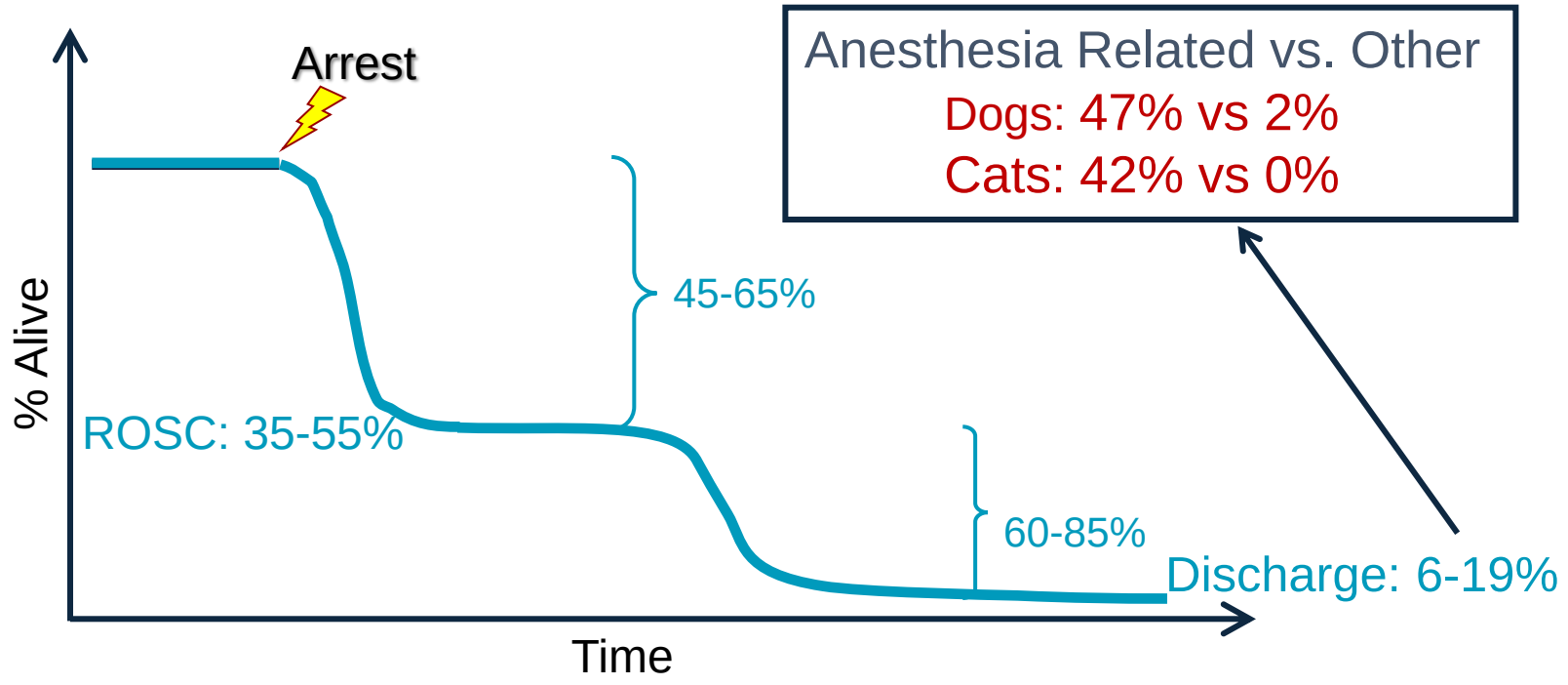


Peberdy et al., Resuscitation 2003
Hofmeister et al., JAVMA 2009
Hoehne et al., Frontiers, 2019

Cardiopulmonary Arrest Epidemiology

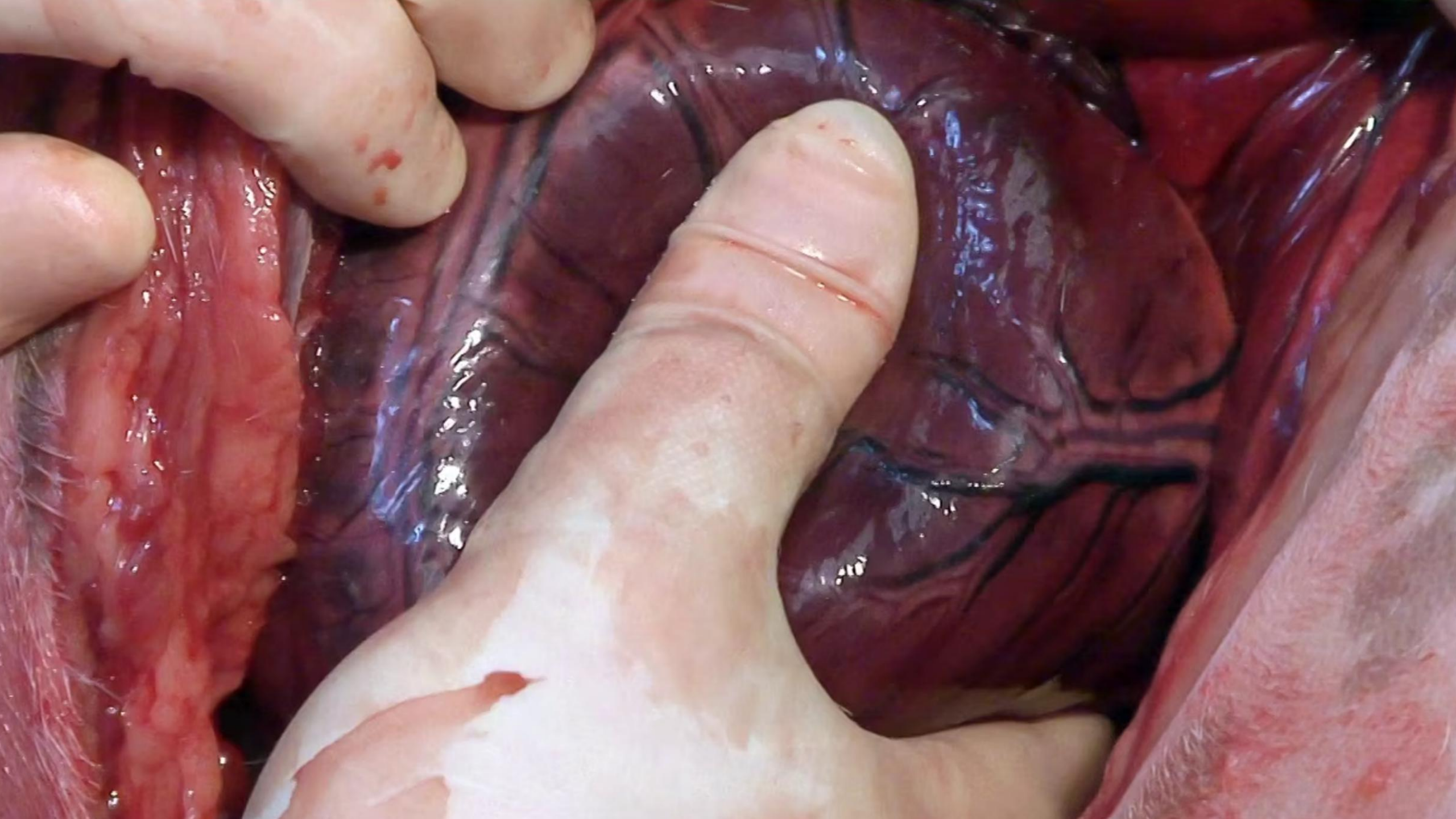
Anesthesia -> 14.82x more likely to survive
Cats -> 4.87x more likely to survive

