Retrospective study of clinical complications occurring after arterial punctures in 111 dogs

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The clinical complications occurring after 111 dogs had undergone arterial punctures were reviewed in relation to the dogs' breed, bodyweight, age, sex and underlying diseases. Seven of the dogs had moderate to extensive ecchymoses, which were significantly more common in dogs under 3·5 kg in bodyweight and in dogs with disorders of the cardiovascular system.

THE risks associated with percutaneous arterial puncture in dogs are a source of anxiety for practitioners, although the procedure is recognised as a simple and useful diagnostic tool for the investigation of clinical oxygenation and acid-base disturbances (McKiernan and Johnson 1992).

In human patients, previous studies have shown that the rate of complications after arterial puncture varies between almost zero (Ward and Green 1965) and 17·3 per cent (Kottke and others 1964). A serious albeit uncommon complication is thrombosis (Malley 1990). Haemorrhage or haematoma may also be a problem, particularly in patients with aortic valvular incompetence, in patients receiving anticoagulation therapy, and in patients with hypertension (Mortensen 1967, Macon and Futrell 1973, Mathieu and others 1973, Neviaser and others 1976, Malley 1990).

However, there has been no detailed analysis of the clinical complications of arterial puncture in dogs, which may partly account for the hesitation of practitioners to use the procedure.

The objectives of this study were to review the clinical complications of arterial puncture in 111 dogs and to analyse the factors associated with them.

MATERIALS AND METHODS

The medical records of all the dogs that underwent arterial puncture between December 1994 and September 1997 were reviewed, and the following information was recorded for each dog: breed, bodyweight, age, sex, underlying diseases, difficulty of the puncture, complications related to it, and the number of days until the dog had recovered from the complications. The consent of the owners had been obtained before the arterial punctures had been performed.

The underlying diseases were classified according to the specific organ system involved, that is, the gastrointestinal system, skin and adnexa, and body cavities and hernias; the classifications were based on those of Slatter (1993) and Ettinger and Feldman (1995).

Each arterial puncture was made into one of the dog's femoral arteries by a trained practitioner, using conventional techniques (King and Hendricks 1995), involving a micropuncture set (Microsampler; AVL) which consisted of two heparinised capillary tubes attached to a 26 gauge needle. After the removal of the needle direct pressure was applied to the artery for two minutes. After each arterial puncture, venous blood samples were also obtained and examined for standard haematological and biochemical parameters.

Each dog was examined one week after the puncture, and any with complications related to it were followed either by observation or by telephone enquiries to the owners until they had resolved.

Analysis of risk factors

The predictor variables used in the statistical analysis were breed, bodyweight, age, sex, and underlying diseases, with complications as the dependent variable.

Continuous variables (age and bodyweight) were divided into four quartiles, according to the distribution of the complications, and these four quartiles were used to evaluate linear trends by using Mantel extension methods. The complication rates in different populations of interest were compared by using Fisher's exact test. A cut-off point, dividing each continuous variable into two categories was determined at the most statistically significant point.

Categorical variables (breed and underlying diseases) were divided into two groups, based on the initial descriptive study; one group was the category in which complications were most frequently encountered, and the other group was the rest of the categories. The complication rates in the two groups were compared by using Fisher's exact test.

Finally, to adjust for confounding factors, a multivariable model was fitted, using a forward stepwise logistic regression analysis (Hosmer and Lemeshow 1989). All the variables with $P<0·2$ in the univariable analysis were included in this model.

The adjusted odds ratio (OR) and its associated 95 per cent confidence interval (CI) was estimated for each variable after the fit of the multivariable model had been assessed by examining the delta-betas (Pregibon 1981) and the classification table (Hosmer and Lemeshow 1989). The statistical analyses were made by using SPSS Version 6.1 (SPSS Inc). A $P<0·05$ was considered significant.

