

WORKSHEET for Evidence-Based Review of Science for Veterinary CPR

1. Basic Demographics

Worksheet author(s)

Elizabeth Rozanski	Date Submitted for review: 8/9/11

2. Clinical question:

In dogs and cats with cardiac arrest under anesthesia (P), do anesthesia-specific CPR recommendations (I), compared to no such recommendations (standard CPR) (C) result in improved outcomes (survival or ROSC)(O)?

3. Conflict of interest specific to this question:

Do any of the authors listed above have conflict of interest disclosures relevant to this worksheet?
No conflict of interest to report

4. Search strategy (including electronic databases searched):

The search strategy includes PUB MED search primarily, with secondary sources including CAB abstracts, and Google. The goal was to cover the published veterinary and human literature

4a. Databases

-MEDLINE via PUBMED (1950 to Jun 2011)
1. CPR and
2. during anesthesia 827 hits ~ 20 relevant
Repeated with Cardiac arrest and resuscitation, no new relevant hits
-CAB (1910 to June 2011)
Repeated with veterinary 82 hits, ~ 10 relevant

4b. Other sources

-GOOGLE SCHOLAR (performed on July 20, 2011)
Report as for Medline

4c. State inclusion and exclusion criteria for choosing studies and list number of studies excluded per criterion

Inclusion criteria

Studies with objective evaluation of anesthesia associated specific guidelines
Studies in animals with evaluation of anesthesia specific guidelines
Clinical reports in animals that include animals that have undergone CPR while under anesthesia

Exclusion criteria

Studies that only were opinion-based, largely review or vague as to the role of anesthesia.

4d. Number of articles/sources meeting criteria for further review:

~ see reference session for particularly useful articles.

5. Summary of evidence

**Evidence Supporting Clinical Question
(Having anesthesia –specific guidelines is associated
with better outcome in CPR)**

Good		Hofmeister 2009, ABC, retrospective veterinary study with improved outcome for those that arrested under anesthesia	Waldrop 2004 ABC, over half of longterm veterinary CPR survivors had arrest associated with anesthesia			<i>Williams 2007 E nor using halothane is better, most anesthetic arrests are preventable; gobbo-braz 2006 E, most pediatric arrests can be prevented with better attention to airway management</i>
Fair						<i>Williams 2010 E. Ketamine is associated with less arrest than other agents in children with Pulmonary hypertension; Garvey 2011 B epi is warranted in unexplained cardiac arrest due to suspected anaphylaxis</i>
Poor						<i>Litz 2006 abc, case report of human treated with lipid rescue</i>
	1	2	3	4	5	6
Level of evidence (P)						

A = Return of spontaneous circulation
B = Survival of event

C = Survival to hospital discharge
D = Intact neurological survival

E = Other endpoint
Italics = Non-target species studies

**Evidence Neutral to Clinical question
(Anesthetic specific guideline are neither helpful nor harmful)**

Good						
Fair						
Poor						
	1	2	3	4	5	6
Level of evidence (P)						

A = Return of spontaneous circulation
B = Survival of event

C = Survival to hospital discharge
D = Intact neurological survival

E = Other endpoint
Italics = Non-target species studies

**Evidence Opposing Clinical Question
(Having anesthesia –specific guidelines is NOT associated with better outcome in CPR)**

Good						<i>Mayr 2008 A, epi and vasopressin better than lipid in hypoxemic bupivacaine arrests in a swine model; Mauch 2011A epi is better than lipid for local anesthetic</i>
Fair						<i>Bushey 2011 A Lipid does not improve survival in a swine model of bupivacaine and hypoxemia; Harvey 2009 a,e Lipid is not helpful in hypoxic rabbits.</i>
Poor						

	1	2	3	4	5	6
Level of evidence (P)						

A = Return of spontaneous circulation
 B = Survival of event

C = Survival to hospital discharge
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E = Other endpoint
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DRAFT

6. REVIEWER'S FINAL COMMENTS AND ASSESSMENT OF BENEFIT / RISK:

In this worksheet, it has been reasonably well established that dogs and cats that arrest during anesthesia and are resuscitated have a much better chance of ROSC and discharge than arrests that occur at another time point. It is considered more likely beneficial to attempt resuscitation in a patient that is under anesthesia when the arrest occurs. In human medicine, resuscitation during anesthesia is considered the norm, and even in high risk anesthetic procedures, aggressive CPR is pursued, typically with a good outcome. Anesthetized patients typically are closely monitored, have IV access and may be intubated. Thus, it is of benefit to actively resuscitate an animal that arrests under anesthesia. No evidence was found for a specific approach, other than clear commonsense recommendation to stop inhalant gases, and to provide support. The one area of possible conflict is the use of lipid rescue in patients with presumptive local anesthetic overdose. This is a much bigger area of research in people due to the increased likelihood of procedures being performed using local and regional blocks. However, the current recommendation is that if the arrest seems clearly linked with a local anesthetic, lipid rescue should be considered.