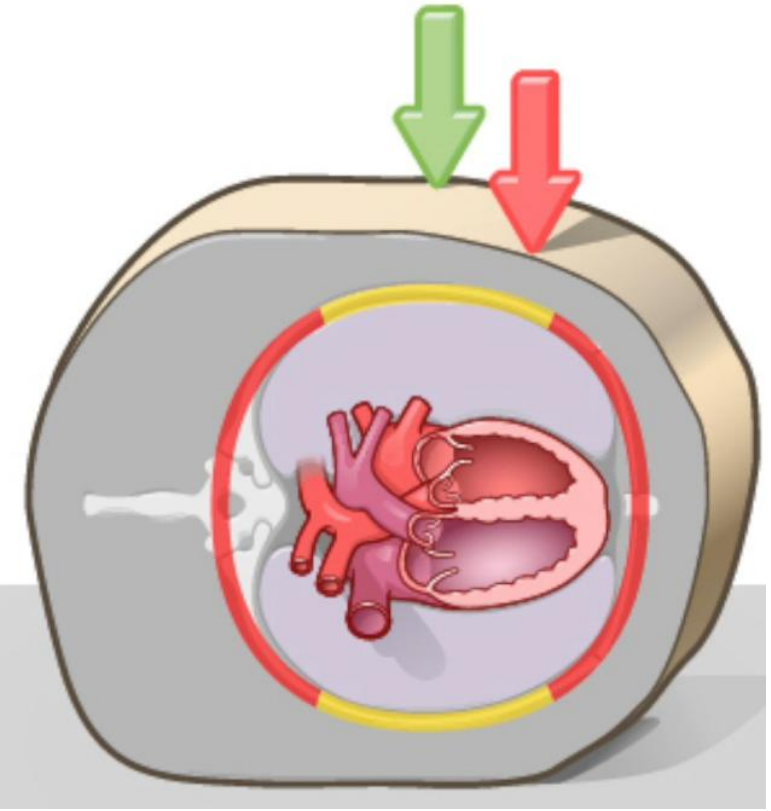
333 dogs and 90 cats with in-hospital CPA

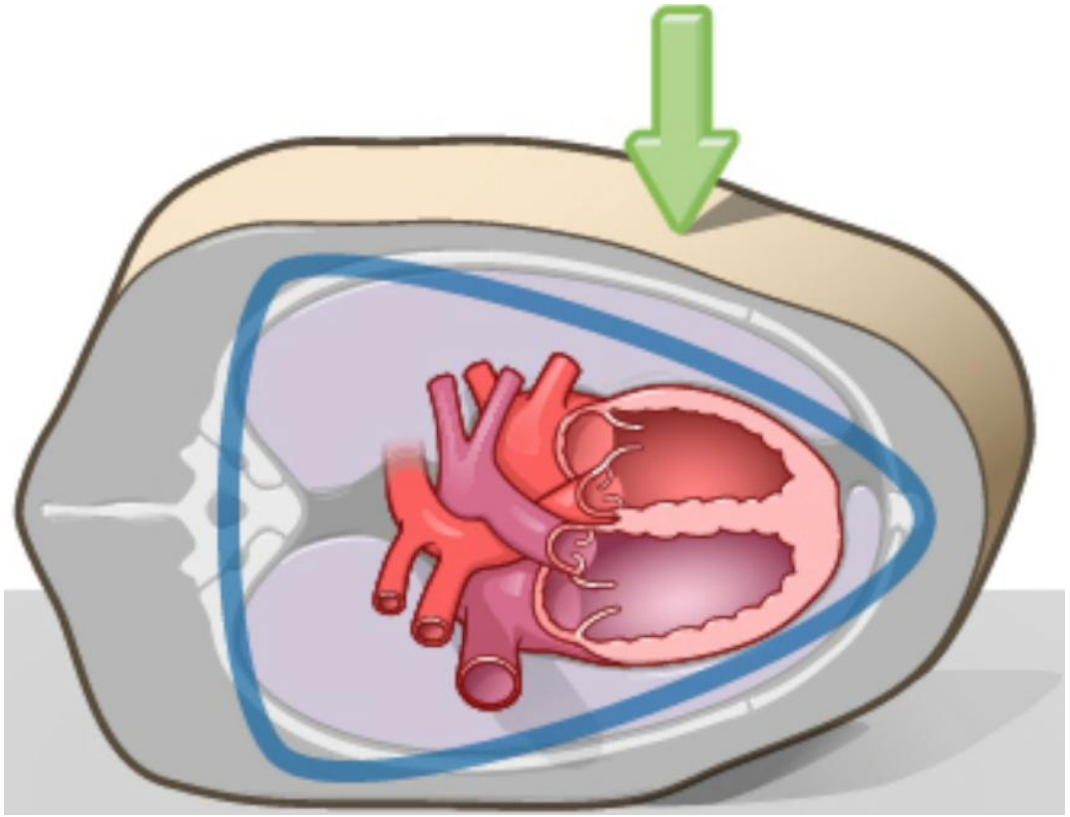


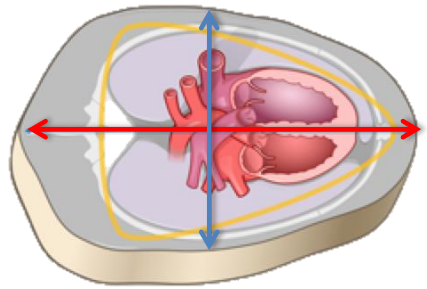
Peberdy et al., Resuscitation 2003
Hofmeister et al., JAVMA 2009
Hoehne et al., Frontiers, 2019

Best way to circulate blood?



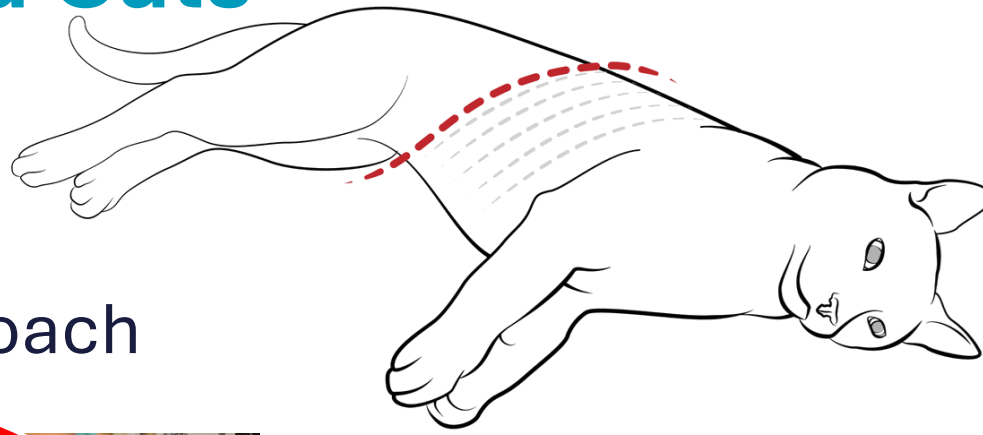






Cats and Small Dogs

Compressions in Small Dogs and Cats



- Hands directly over the heart
- Maximally employ the cardiac pump approach

Model created by:
https://jspbb.or.jp/

一般社団法人
日本ペットBLS防災学会
JAPAN SOCIETY OF PET BLS AND BOSAI


Model created by:
https://jspbb.or.jp/
一般社団法人
日本ペットBLS防災学会
JAPAN SOCIETY OF PET BLS AND BOSAI


Model created by:
https://jspbb.or.jp/
一般社団法人
日本ペットBLS防災学会
JAPAN SOCIETY OF PET BLS AND BOSAI

$ETCO_2$ Guidelines

- **Helps confirm endotracheal intubation (>12 mmHg)**
  - Visually confirm endotracheal intubation if <5 mmHg

- **Assess Compression Quality**
  - **Goal: $ETCO_2$ > 18 mmHg. If lower…**
    - Evaluate compression quality: Rate, depth, recoil / leaning, location, posture, etc.
    - Confirm correct ventilation: RR = 10 / min (6 seconds between breaths)
  - Especially feasible in cats where compressions are more likely to be effective

- **Indication of ROSC**
  - If $ETCO_2$ increases suddenly by ≥ 15 mmHg or value ≥ 35 mmHg
  - Don't stop compressions until you confirm the pulse!