RESULTS

Dogs

One hundred and twenty dogs underwent arterial puncture and, in 111 of them, the procedure was carried out without difficulty. The procedure failed in the other cases because of excitation in one dog, venous contamination in one, severe oedema in one, and obesity in six. The records of the 111 dogs in which the procedure was successful have been analysed. The median bodyweight was 9 kg with a range from1·3 kg to 29·2 kg. The median age was seven years with a range from 16 weeks to 16 years. The male: female ratio was 1·2:1 (54 per cent male). The most common underlying diseases involved the respiratory system (15), urinary system (12), cardiovascular system (11), gastrointestinal system (10), and skin and adnexa (10). There was no history of a tendency to bleed in any of the dogs, and none of the dogs experienced bleeding complications after the venous puncture.

Complications

Of the 111 dogs, seven had complications (Table 1).

All seven cases had moderate to extensive ecchymoses, which became evident two to three days after the arterial puncture and persisted for seven to 16 days. Of the seven dogs, three had focal, moderate ecchymoses, characterised by a radiating area of bruising 3 to 5 cm in diameter, around the puncture site (dogs 1, 6 and 7), two had ecchymoses distant from the puncture site on the same medial surface of the pelvic limb (dogs 3 and 4), and two developed purple discol-

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TABLE 1: Characteristics of seven dogs which had complications after an arterial puncture

Dog	Breed	Bodyweight (kg)	Age (yrs)	Sex	Clinical diagnosis and appearance	Disease classification	Nature of complications	Outcome
1	Pomeranian	1·90	16	Female	MI (Cardiac murmur; Levine IV/VI)	Cardiovascular system	Ecchymosis at puncture site (5 cm in diameter)	Recovered in 7 days
2	Maltese	3·40	6	Male	MI (Cardiac murmur; Levine I/VI); chronic patellar dislocation (grade I)	Cardiovascular system	Extensive ecchymosis and lameness	Recovered in 7 days
3	Pomeranian	2·02	10	Female	Abscess on buccal region; chronic patellar dislocation (grade I)	Skin and adnexa	Ecchymosis apart from pucture site (6 cm)	Recovered in 7 days
4	Chihuahua	2·90	10	Male	Second-degree A-V block (Mobitz type II); chronic rhinitis	Cardiovascular system	Ecchymosis at puncture and other sites (2 cm, 1·5 cm)	Recovered in 7 days
5	Yorkshire terrier	3·08	12	Male	Perineal hernia	Body cavities and hernias	Extensive ecchymosis	Recovered in 10 days
6	Shih tzu	5·32	4	Female	Chronic renal failure (BUN 79 mg/100 ml; creatinine 3·9 mg/100 ml)	Urinary system	Ecchymosis at puncture site (3 cm)	Recovered in 7 days
7	Mongrel	9·70	11	Male	MI (Cardiac murmur; Levine II/IV); platelets 46·4 x 10^4/µl, ACT=109s, PATI >800 µM	Cardiovascular system	Ecchymosis at puncture site (5 cm)	Recovered in 16 days

MI Mitral insufficiency, ACT Activated coagulation time; the normal value ranges from 83 to 129 seconds at room temperature (Middleton and Watson 1978), PATI Platelet aggregatory threshold index: a method of evaluating platelet aggregation, which represents the threshold concentration of aggregating agent (ADP) necessary to obtain platelet aggregation (Imiya and Matsuo 1993). From the authors' data in six healthy dogs, normal PATI ranges from 3·5 to 6·6 µM; PATI>800 µM means that platelets showed extremely low aggregation; BUN Blood urea nitrogen

oration all over the skin around the puncture site (dogs 2 and 5). Initially, one of these last two dogs (5) had a small focal ecchymosis around the puncture site (Fig 1a). The discoloration then extended to almost the entire surface of the limb five days after the puncture (Fig 1b). In dog 7, the platelets showed extremely low aggregation, although the platelet count and activated coagulation time were within normal limits. All the bruising resolved within seven to 16 days without treatment.

A temporary weakness of the distal pulse, which was assumed to be an arteriospasm, was observed in each dog, but the pulse returned to baseline values within about 60 minutes. Dog 2 became temporarily lame on the affected leg immediately after the puncture. The dog had chronic patellar dislocation in conjunction with a disorder of the cardiovascular system.