7. Conclusion

DISCLAIMER: Potential possible wording for a Consensus on Science Statement. Final wording will differ due to other input and discussion.

Cardiopulmonary arrest that occurs under anesthesia should be aggressively treated and is associated with a reasonable chance of survival in cats and dogs. If the arrest is temporally associated with local anesthetic, or other lipophilic drug (diltiazem etc), then lipid rescue (1.5 ml/kg IV bolus) should be considered in addition to other supportive efforts. Lipid administration should not be routinely used in CPR. See RECOVER question on narcotic depression relative to use of naloxone.

8. Acknowledgement

The recover team.

9. Citation list

Veterinary specific

[J Am Vet Med Assoc](#). 2009 Jul 1;235(1):50-7.

Prognostic indicators for dogs and cats with cardiopulmonary arrest treated by cardiopulmonary cerebral resuscitation at a university teaching hospital.

Hofmeister EH, Brainard BM, Egger CM, Kang S.

Abstract

OBJECTIVE:

To determine the association among signalment, health status, other clinical variables, and treatments and events during cardiopulmonary cerebral resuscitation (CPCR) with the return of spontaneous circulation (ROSC) for animals with cardiopulmonary arrest (CPA) in a veterinary teaching hospital.

DESIGN:

Cross-sectional study.

ANIMALS:

161 dogs and 43 cats with CPA.

PROCEDURES:

Data were gathered during a 60-month period on animals that had CPA and underwent CPCR. Logistic regression was used to evaluate effects of multiple predictors for ROSC.

RESULTS:

56 (35%) dogs and 19 (44%) cats had successful CPCR. Twelve (6%) animals (9 dogs and 3 cats) were discharged from the hospital. Successfully resuscitated dogs were significantly more likely to have been treated with mannitol, lidocaine, fluids, dopamine, corticosteroids, or vasopressin; had CPA while anesthetized; received chest compressions while positioned in lateral recumbency; and had a suspected cause of CPA other than hemorrhage or anemia, shock, hypoxemia, multiple organ dysfunction syndrome, cerebral trauma, malignant arrhythmia, or an anaphylactoid reaction and were less likely to have been treated with multiple doses of epinephrine,

had a longer duration of CPA, or had multiple disease conditions, compared with findings in dogs that were not successfully resuscitated. Successfully resuscitated cats were significantly more likely to have had more people participate in CPR and less likely to have had shock as the suspected cause of CPA, compared with findings in cats that were not successfully resuscitated.

CONCLUSIONS AND CLINICAL RELEVANCE:

The prognosis was grave for animals with CPA, except for those that had CPA while anesthetized.

Waldrop J et al. Causes of cardiopulmonary arrest, resuscitation management, and functional outcome in dogs and cats surviving cardiopulmonary arrest. JVECC 2004 14(1) 22-29

Abstract

Objective: To describe the functional outcome of canine and feline survivors of cardiopulmonary arrest (CPA) and the clinical characteristics surrounding their resuscitation.

Design: Retrospective study.

Setting: Veterinary teaching hospital.

Animals: Client-owned dogs (15) and cats (3) with CPA.

Interventions: None.

Measurements and main results: Eighteen animals were identified to have survived to discharge following CPA. Cardiopulmonary arrest was associated with anesthesia with or without pre-existing disease in 10 animals, cardiovascular collapse in 5 animals, and chronic disease with an imposed stress in 3 animals. All CPAs were witnessed in the hospital. The most common initial rhythm at CPA was asystole (72%). Return of spontaneous circulation (ROSC) was achieved in less than 15 minutes from the onset of cardiopulmonary cerebral resuscitation (CPCR) in all animals. No animals had a recurrence of CPA after the initial CPA. Animals were of a wide range of ages (0.5–16 years) and breeds. Two animals were neurologically abnormal at discharge, one of which was normal at 2 months following CPA.