ORIGINAL RESEARCH article

Front. Vet. Sci., 09 December 2019

Sec. Veterinary Emergency and Critical Care Medicine

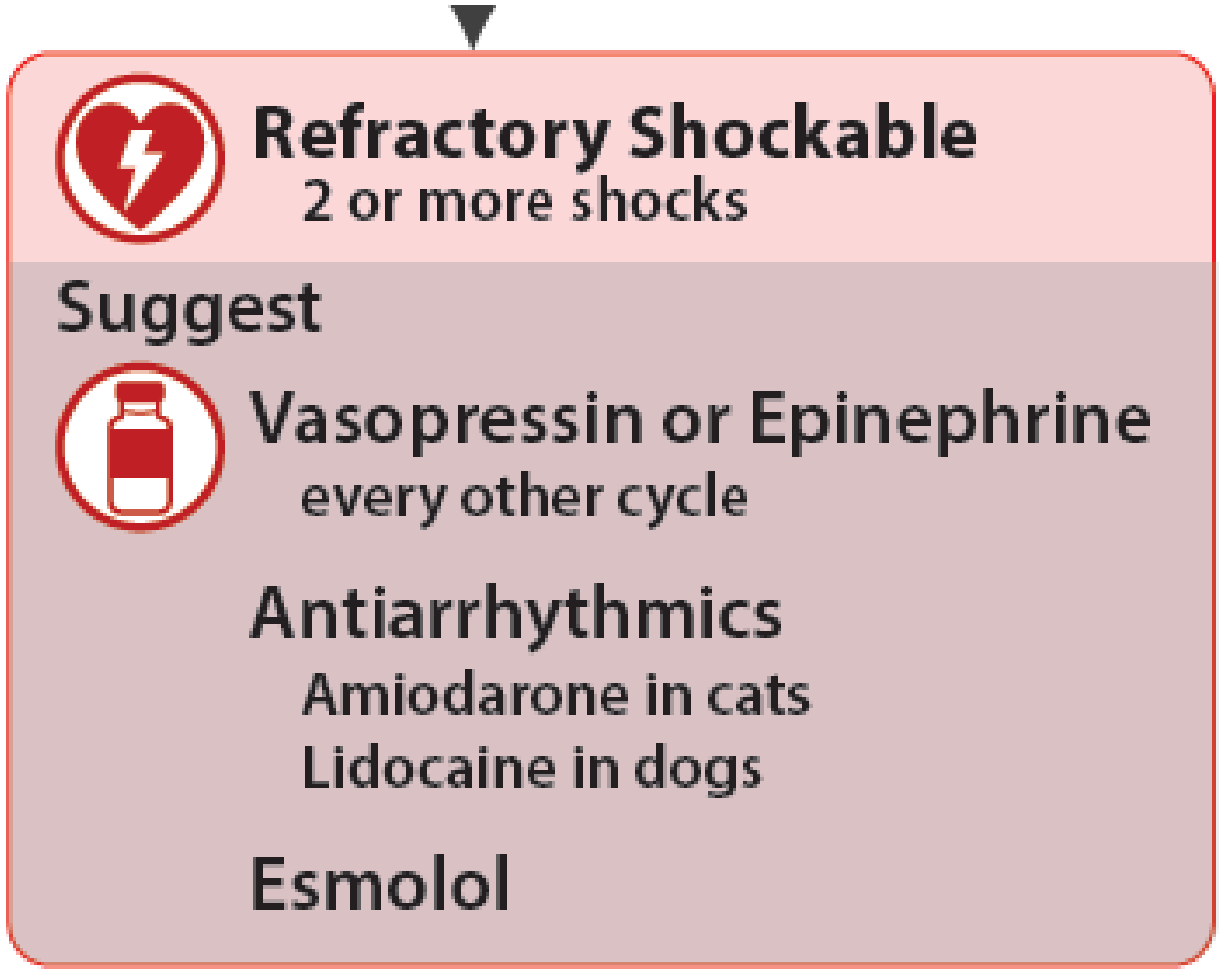
Volume 6 - 2019 | https://doi.org/10.3389/fvets.2019.00439

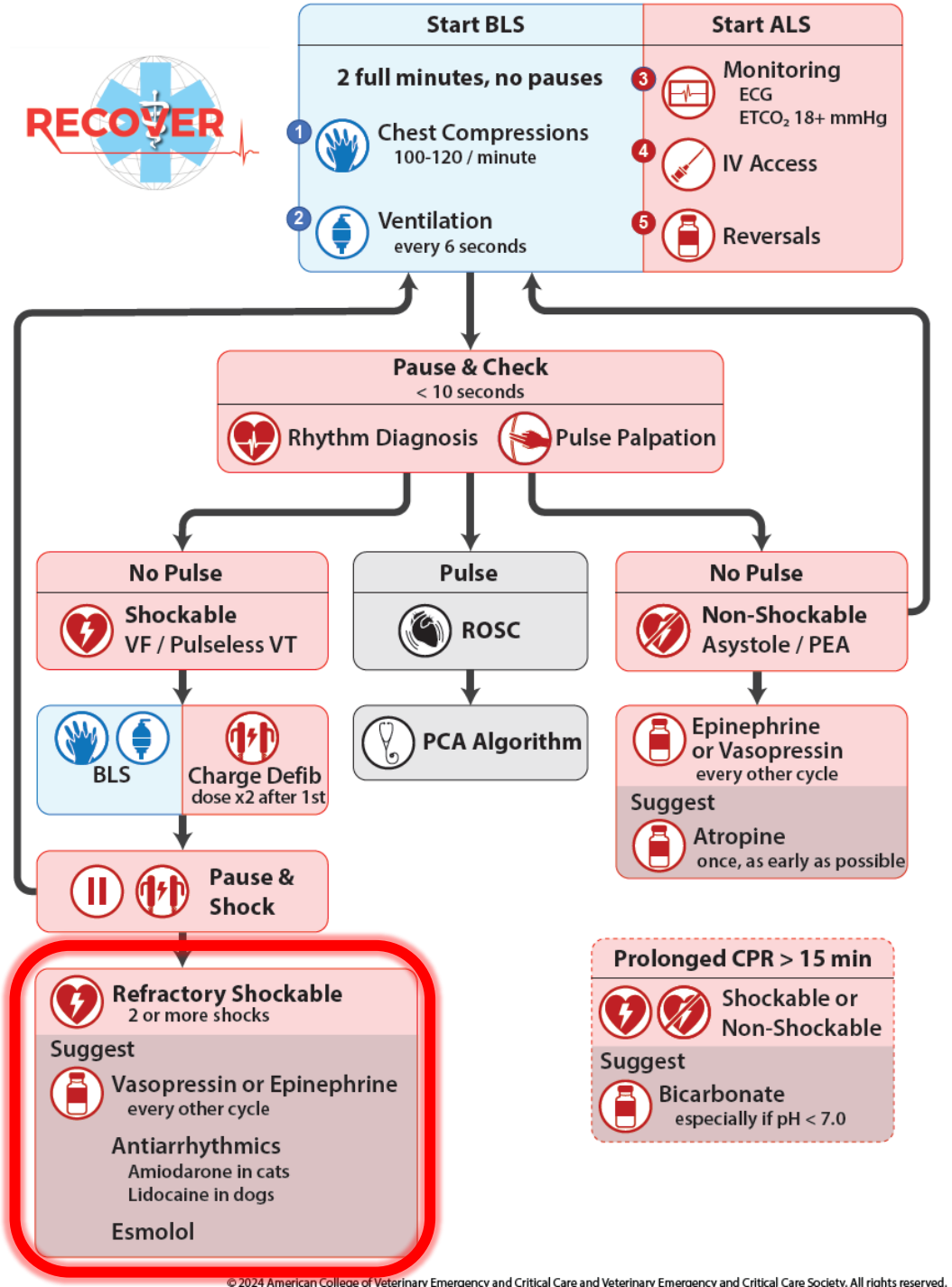
Prospective Evaluation of Cardiopulmonary Resuscitation Performed in Dogs and Cats According to the RECOVER Guidelines. Part 2: Patient Outcomes and CPR Practice Since Guideline Implementation

Sabrina N. Hoehne[1*†] Kate Hopper[2] Steven E. Epstein[2]

