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NOTE

Surgery

Retrospective investigation of cardiopulmonary resuscitation outcome in 146 exotic animals

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ABSTRACT. The outcomes of cardiopulmonary resuscitation (CPR) were retrospectively evaluated in 146 exotic animals including 20 pet birds, 47 rabbits, 34 hamsters, 18 ferrets, 7 turtles and 20 other small mammals in cardiopulmonary arrest (CPA) at presentation or during hospitalization at an animal clinic. The rates of return of spontaneous circulation, survival after CPR and discharge were 9.3, 2.3 and 1.2%, respectively. The mean success rate of CPR in animals included in this study was lower than those previously reported in dogs and cats. This might have been because of the challenges in effective chest compression, airway management and monitoring as well as establishment of intravenous catheterization route in exotic animals.

KEY WORDS: cardiopulmonary arrest, cardiopulmonary resuscitation, exotic animals, survival rate

In 2012, the Veterinary Emergency and Critical Care Society (VECCS) and American College of Veterinary Emergency and Critical Care (ACVECC) formulated new guidelines for cardiopulmonary resuscitation (CPR) in dogs and cats, the Reassessment Campaign on Veterinary Resuscitation (RECOVER), with the aim of improving the outcome of cardiopulmonary resuscitation (CPR) [1, 3]. The RECOVER guidelines include descriptions of the basic life support (BLS) and advanced life support (ALS) protocols. The most important BLS step in case of cardiopulmonary arrest (CPA) is to initiate life support on the basis of the "circulation, airway and breathing" concept as soon as possible [1, 3].

A study involving the treatment of 161 dogs and 43 cats in CPA by cardiopulmonary-cerebral resuscitation (CPCR) reported that the procedure was successful in 53 and 44% of the dogs and cats, respectively [5]; additionally, about 16% (12/75) of dogs and cats successfully treated by CPCR were discharged. However, neither CPR guidelines nor reports on CPCR and CPA in exotic animals are available. In the present study, we retrospectively evaluated the incidence of CPA as well as the success and discharge rates of CPR in exotic animals at an animal clinic.

A total of 3,921 exotic animals were presented at Oosagami Animal Clinic for treatment between September 1995 and March 2014. These animals included small birds including budgerigars, cockatiels and Java sparrows (921); rabbits (879), hamsters (845), ferrets (438), turtles (351) and other small mammals (487). Animals of 7 species, including chipmunks, prairie dogs, sugar gliders, chinchillas, guinea pigs and degus, were collectively grouped as other small mammals for statistical analysis, because of the small numbers of animals of each species. Incidence of CPA at presentation and that during hospitalization were recorded separately. The rates of CPR application, return of spontaneous circulation, application of airway management and chest compression as BLS procedures, administration of drugs and fluids as ALS procedures, survival and discharge were evaluated.

The results of analysis of the above-mentioned factors are presented in Tables 1 and 2. Of the 3,921 exotic animals treated at the clinic, 146 presented with CPA. While 99 animals (67.8%) experienced CPA at the clinic, 47 (32.2%) were in CPA at presentation. The rates of CPR application and return of spontaneous circulation among animals that experienced CPA at the clinic were 78.7 and 8.97%, respectively; among animals administered CPR in this group, the rates of application of airway management and chest compression, administration of drugs and fluids, survival and discharge were 84.6, 100, 80.9, 30.8, 2.6 and 1.3%, respectively. Among animals that presented CPA upon arrival, the rates of CPR application and return of spontaneous circulation were 17.0 and

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Table 1. Characteristics of animals in CPA according to species

Species	CPA (%)	Number of registered animals (n)	Age (years)			Sex ratio (sterilized)		
			Range	Mean	Unclear	Female	Male	Unclear
Rabbit	47 (32.2)	879	0.1–10	4.15	6	21 (3)	24 (3)	2
Hamster	34 (23.3)	845	0.1–3	1.13	10	10	18 (1)	6
Small bird	20 (13.7)	921	0.08–11	3.37	5	3	5	12
Others[a)]	20 (13.7)	487	0.17–8	2.68	2	13	7	0
Ferret	18 (12.3)	438	0.5–8	4.77	3	10 (10)	7 (7)	1
Turtle	7 (4.79)	351	0.1–12	7.75	3	2	1	4
Total	146 (100)	3,921	0.08–12	3.98	29	59 (13)	62 (11)	25

CPA: Cardiopulmonary arrest. a) Other small mammals.