Conclusions: A good functional recovery after CPCR was documented in the small number of CPA survivors presented in this study. This may be due to the reversible nature of their inciting cause of CPA, early detections of CPA ('witnessed'), and/or the animal's underlying normal health status.

Case reports in people

[Anaesthesia](#). 2006 Aug;61(8):800-1.

Successful resuscitation of a patient with ropivacaine-induced asystole after axillary plexus block using lipid infusion.

[Litz RJ](#), [Popp M](#), [Stehr SN](#), [Koch T](#).

Source

Department of Anaesthesiology and Intensive Care Medicine, Fetscher Str. 74, University Hospital Dresden, 01307 Dresden, Germany. rainer.litz@uniklinikum-dresden.de

Abstract

Ropivacaine 1% 40 ml was mistakenly injected as part of an axillary plexus block in an 84-year-old woman. After 15 min the patient complained of dizziness and drowsiness and developed a generalised tonic-clonic seizure followed by an asystolic cardiac arrest. After 10 min of unsuccessful **cardiopulmonary resuscitation**, a bolus of 100 ml of Intralipid 20% (2 ml.kg(-1)) was administered followed by a continuous infusion of 10 ml.min(-1). After a total dose of 200 ml of Intralipid 20% had been given spontaneous electrical activity and cardiac output was restored. The patient recovered completely. We believe the cardiovascular collapse was secondary to ropivacaine absorption following the accidental overdose. This case shows that **lipid** infusion may have a beneficial role in cases of local anaesthetic toxicity when conventional **resuscitation** has been unsuccessful.

Human studies

[Paediatr Anaesth](#). 2010 Jan;20(1):28-37.

Perioperative complications in children with pulmonary hypertension undergoing general anesthesia with ketamine.

[Williams GD](#), [Maan H](#), [Ramamoorthy C](#), [Kamra K](#), [Bratton SL](#), [Bair E](#), [Kuan CC](#), [Hammer GB](#), [Feinstein JA](#).

Source

Division of Pediatric Cardiology, Department of Anesthesia, Lucile Packard Children's Hospital, Stanford University, Stanford, CA, USA. jumbo@stanford.edu

Abstract

BACKGROUND:

Pulmonary arterial hypertension (PAH) is associated with significant perioperative risk for major complications in children, including pulmonary hypertensive crisis and cardiac arrest. Uncertainty remains about the safety of ketamine anesthesia in this patient population.

AIM:

Retrospectively review the medical records of children with PAH to ascertain the nature and frequency of peri-procedural complications and to determine whether ketamine administration was associated with peri-procedural complications.

METHODS:

Children with PAH (mean pulmonary artery pressure > or =25 mmHg and pulmonary vascular resistance index > or =3 Wood units) who underwent general anesthesia for procedures during a 6-year period (2002-2008) were enrolled. Details about the patient, PAH, procedure, anesthetic and postprocedural course were noted, including adverse events during or within 48 h of the procedure. Complication rates were reported per procedure. Association between ketamine and peri-procedural complications was tested.

RESULTS:

Sixty-eight children (median age 7.3 year, median weight 22 kg) underwent 192 procedures. Severity of PAH was mild (23%), moderate (37%), and severe (40%). Procedures undertaken were major surgery (n = 20), minor surgery (n = 27), cardiac catheterization (n = 128) and nonsurgical procedures (n = 17). Ketamine was administered during 149 procedures. Twenty minor and nine major complications were noted. Incidence of cardiac arrest was 0.78% for cardiac catheterization procedures, 10% for major surgical procedures and 1.6% for all procedures. There was no procedure-related mortality. Ketamine administration was not associated with increased complications.

CONCLUSIONS:

Ketamine appears to be a safe anesthetic option for children with PAH. We report rates for **cardiopulmonary resuscitation** and mortality that are more favorable than those previously reported.

[Anesth Analg](#). 2007 Aug;105(2):344-50.

Anesthesia-related cardiac arrest in children: update from the Pediatric Perioperative Cardiac Arrest Registry.

[Bhananker SM](#), [Ramamoorthy C](#), [Geiduschek JM](#), [Posner KL](#), [Domino KB](#), [Haber Kern CM](#), [Campos JS](#), [Murray JP](#).