	Dogs	Cats
ROSC Rate	44%	55%
Survival Rate	7%	19%

ETCO2 as high as 23 mmHg


Refractory Shockable
2 or more shocks
Suggest
Vasopressin or Epinephrine
every other cycle
Antiarrhythmics
Amiodarone in cats
Lidocaine in dogs
Esmolol


RECOVER
Start BLS
2 full minutes, no pauses
1 Chest Compressions
100-120 / minute
2 Ventilation
every 6 seconds
Start ALS
3 Monitoring
ECG
ETCO2 18+ mmHg
4 IV Access
5 Reversals
Pause & Check
< 10 seconds
Rhythm Diagnosis
Pulse Palpation
No Pulse
Shockable
VF / Pulseless VT
Pulse
ROSC
No Pulse
Non-Shockable
Asystole / PEA
BLS
Charge Defib
dose x2 after 1st
PCA Algorithm
Epinephrine
or Vasopressin
every other cycle
Suggest
Atropine
once, as early as possible
Pause &
Shock
Refractory Shockable
2 or more shocks
Suggest
Vasopressin or Epinephrine
every other cycle
Antiarrhythmics
Amiodarone in cats
Lidocaine in dogs
Esmolol
Prolonged CPR > 15 min
Shockable or
Non-Shockable
Suggest
Bicarbonate
especially if pH < 7.0
© 2024 American College of Veterinary Emergency and Critical Care and Veterinary Emergency and Critical Care Society. All rights reserved.

Antiarrhythmics in Dogs

Amiodarone can contain Polysorbate 80

Hypotension
Bradycardia
AV blocks

Lidocaine is recommended

J Cardiovasc Pharmacol. 1982 May-Jun;4(3):375-80. doi: 10.1097/00005344-198205000-00006.

Hypotensive action of commercial intravenous amiodarone and polysorbate 80 in dogs

W B Gough, R H Zeiler, P Barreca, N El-Sherif

PMID: 6177932 DOI: 10.1097/00005344-198205000-00006

ACVIM American College of Veterinary Internal Medicine
JOURNAL OF VETERINARY INTERNAL MEDICINE Open Access

Open Access

Adverse Effects of Intravenous Amiodarone in 5 Dogs

R.E. Cober, K.E. Schober, N. Hildebrandt, E. Sikorska, S.C. Riesen

First published: 19 May 2009 | https://doi.org/10.1111/j.1939-1676.2009.0314.x | Citations: 19

Corresponding author: Dr Richard E. Cober, DVM, Department of Veterinary Clinical Sciences, College of Veterinary Medicine, The Ohio State University, 601 Vernon L. Tharp Street, Columbus, OH 43210; e-mail: cober.1@osu.edu.

Antiarrhythmics in Cats

Anesthesiology
63:385–390, 1985

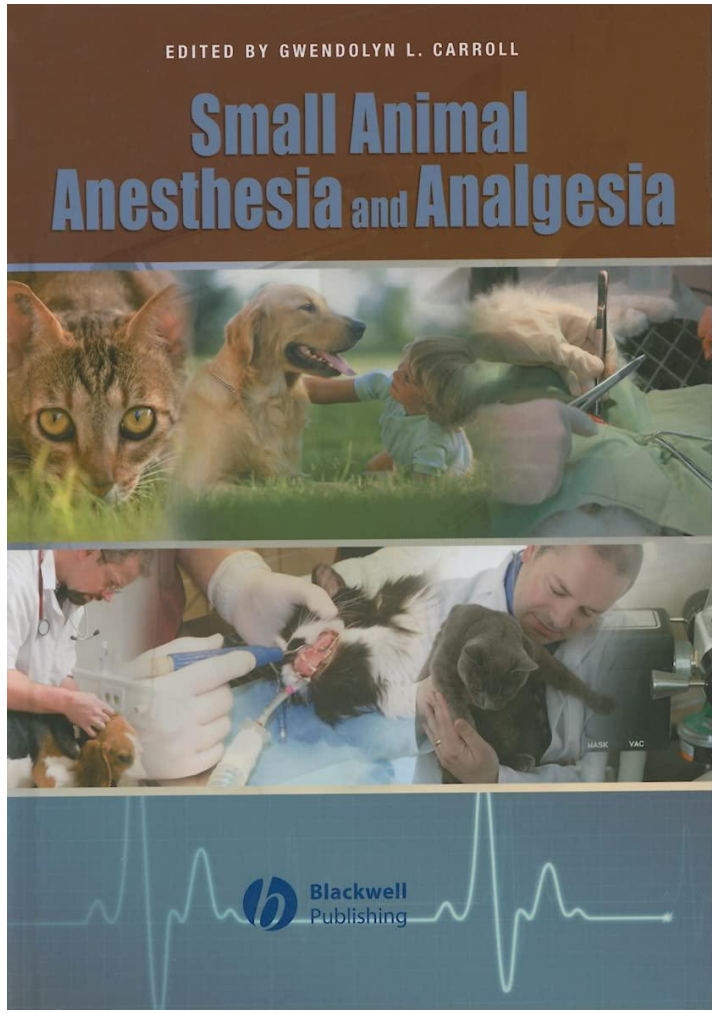
Toxicity and Resuscitation in Lidocaine- or Bupivacaine-infused Cats

H. S. Chadwick, M.D.*

CNS toxicosis with Lidocaine
- Twitching
- Weakness of muscles
- Drowsiness
- Seizures
- Coma (severe)

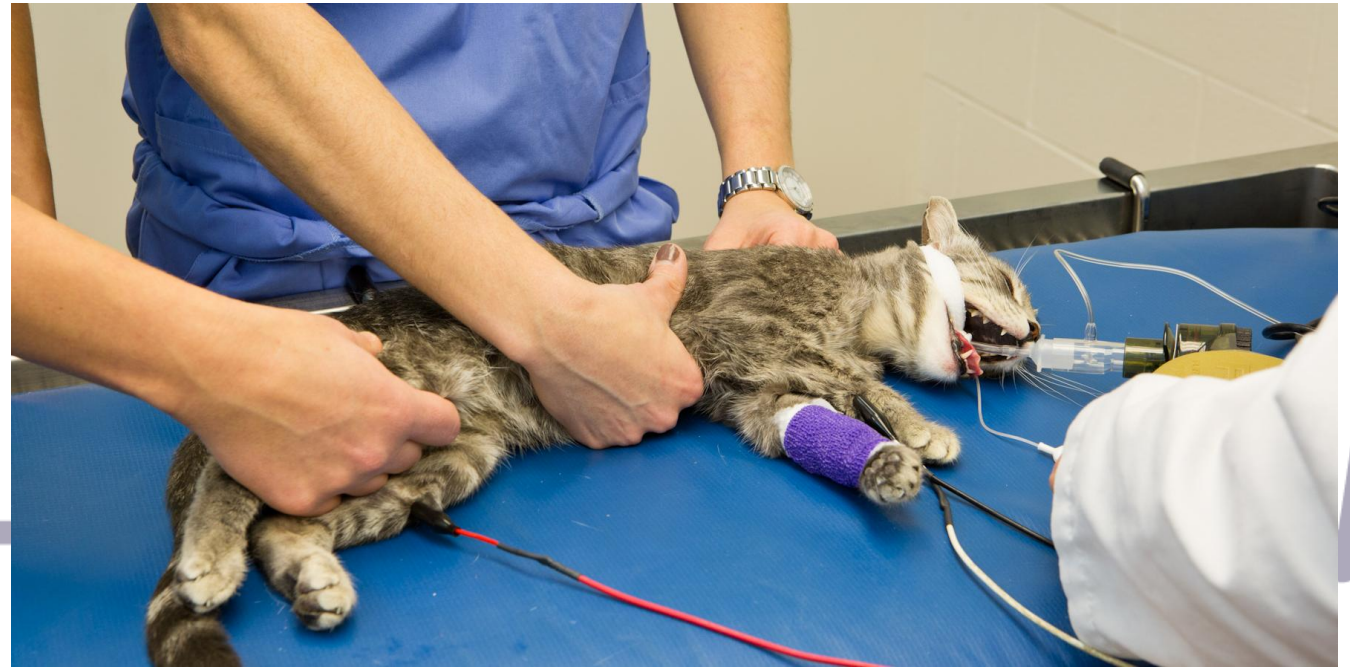
~6mg/kg

Reduced glucuronidation capacity of the liver



Feline Specific Updates

- Higher EtCO2 target more realistic in cats, where compression might be more effective in generating blood flow
- Do not overcompress. 2-handed approach is risky.
- Arrhythmia Management away from lidocaine, instead use amiodarone
- Open chest less of a consideration for ineffective closed chest compressions alone, while it is a higher level early consideration in dogs