Table 2. Results of data survey of CPR application in animals in CPA

Animal species n (%)		CPA Total (%)	CPR application (rate) (excluding rigor mortis)	Rate of return of spontaneous circulation	Basic Life Support (BLS)		Advanced Life Support (ALS)		CPR-applied cases	
					Cardiac massage[a)]	Airway maintenance (%)[b)]	Drugs[c)]	Infusion[d)]	Survival rate	Discharge rate
Rabbit	CPA in the clinic	36 (76.6)	36 (100)	5 (13.9)	33 (91.7)	36 (100) [5]	33 (91.7)	6 (16.7)	2 (5.6)	1 (2.8)
n=47 (32.2)	CPA at arrival	11 (23.4)	4 (57.1)	1 (25)	4 (100)	4 (100)	4 (100)	1 (25)	0	0
	Total	47	40 (85.1)	6 (15)	37 (92.5)	40 (100) [5]	37 (92.5)	7 (17.5)	2 (5)	1 (2.5)
Hamster	CPA in the clinic	20 (58.8)	10 (50)	0	10 (100)	10 (100)	8 (80)	6 (60)	0	0
n=34 (23.3)	CPA at arrival	14 (41.2)	0	0	0	0	0	0	0	0
	Total	34	10 (29.4)	0	10 (100)	10 (100)	8 (80)	6 (60)	0	0
Small bird	CPA in the clinic	12 (60)	8 (66.7)	0	0	8 (100) [2]	7 (87.5)	0	0	0
n=20 (13.7)	CPA at arrival	8 (40)	0	0	0	0	0	0	0	0
	Total	20	8 (40)	0	0	8 (100)	7 (87.5)	0	0	0
Other small mammals	CPA in the clinic	18 (90)	13 (72.2)	3 (16.7)	12 (92.3)	13 (100) [2]	13 (100)	5 (38.5)	2 (15.4)	0
n=20 (13.7)	CPA at arrival	2 (10)	1 (50)	0	1 (100)	1 (100)	1 (100)	0	0	0
	Total	20	14 (70)	2 (14.3)	13 (92.9)	14 (100)	14 (100)	5 (35.7)	2 (14.3)	0
Ferret	CPA in the clinic	12 (66.7)	11 (91.7)	0	11 (100) [1]	11 (100)	11 (100)	6 (54.5)	0	0
n=18 (12.3)	CPA at arrival	6 (33.3)	3 (50)	0	3 (100)	3 (100)	3 (100)	0	0	0
	Total	18	14 (77.8)	0	14 (100)	14 (100)	14 (100)	6 (42.9)	0	0
Turtle	CPA in the clinic	2 (28.6)	0	0	0	0	0	0	0	0
n=7 (4.8)	CPA at arrival	5 (71.4)	0	0	0	0	0	0	0	0
	Total	7	0	0	0	0	0	0	0	0

CPR: Cardiopulmonary resuscitation. CPA: Cardiopulmonary arrest. a) Impossible in birds and turtles. Thoracotomy was performed in one ferret (the number of animals is presented in [ ]). b) Tracheal intubation was applied in 100% of ferrets. A tracheal tube or tracheotomy was applied in some rabbits and prairie dogs (the number of animals is presented in [ ]). The airway was maintained using a mask in all other animals. c) Mainly epinephrine (76/80, 95%), doxapram hydrochloride hydrate (23/80, 28.8%), atropine or glycopyrrolate only for rabbits (7/80, 8.75%), dexamethasone (12/80, 15.0%). d) Intraperitoneal administration for very small animals (no intramedullary administration was performed).

12.5%, respectively; among animals that were administered CPR in this group, all were treated by airway management, chest compression and drug administration, while none were administered fluids. The rates of survival and discharge in this group were both 0%.

With regard to the time of start of BLS, since we started administering chest compressions just after CPA, there was no difference in the start time of BLS among the included animals. The results of CPR in all species are presented in Table 3.

In the present study, the overall rate of return of spontaneous circulation was only 9.3%, while the overall survival and discharge rates were 2.3 and 1.2%, respectively. These rates were lower than those reported in dogs and cats in the previous study. These discrepancies in results may be attributed to differences among the animals included in the two studies in terms of physique and anatomy, such as cardiac arrest as a direct result of respiratory arrest in small animals, the thoracic region being covered with bones in birds and turtles, and difficulty in airway maintenance by tracheal intubation in most animals other than ferrets, birds and turtles; in addition, the absence of the diaphragm in birds and turtles precludes the application of the thoracic pump despite chest compression [8].

Airway maintenance was previously the most prioritized among the processes of CPR. However, on the basis of a report that CPR with only chest compression (i.e., hands-only CPR) was equivalent to CPR with an artificial respirator, the order of priority of steps in CPR was revised as circulation-airway maintenance-respiration according to the 2005 American Heart Association guidelines [7]. Studies have also described CPR with only ventilation and without cardiac output as ineffective and chest

Table 3. Results of data survey of CPR with all cases

Animal species n (%)		CPA Total (%)	CPR application (rate) (excluding rigor mortis)	Rate of return of spontaneous circulation	CPR-applied cases	
					Survival rate	Discharge rate
Total	CPA in the clinic	99 (67.8)	78 (78.7)	7 (8.97)	2 (2.6)	1 (1.3)
n=146	CPA at arrival	47 (32.2)[a)]	8 (17.0)	1 (12.5)	0	0
	Total	146	86/146 (58.9)[b)]	8/86 (9.3)	2/86 (2.3)	1/86 (1.2)

CPR: Cardiopulmonary resuscitation. a) Twenty-six of the 47 animals were in rigor mortis. b) The application rate after excluding animals in rigor mortis was 71.7% (86/120).

compression as the most important process of CPR [1, 3]. In very small animals, such as the exotic animals included in the present study, chest compression is applied one-handed, similar to that in cats and small dogs, where the sternum is strongly pushed to the chest wall with one hand, because of high thoracic compliance and low thoracic width [1, 3]. However, in the present study, chest compression might have been ineffective, because of the smaller physiques of the included animals in comparison with those of cats and small dogs as well as the impracticality of chest compression in birds and turtles. The rate of application of cardiac compression in the present study was high (86%), while that of return of spontaneous circulation was low (9.3%). Although cardiac compression at about 100 per min has been recommended in ferrets, no detailed studies have been reported in other species. Therefore, it is necessary to investigate alternative methods for chest compression according to species [8].