Source

Department of Anesthesiology, University of Washington School of Medicine, Seattle, WA, USA.

Abstract**BACKGROUND:**

The initial findings from the Pediatric Perioperative Cardiac Arrest (POCA) Registry (1994-1997) revealed that medication-related causes, often cardiovascular depression from halothane, were the most common. Changes in pediatric anesthesia practice may have altered the causes of cardiac arrest in anesthetized children.

METHODS:

Nearly 80 North American institutions that provide anesthesia for children voluntarily enrolled in the Pediatric Perioperative Cardiac Arrest Registry. A standardized data form for each perioperative cardiac arrest in children ≤ 18 yr of age was submitted anonymously. We analyzed causes of anesthesia-related cardiac arrests and related factors in 1998-2004.

RESULTS:

From 1998 to 2004, 193 arrests (49%) were related to anesthesia. Medication-related arrests accounted for 18% of all arrests, compared with 37% from 1994 to 1997 ($P < 0.05$). Cardiovascular causes of cardiac arrest were the most common (41% of all arrests), with hypovolemia from blood loss and hyperkalemia from transfusion of stored blood the most common identifiable cardiovascular causes. Among respiratory causes of arrest (27%), airway obstruction from laryngospasm was the most common cause. Vascular injury incurred during placement of central venous catheters was the most common equipment-related cause of arrest. The cause of arrest varied by phase of anesthesia care ($P < 0.01$). Cardiovascular and respiratory causes occurred most commonly in the surgical and postsurgical phases, respectively.

CONCLUSIONS:

A reduction in the proportion of arrests related to cardiovascular depression due to halothane may be related to the declining use of halothane in pediatric anesthetic practice. The incidence of the most common remaining causes of arrest in each category may be reduced through preventive measures.

[Paediatr Anaesth](#). 2006 Aug;16(8):860-6.

Perioperative cardiac arrest and its mortality in children. A 9-year survey in a Brazilian tertiary teaching hospital.

[Gobbo Braz L](#), [Braz JR](#), [Módolo NS](#), [do Nascimento P](#), [Brushi BA](#), [Raquel de Carvalho L](#).

BACKGROUND:

The incidence of perioperative cardiac arrest and mortality in children is higher than in adults. This survey evaluated the incidence, causes, and outcome of perioperative cardiac arrests in a pediatric surgical population in a tertiary teaching hospital between 1996 and 2004.

METHODS:

The incidence of cardiac arrest during anesthesia was identified from an anesthesia database. During the study period, 15,253 anesthetics were performed in children. Data collected included patient demographics, surgical procedures (elective, urgent, or emergency), ASA physical status classification, anesthesia provider information, type of surgery, surgical areas, and outcome. All cardiac arrests were reviewed and grouped by the cause of arrest and death into one of four groups: totally anesthesia-related, partially anesthesia-related, totally surgery-related, or totally child disease or condition-related.

RESULTS:

There were 35 cardiac arrests (22.9 : 10,000) and 15 deaths (9.8 : 10,000). Major risk factors for cardiac arrest were neonates and children under 1 year of age ($P < 0.05$) with ASA III or poorer physical status ($P < 0.05$), in emergency surgery ($P < 0.05$), and general anesthesia ($P < 0.05$). Child disease/condition was the major cause of cardiac arrest or death ($P < 0.05$). There were seven cardiac arrests because of anesthesia (4.58 : 10,000)--four totally (2.62 : 10,000) and three partially related to anesthesia (1.96 : 10,000). There were no anesthesia attributable deaths reported. The main causes of anesthesia attributable cardiac arrest were respiratory events (71.5%) and medication-related events (28.5%).

CONCLUSIONS:

Perioperative cardiac arrests were relatively higher in neonates and infants than in older children with severe underlying disease and during emergency surgery. The fact that all anesthesia attributable cardiac arrests were related to airway management and medication administration is important in prevention strategies.

[Anesthesiology](#). 2011 Jul;115(1):111-116.

Treatment with Epinephrine (Adrenaline) in Suspected Anaphylaxis during Anesthesia in Denmark.

[Garvey LH](#), [Belhage B](#), [Krøigaard M](#), [Husum B](#), [Malling HJ](#), [Mosbech H](#).