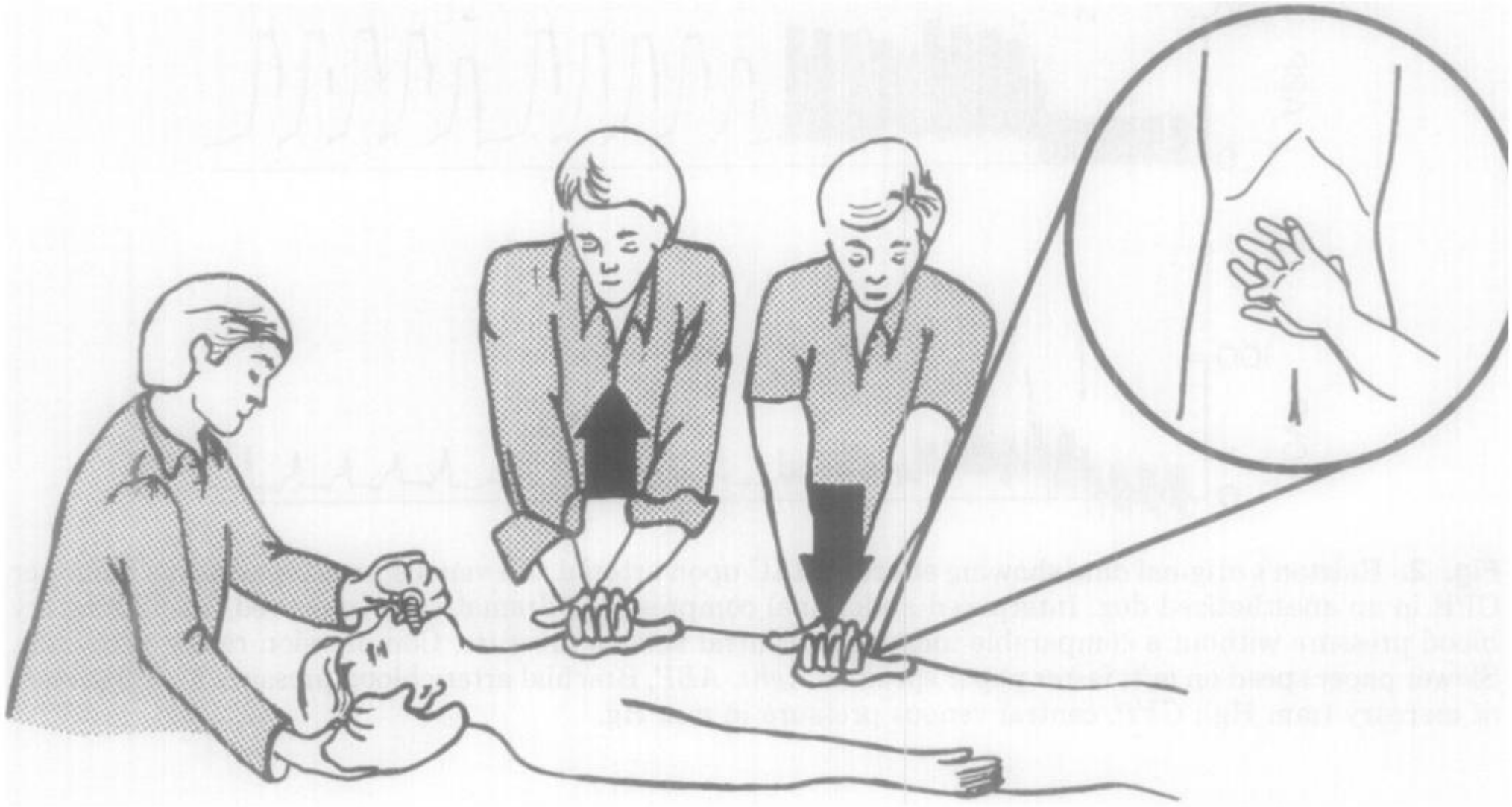


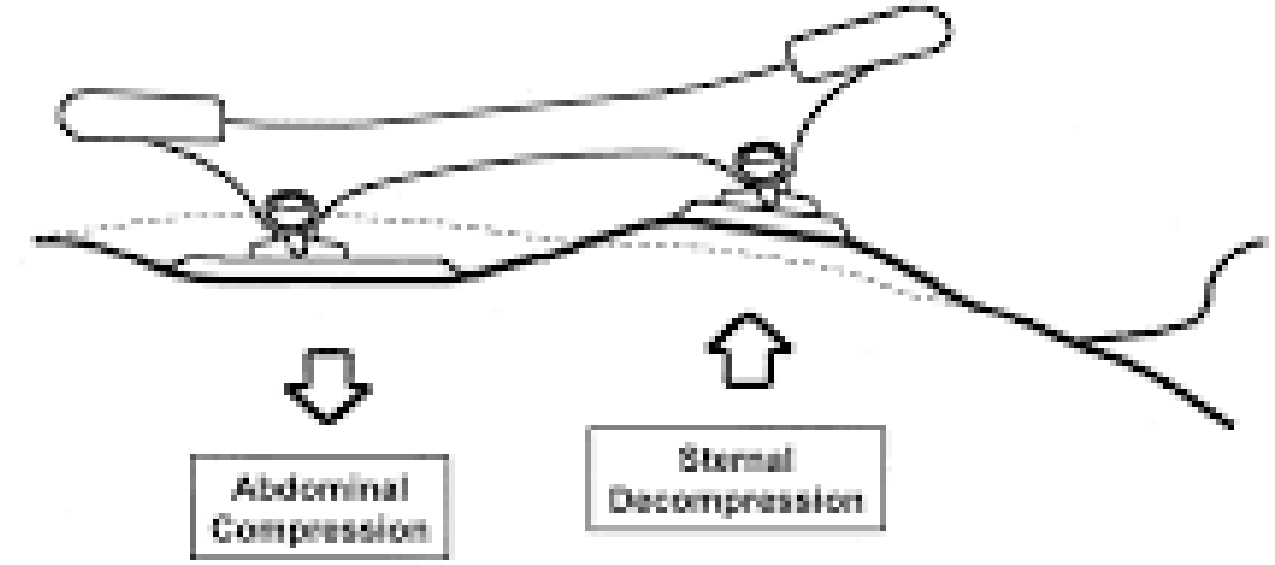
How long is too long?