One of the effective methods for chest compression is direct cardiac compression during open-chest CPR, which yields higher cardiac output than closed-chest CPR; however, this method is highly invasive and should be indicated only for intraoperative CPA [1, 3]. In the ferret included in our study, cardiac massage was administered to resolve intraoperative CPA. Although the animal died, we believe that open-chest CPR is an option in cases where chest compression during closed-chest CPR is ineffective.

The prognosis of respiratory arrest induced by anesthetic overdose with isoflurane has been reported to be favorable in birds; however, cardiac arrest has been reported to occur immediately after respiratory arrest in small exotic animals [8]. The low survival rate among animals with CPA in the present study might have been related to issues with airway maintenance. Administration of 100% oxygen, positive pressure ventilation and doxapram has been recommended after intubation in birds and small animals [8]. In the present study, return of spontaneous circulation was achieved by tracheotomy in a few animals. Thus, in cases where tracheal intubation is difficult, tracheotomy should be actively applied.

Body temperature, electrocardiographic output, femoral arterial pressure, end-tidal CO_2 ($EtCO_2$) and blood gas levels are used as indicators for monitoring the efficacy of ALS protocols. Although palpable pulses are ineffective for evaluation of ALS in birds and very small animals, $EtCO_2$ and blood gas measurements have been reported to be effective for the same [8]. However, $EtCO_2$ might not be accurately evaluated, because of dead space in mask management. Therefore, it is mainly necessary to monitor the body temperature, electrocardiographic output and blood gas levels, as was done in this survey.

In a previous study, dogs resuscitated by CPR received fluid replacement and treatment with mannitol, lidocaine, dopamine, corticosteroids, epinephrine or vasopressin [5]. Epinephrine is the vasopressor of choice for treatment of ventricular fibrillation, asystole and pulseless electrical activity (PEA) in exotic animals. A few studies have reported the efficacy of vasopressin in rabbits, and its use has been recommended in other small mammals and birds as well [8]. The efficacy of vasopressin in increasing the success rate of CPR should be further investigated.

The use of corticosteroids (dexamethasone) was effective for treatment of trauma and hypovolemic shock in 15% of rabbits in a previous study [4]. However, the efficacy of corticosteroids in dogs and cats has not been specified in the RECOVER guidelines. Moreover, administration of high doses of corticosteroids is not recommended, because of the severe adverse reactions associated with their use [1, 3]. In addition, previous studies have not described the drugs recommended for treatment of CPA in exotic animals [8], although adverse events have been reported in rabbits treated with corticosteroids [4], which indicates that corticosteroids might not be recommended for use in exotic animals. Doxapram hydrochloride hydrate is also used for prevention of respiratory arrest during anesthesia. Although doxapram was effective in many cases in the present study, its association with the rate of return of spontaneous circulation in animals with CPA was unclear. With regard to fluid replacement, it is difficult to establish a venous route in many individual animals as well as in members of certain species of exotic animals, which might have been a factor for the low success rate of CPR in the present study. We performed intraperitoneal administration in very small animal species where establishment of venous route was difficult. Intramedullary administration should be investigated as an alternative method for fluid replacement to improve the outcomes of CPR in future studies.

In cats, the success rate of CPR was reported to be significantly higher in a group involving many staff members for treatment than in that involving fewer staff members [5]. However, in most cases, it is difficult to engage many staff members to work around very small exotic animals other than in drug preparation, which might be one of the factors for the poor outcomes of CPR in the present study.

The survival rate after bystander CPR is about two times higher than that after CPR by emergency services alone [2, 6]. To increase the rate of return of spontaneous circulation in exotic animals in which respiratory arrest directly results in cardiac arrest, widespread awareness of bystander CPR in owners is required.

The results of our study identified several issues regarding CPR in small exotic animals. There appear to be several challenges with administration of BLS protocols in exotic animals. The success rate of CPR in exotic animals was low, because several factors including the physical and anatomical characteristics of several species, challenges in airway maintenance and impracticality of engaging several staff members for treatment rendered chest compression ineffective. Issues with ALS include limitations in monitoring, difficulty in establishment of a venous route for drug administration and fewer instances of drug efficacy, including that with vasopressin. It is necessary to prepare CPR guidelines focusing on BLS according to species and with consideration of these problems. We will make efforts towards preparation of CPR guidelines by sharing information with veterinarians treating exotic animals.

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