Analysis of risk factors

Predictor variables For each predictor variable, ecchymoses appeared most frequently in dogs in the toy breed group (five of 28 toy breed dogs); in dogs under 3·5 kg in bodyweight (five of 15), and over 10 years of age (five of 50); in males (four of 60); and in dogs with disorders of the cardiovascular system (four of 11).

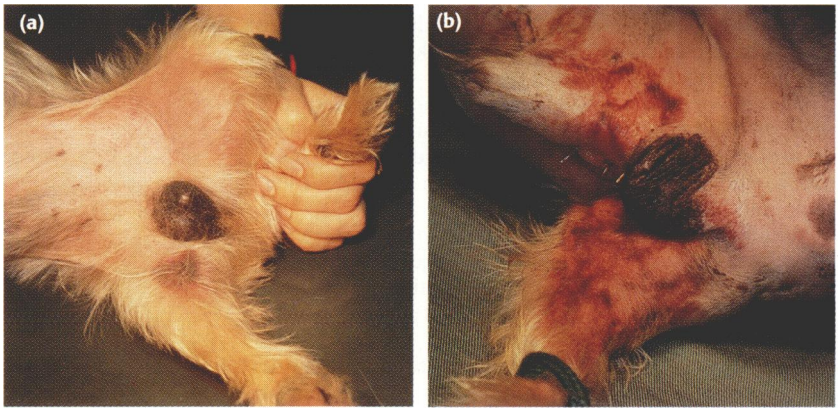

FIG 1: (a) Small focal ecchymosis observed initially around the puncture site in dog 5; (b) Five days later the discoloration had extended over almost the entire surface of the limb

Univariable analysis Table 2 shows the unvariable relationships between complication rate and all the variables with a P value less than 0·2. A higher bodyweight was strongly associated with a lower risk of complication (P for trend <0·001). Dogs under 3·5 kg in bodyweight were significantly associated with a higher complication rate when compared with heavier animals (P=0·0004). Toy breed dogs and dogs with cardiovascular disorders also had significantly higher complication rates (P=0·011 and 0·002, respectively). No significant relationship was observed between complication rate and age or sex.

Multivariable analysis Two variables (bodyweight and disorders of the cardiovascular system) were included in the final model (Table 3). The risk of a complication was significantly higher in dogs under 3·5 kg in bodyweight (adjusted OR 5·34, 95 per cent CI 1·62 to 17·6, P=0·006) and dogs with disorders of the cardiovascular system (adjusted OR 3·74, 95 per cent CI 1·26 to 11·2, P=0·018).

Multivariable model The deletion of only one extreme outlier with a high delta-beta (dog 6) resulted in major changes in the values of the estimated coefficients. After the deletion of this outlier, the final model correctly classified 50·0 per cent of the dogs with complications and 98·1 per cent of the dogs without complications, using a cut-off probability of 0·5.

DISCUSSION

Seven of the 111 dogs (6·3 per cent) suffered complications after undergoing an arterial puncture, with the nature of the complication ranging from moderate to extensive ecchymoses. The complication rate was significantly higher in dogs under 3·5 kg in bodyweight and in dogs with disorders of the cardiovascular system. This is the first reported attempt to analyse the factors affecting the rate of clinical complications in dogs undergoing arterial puncture.

The authors prefer the femoral artery for arterial puncture because it is larger and more easily accessible than other arteries, and is thus the most feasible site for dogs of any size. One disadvantage, however, is that it lies extremely close to a large vein and nerve, which pose a risk of inadvertent venous punc-

TABLE 2: Univariable analysis of risk factors associated with complications of arterial puncture in 111 dogs (P<0·2)