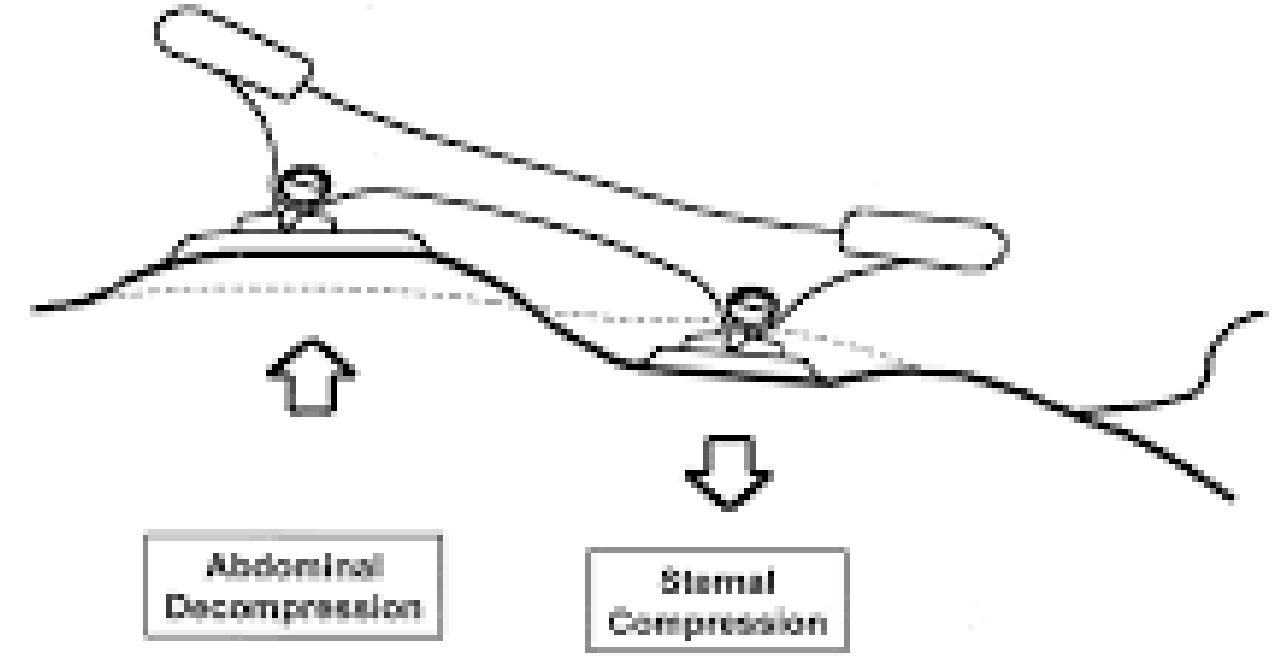
Are there any differences in cat vs dog CPR?

Are interposed abdominal compression effective?

Interposed Abdominal Compressions




Abdominal Compression
Sternal Decompression

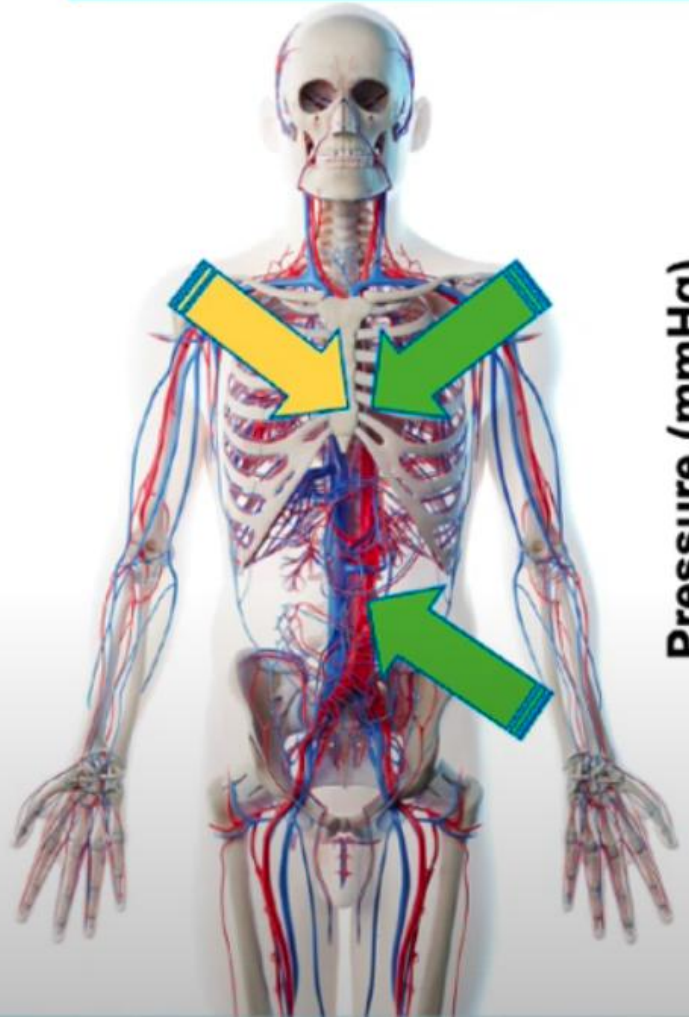

Abdominal Decompression
Sternal Compression

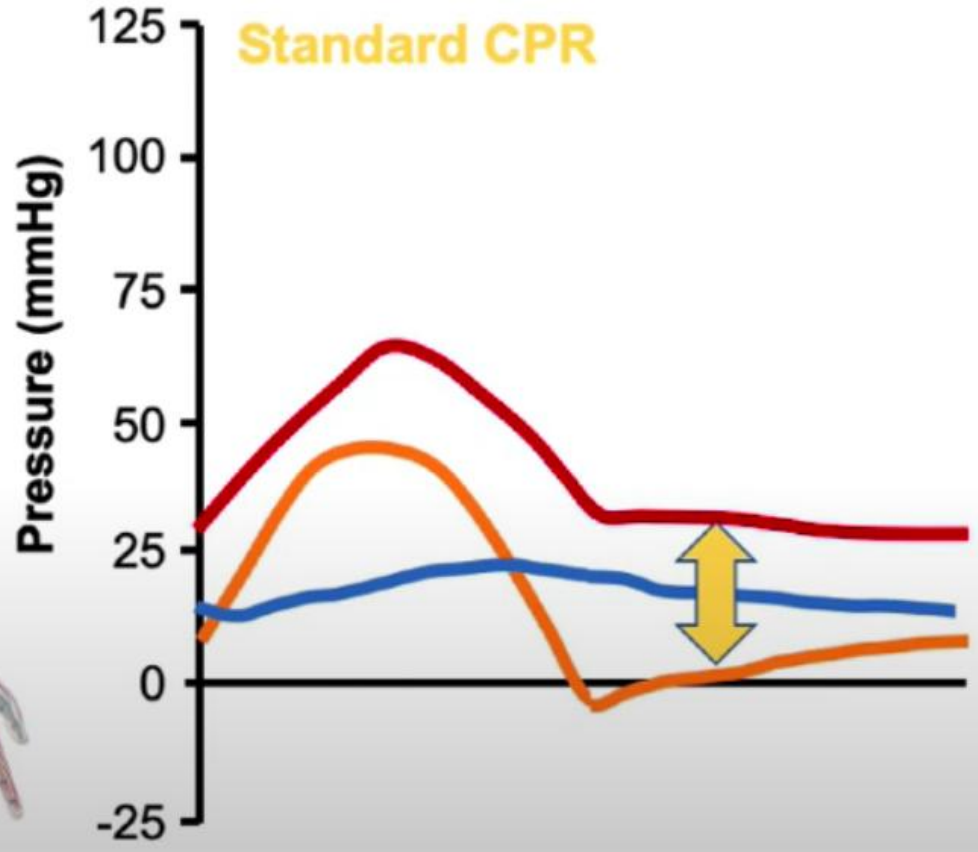
$$CoPP = P_{ao\text{-}D} - P_{RA\text{-}D}$$