Abstract**BACKGROUND:**

Literature on the use of epinephrine in the treatment of anaphylaxis during anesthesia is very limited. The objective of this study was to investigate how often epinephrine is used in the treatment of suspected anaphylaxis during anesthesia in Denmark and whether timing of treatment is important.

METHODS:

A retrospective study of 270 patients investigated at the Danish Anaesthesia Allergy Centre after referral due to suspected anaphylaxis during anesthesia was performed. Reactions had been graded by severity: C1, mild reactions; C2, moderate reactions; C3, anaphylactic shock with circulatory instability; C4, cardiac arrest. Use of epinephrine, dosage, route of administration, and time between onset of circulatory instability and epinephrine administration were noted.

RESULTS:

A total of 122 (45.2%) of referred patients had C3 or C4 reactions; of those, 101 (82.8%) received epinephrine. Route of administration was intravenous in 95 (94%) patients. Median time from onset of reported hypotension to treatment with epinephrine was 10 min (range, 1-70 min). Defining epinephrine treatment less than or equal to 10 min after onset of hypotension as early, and more than 10 min as late, infusion was needed in 12 of 60 patients (20%) treated early versus 12 of 35 patients (34%) treated late (odds ratio, 2.09) (95% confidence interval, 0.81-5.35).

CONCLUSION:

Anaphylaxis may be difficult to diagnose during anesthesia, and treatment with epinephrine can be delayed as a consequence. Anaphylaxis should be considered and treated in patients with circulatory instability during anesthesia of no apparent cause who do not respond to the usual treatments.

Non-target Animal studies

[AANA J.](#) 2011 Apr;79(2):129-38.

Combined lipid emulsion and ACLS resuscitation following bupivacaine- and hypoxia-induced cardiovascular collapse in unanesthetized swine.

[Bushey BA](#), [Auld VH](#), [Volk JE](#), [Vacchiano CA](#).

This study examined whether combining lipid emulsion and advanced cardiac life support (ACLS) improves survival in an unanesthetized swine model of bupivacaine- and hypoxia-induced cardiovascular collapse. Arterial and venous catheters and a tracheostomy were surgically placed in 26 swine receiving inhalation **anesthesia**. After a 1-hour recovery period, bupivacaine (5 mg/kg) was administered intravenously over 15 seconds. Following 1 minute of observation and 3 minutes of mechanical airway obstruction, during which all animals exhibited complete cardiovascular collapse, ACLS was initiated. Animals were randomized to receive either intravenous saline or 20% lipid emulsion commencing with the initiation of ACLS. Survival was defined as a return of spontaneous circulation (ROSC) with unsupported blood pressure greater than 60 mm Hg for 10 minutes after 25 minutes of **resuscitation** effort. Data collection included electrocardiogram, arterial blood pressure, and arterial and mixed venous oxygen saturations. There was no significant difference in survival between the saline group (4/12, 33%) and lipid emulsion group (6/12, 50%; $P > .05$). Additionally, there was no significant difference between groups of surviving animals in the time to ROSC ($P > .05$). The combination of lipid emulsion and ACLS did not improve survival from bupivacaine- and hypoxia-induced cardiovascular collapse in unanesthetized swine.

[Anesth Analg.](#) 2009 Apr;108(4):1163-8.

Intralipid infusion diminishes return of spontaneous circulation after hypoxic cardiac arrest in rabbits.

[Harvey M](#), [Cave G](#), [Kazemi A](#).

BACKGROUND:

Infusion of **lipid** emulsion has been shown to reverse lipophilic drug-induced cardiovascular collapse in laboratory models and humans. The effect of high dose **lipid** in nondrug-induced cardiac arrest is, however, uncertain. In a rabbit model of asphyxial pulseless electrical activity (PEA) we compared **lipid** augmented with standard advanced cardiac life support (ACLS) **resuscitation**. **METHOD:**

Adult New Zealand White rabbits underwent hypoxic PEA via tracheal clamping. After 2 min of cardiac arrest, basic life support **cardiopulmonary resuscitation** was commenced and 3 mL/kg 20% Intralipid or 3 mL/kg 0.9% saline solution infused. Adrenaline (100 microg/kg) was administered at 4 and 5 min. Return of spontaneous circulation (ROSC), hemodynamic metrics, and survival to 50 min were recorded.

RESULTS:Seven of 11 saline-treated rabbits developed ROSC versus 1 of 12 Intralipid-treated animals; $P = 0.009$. No significant difference in survival to 50 min was observed (3/11 saline vs 0/12 Intralipid; $P = 0.211$).