Variable	Complication rate	OR	95% CI	P
Breed				
Not toy breed	2/83	1·00		
Toy breed	5/28	8·80	2·03-38·1	0·011
Bodyweight				
<3·5kg	5/15	1·00		
<7·0kg	1/31	0·07	0·01-0·44	0·011
<10·5kg	1/22	0·01	0·0002-0·47	0·031
≥10·5	0/43	0*	0	
Bodyweight (two groups)				
≥3·5kg	2/96	1·00		
<3·5kg	5/15	23·5	6·18-89·4	0·0004
Disease				
Without CVS disorders	3/100	1·00		
With CVS disorders	4/11	18·5	4·92-69·5	0·002

*Test for trend, P<0·001, CI Confidence interval, OR Odds ratio, CVS Cardiovascular system

TABLE 3: Multivariable logistic regression model of variables associated with complications in the univariable analysis of risk factors associated with complications of arterial puncture in 111 dogs

Variable	OR	95% CI	P
Bodyweight			
≥3·5kg	1·00		
<3·5kg	5·34	1·62–17·6	0·006
CVS disorders			
Absent	1·00		
Present	3·74	1·26–11·2	0·018

CI Confidence interval, OR Odds ratio, CVS Cardiovascular system

ture or significant pain in association with the procedure (Malley 1990). However, only one of 120 arterial punctures of this artery was accompanied by venous contamination.

In human patients repeated arterial punctures have been reported to be followed by a large haematoma (Neviaser and others 1976) and by an expanding aneurysm (Mathieu and others 1973). Both cases required surgical intervention. Owing to the potential risks associated with multiple punctures, if multiple samples were required during the monitoring of critically ill or anaesthetised animals, the authors catheterised the artery.

In the dog, the dorsal metatarsal artery on the dorsomedial aspect of the foot is the preferred artery for catheterising or for taking arterial blood samples. The dorsal metatarsal artery is smaller and more meandering than the femoral artery (Evans 1993). As a result, the catheterisation or puncture of this artery seems to be less invasive, but is more difficult than using the femoral artery, especially in small dogs. Another artery recommended for percutaneous puncture is the dorsal pedal artery (Orton and Park 1993), which is larger and straighter than the dorsal metatarsal artery but smaller than the femoral artery (Evans 1993).

More than 30 years ago, studies of the complication associated with arterial puncture were made in human beings. Of these reports, Mortensen (1967) reviewed 1466 arterial punctures that were carried out in clinical conditions and reported that the complication rate was 11·3 per cent. In the present study, seven ecchymoses occurred after 111 arterial punctures in dogs. The diameter of the femoral artery in a dog weighing 20 kg is about 0·8 mm smaller than that in a man weighing 75 kg (Nichols and O'Rourke 1998). As a result, it has been assumed that making an accurate arterial puncture in dogs without complications would be more difficult than in people. However, in this study the complication rate in dogs was lower than in the human cases.

Fortunately, none of the ecchymoses required any medical or surgical intervention. Similar findings on the ecchymoses developing after arterial puncture in human beings have been documented by Mortensen (1967), who reported that the complications were sufficient to cause local swelling, tenderness and discoloration of an area more than 8 cm in diameter, but not severe enough to require major therapy.

Ecchymosis is clinically associated with a platelet or vascular defect (Johnstone 1988). In the present study, dog 7 had a platelet function defect rather than a coagulation defect. The findings in dogs 3 and 4 suggest that the ecchymosis may appear at some distance from the puncture site.

Distal ischaemia, implying thrombosis at the puncture site, and other complications, such as haemorrhage, haematoma, or infection, which have been reported in humans cases (Malley 1990), were not encountered in this study. The very thin needle used may have minimised the risk, since the incidence of bleeding is considered to vary directly with the diameter of the needle (Malley 1990).

Mortensen (1967) reported that the factor associated with the highest risk of complications was the presence of aortic valvular incompetence, followed by the patient being an infant or young child. Low bodyweight was also a risk factor in the present study.

Of the seven cases which developed complications, five were under 3·5 kg in bodyweight, and the risk among dogs under 3·5 kg in bodyweight was 5·34 times that of heavier animals. It is more difficult to make a clean puncture into a small vessel than into a larger vessel, and the higher complication rate in these smaller dogs may be associated with this technical difficulty.