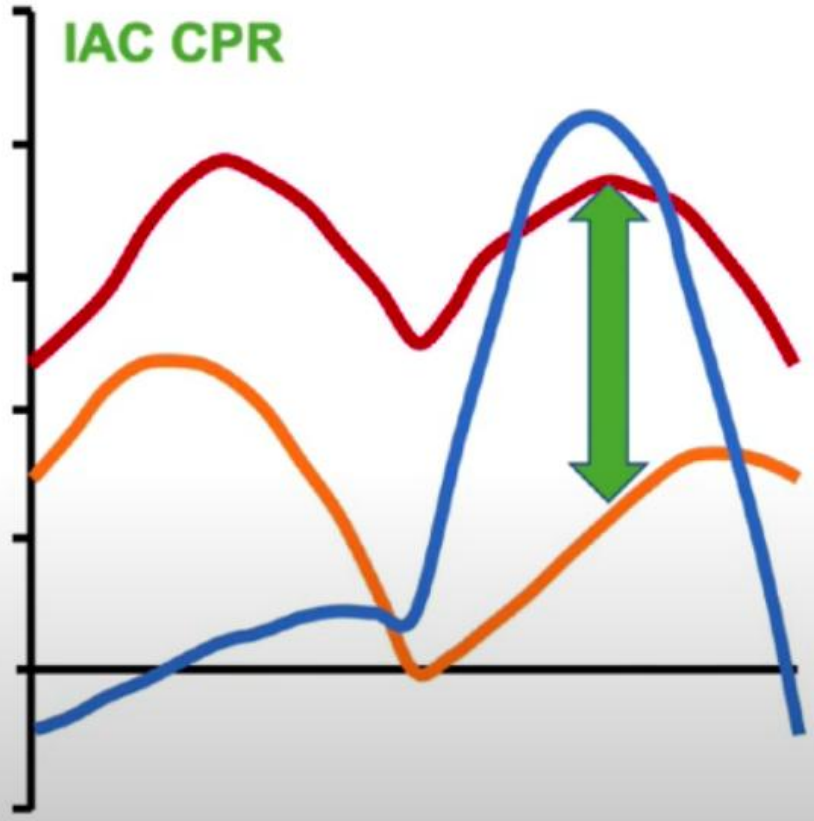
Aortic Pressure

Right Heart Pressure

CVC Pressure





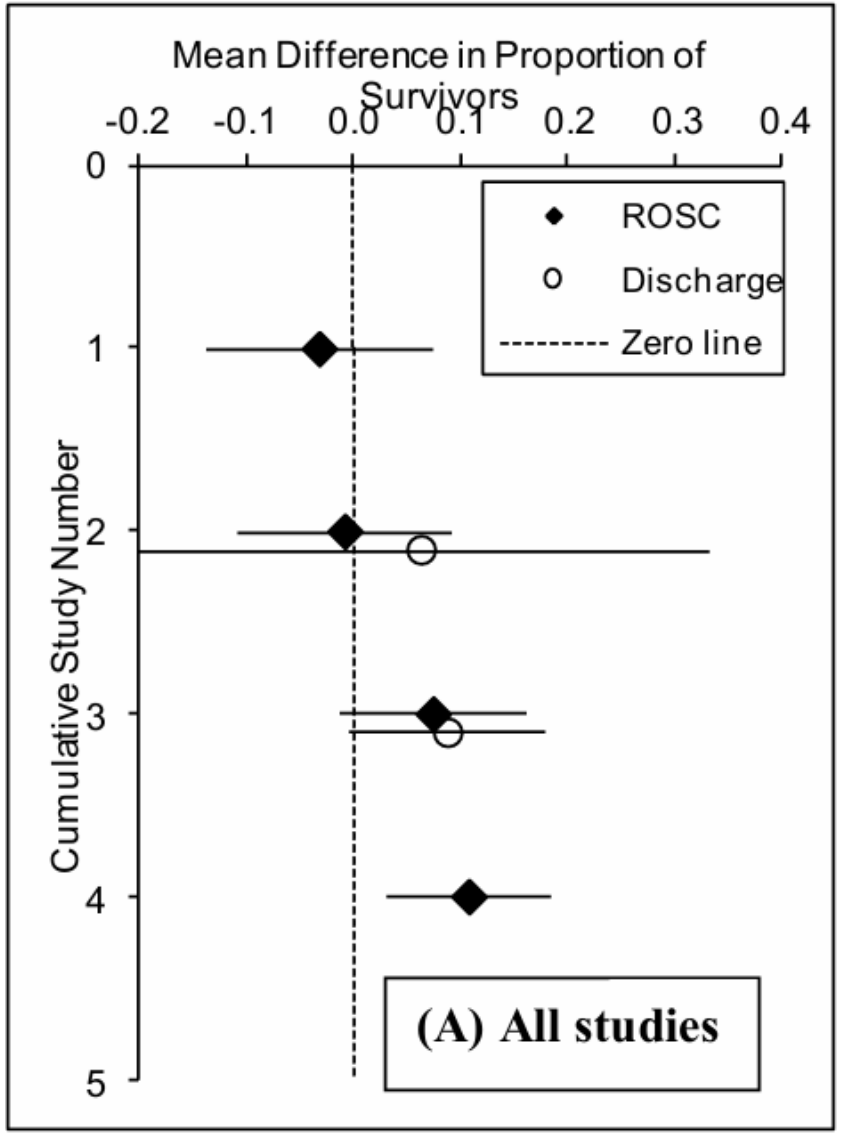


2003

Interposed Abdominal Compression CPR: A Comprehensive Evidence Based Review

Charles F. Babbs
Purdue University, babbs@purdue.edu

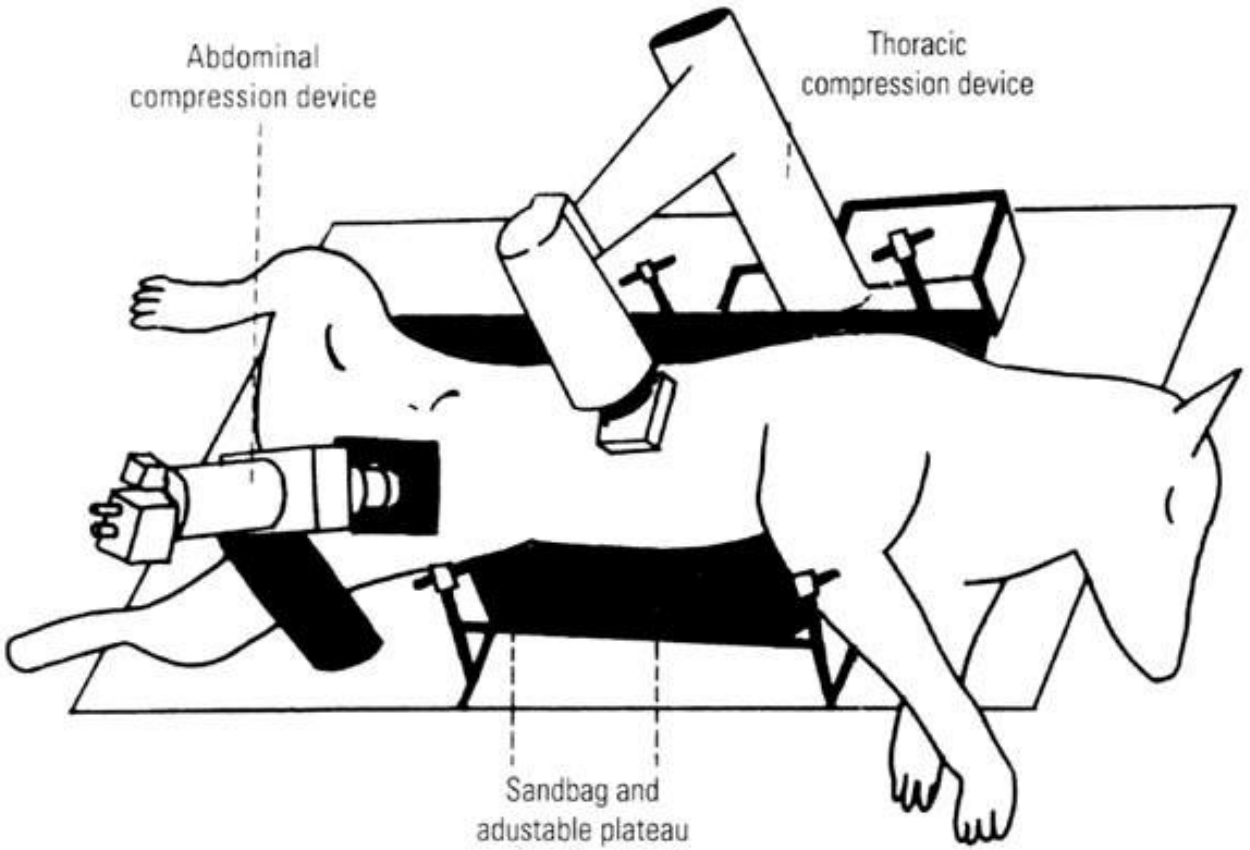
Outcome Measure	Studies	IAC-CPR	Standard CPR
Return of spontaneous circulation (ROSC) in or out-of-hospital	Mateer[53]	40/145 (28%)	45/146 (31%)
	Ward[33]	6/16 (38%)	3/17 (18%)
	Sack #1[1]	29/48 (60%)	14/55 (25%)
	Sack#2[41]	33/67 (49%)	21/76 (28%)
	All 4 studies	108/276 (39%)	83/294 (28%)
Return of spontaneous circulation (ROSC) after in-hospital resuscitation	Ward[33]	6/16 (38%)	3/17 (18%)
	Sack #1[1]	29/48 (60%)	14/55 (25%)
	Sack#2[41]	33/67 (49%)	21/76 (28%)
	All 3 studies	68/131 (52%)	38/148 (26%)
Survival to discharge, neurologically intact after in-hospital resuscitation	Ward[33]	1/16 (6%)	0/17 (0%)
	Sack #1[1]	8/48 (17%)	3/55 (5%)
	Both studies	9/64 (14%)	3/72 (4%)



ROSC p <0.05

Survival showed an upward trend

Demonstration



A pneumatic device performs abdominal compressions interposed between thoracic one.