CONCLUSION:In this model of hypoxia-induced PEA, standard ACLS resulted in greater coronary perfusion pressure and increased ROSC compared with ACLS plus **lipid** infusion. **Lipid** emulsion may be contraindicated in cardiac arrest complicated by significant hypoxia.

[Anesth Analg.](#) 2008 May;106(5):1566-71

A comparison of the combination of epinephrine and vasopressin with lipid emulsion in a porcine model of asphyxial cardiac arrest after intravenous injection of bupivacaine.

[Mayr VD](#), [Mitterschiffthaler L](#), [Neurauter A](#), [Gritsch C](#), [Wenzel V](#), [Müller T](#), [Luckner G](#), [Lindner KH](#), [Strohmenger HU](#).

BACKGROUND:

In a porcine model, we compared the effect of the combination of vasopressin/epinephrine with that of a lipid emulsion on survival after bupivacaine-induced cardiac arrest. **METHODS:**After administration of 5 mg/kg of a 0.5% bupivacaine solution i.v., ventilation was interrupted for 2 +/- 0.5 (mean +/- SD) min until asystole occurred. Cardiopulmonary resuscitation (CPR) was initiated after 1 min of untreated cardiac arrest. After 2 min of CPR, 10 animals received, every 5 min, either vasopressin combined with epinephrine or 4 mL/kg of a 20% lipid emulsion. Three minutes after each drug administration, up to three countershocks (4, 4, and 6 J/kg) were administered; all subsequent shocks with 6 J/kg. Blood for determination of the plasma bupivacaine concentration was drawn throughout the experiment. **RESULTS:**

In the vasopressor group, all five pigs survived, whereas none of five pigs in the lipid group had restoration of spontaneous circulation ($P < 0.01$).

There was no significant difference between groups in the plasma concentration of total bupivacaine. **CONCLUSION:**

In this model of a bupivacaine-induced cardiac arrest, the vasopressor combination of vasopressin and epinephrine compared with lipid emulsion

resulted in higher coronary perfusion pressure during CPR and survival rates.

Paediatr Anaesth. 2011 Jul 18. doi: 10.1111/j.1460-9592.2011.03652.x. [Epub ahead of print]

Comparison of epinephrine vs lipid rescue to treat severe local anesthetic toxicity - an experimental study in piglets.

Mauch J, Martin Jurado O, Spielmann N, Bettschart-Wolfensberger R, Weiss M.

Objectives: Local anesthetic (LA) intoxication with severe hemodynamic compromise is a potential catastrophic event. Lipid resuscitation has been recommended for the treatment of LA-induced cardiac **arrest**. However, there are no data about effectiveness of Intralipid® for the treatment of severe cardiovascular compromise prior to cardiac **arrest**. Aim of this study was to compare effectiveness of epinephrine and Intralipid® for the treatment of severe hemodynamic compromise owing to bupivacaine intoxication. **Methods:** Piglets were anesthetized with sevoflurane, intubated, and ventilated. Bupivacaine was infused with a syringe driver via a central venous catheter at a rate of $1 \text{ mg} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ until invasively measured mean arterial pressure (MAP) dropped to 50% of the initial value. Bupivacaine infusion was then stopped, and epinephrine $3 \text{ } \mu\text{g} \cdot \text{kg}^{-1}$ (group 1), Intralipid® 20% $2 \text{ ml} \cdot \text{kg}^{-1}$ (group 2), or Intralipid® 20% $4 \text{ ml} \cdot \text{kg}^{-1}$ (group 3) was immediately administered. Survival, hemodynamic course, and ET(CO₂) were recorded. **Results:** Twenty-one piglets (3×7), with median age of 26 days (19-43) and weighing 4.9 kg (4.3-5.8), were investigated. All animals in group 1 (100%) but only four of seven (57%) piglets in group 2 and group 3, respectively, survived. Normalization of hemodynamic parameters (HR, MAP) and ET(CO₂) was fastest in group 1 with all piglets achieving HR and MAP values at or above baseline within 1 min. **Conclusion:** For the treatment of severe hemodynamic compromise owing to bupivacaine intoxication in piglets, first-line rescue with epinephrine was more effective than Intralipid® with regard to survival as well as normalization of hemodynamic parameters and ET(CO₂).