Of the seven dogs with complications, four had disorders of the cardiovascular system; three had mitral insufficiency and one had arrhythmia. The reason for this significant association between heart diseases and ecchymosis is uncertain. Although heart disease in dogs may be expected to be associated with platelet or vascular defects, the cause is unknown.

Age had no statistically significant effect on the probability of complications although older animals might have been expected to lack sufficient elastic tissue to seal the puncture site. This observation is supported by previous, not statistically significant findings, which suggested that people over 65 years of age did not have a higher incidence of complications than people under 65 (Mortensen 1967).

Dog 6 was considered as an outlier for the multivariable model, because the complication in such a dog was quite unusual. The dog had chronic renal failure but was not 'under 3·5 kg in bodyweight' and had no 'cardiovascular system disorders'. Some dogs with azotaemia have been shown to have prolonged bleeding times (Jergens and others 1987), suggesting that azotaemia may be a potential risk factor, although ecchymosis appears uncommon.

The temporary lameness in dog 2 was most probably due to the restraint applied during the procedure rather than to the procedure itself. Careful attention should be paid to dogs with conditions such as patellar dislocation to avoid further complications.

Although the clinical complications following arterial puncture in dogs did not seem to be as frequent or severe as expected, significantly higher complication rates were observed in dogs under 3·5 kg in bodyweight and in dogs with disorders of the cardiovascular system.

Unfortunately, the dog's history, or the results of venous puncture or other diagnostic procedures in routine clinical examinations cannot predict the likelihood of complications. However, the results of this study suggest that particular care should be taken when subjecting small dogs and

dogs with disorders of the cardiovascular system to arterial puncture.

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SHORT COMMUNICATIONS

Deletrocephalus dimidiatus in greater rheas (*Rhea americana*) in the UK

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RHEAS belong to one of several orders of flightless, ground-dwelling birds, collectively referred to as ratites. The ratites include the largest living bird, the ostrich (*Struthio camelus*), the emu (*Dromaius novaehollandiae*), rheas (the greater rhea, *Rhea americana* and the lesser or Darwin's rhea, *Pterocnemia pennata*), cassowaries and kiwis. Many of these species are assuming greater importance in veterinary medicine because of an increasing interest in their commercial farming. Ostriches, emus and rheas are now kept for meat, egg and feather production in several countries. Both species of rhea (order Rheiformes) originate from South America. The greater rhea inhabits grassy plains from Bolivia and Brazil to Argentina. The lesser rhea is found mainly in the high puna region of the southern Andes.

Rheas can be infected with a range of internal and external parasites indigenous to their natural habitats. The importation of live birds carries with it the risk of also introducing these parasites to new localities. In addition, those parasites of imported birds which have direct life cycles are the most likely to become established in the countries to which the birds are imported. This short communication reports the presence of the intestinal nematode, *Deletrocephalus dimidiatus* in a flock of greater rheas (*R americana*) which was first established in the UK in 1994.

During routine parasitological screening of a group of rheas, comprising 32 adult breeding birds and 32 1998-hatched young birds, located on a farm in south Wales, the presence of nematode eggs in some faecal samples was observed. Gastrointestinal parasitism had not been suspected and no routine worming had been practised over the four years since introduction, although the birds had, within the previous few months, been given prophylactic in-feed medication with flubendazole (Flubenol; Janssen) by the farmer. Faeces were then submitted to the Veterinary Laboratories Agency for parasite identification. Based on egg shape and size, and larval morphology, the parasite was tentatively identified as *Deletrocephalus* species.

Subsequent to this identification, the intestines from two birds were submitted for further parasitological investigation. One was from a homebred, one-and-a-half-year-old bird weighing 13·5 kg, which postmortem examination confirmed had died of traumatic proventriculitis as a result of ingestion of a wire. No parasites were found in the intestines. The second was from a one-and-three-quarter-year-old bird which was slaughtered for meat and was considered to have been underweight for its age and size. The intestinal contents contained over 1000 adult worms which were all subsequently confirmed to be *D dimidiatus*. Both sexes of the adult worms

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