How Much Pressure?

Fill to about 10mmHg

Compress to 100mmHg

Is It Worth Doing it?

IAC can improve blood flow and outcome

Lateral abdominal compressions unhelpful

Use a BP cuff and sphygmomanometer to monitor

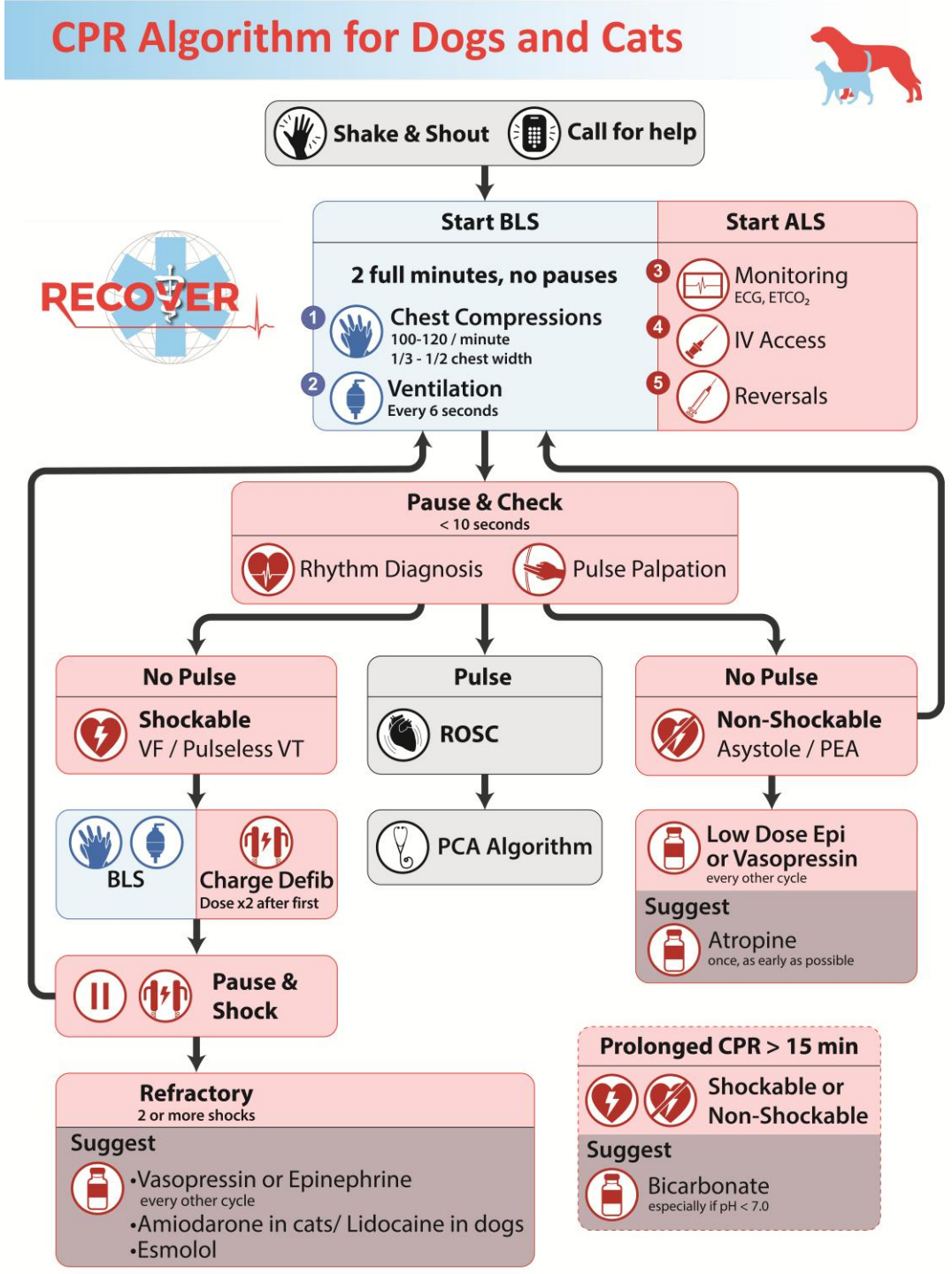
Requires practice and coordination

Do not compromise compression rate

Reassessment Campaign on Veterinary Resuscitation

Updates to Guidelines

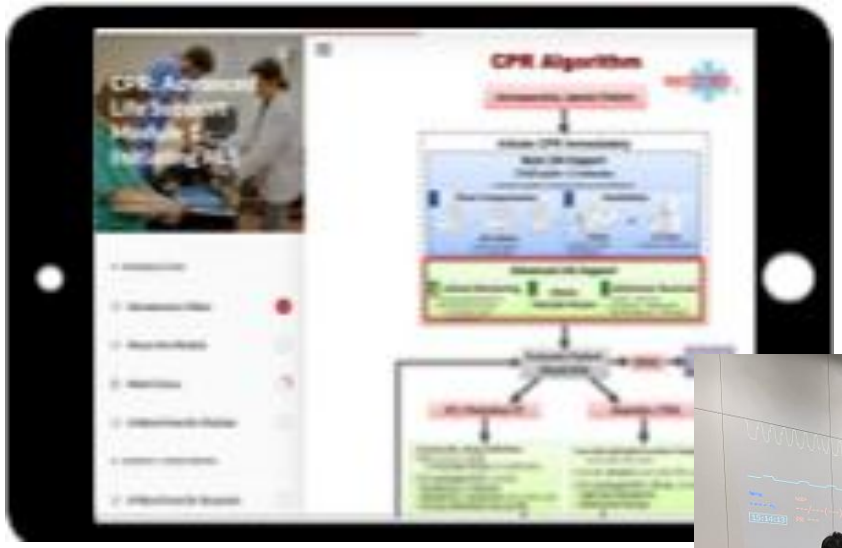
- Cognitive Aid algorithm design
- 3 Compression techniques for small patients
- Shallower compression goal (25%) in dorsal recumbency
- Face mask+O_2 over mouth-to-nose when possible
- $ETCO_2$ goal ≥ 18 mmHg
- OK to stop mid-cycle if $ETCO_2$ ≥ 35 mmHg w/pulse
- **No high dose epinephrine**
- Atropine? If yes, once early & no more
- 2x defib dose on 2nd shock & stay there
- 2+ shocks and still shockable?
  - Suggest vasopressor
  - Suggest anti-arrhythmic
  - Suggest esmolol



CPR Training

https://recoverinitiative.org

1. Online BLS and ALS
   - ACVECC certification
   - Endorsed by VECCS
   - 6 hours of RACE approved CE
2. In-person CPR Rescuer certification



RECOVER CERTIFIED BLS RESCUER

RECOVER CERTIFIED ALS RESCUER


RECOVER
Basic Life Support Skills Lab and Certification

Questions?

Kenichiro Yagi, MS, RVT, VTS (ECC) (SAIM)

Email: kenyagirvt@gmail.com