Arterial blood pressure in anaesthetized African elephants

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A number of elephants previously captured in the Kruger National Park developed a pink frothy discharge from the external nares. Some of these elephants subsequently died and histopathological examinations indicated severe lung oedema. In view of the current hypothesis that high blood pressure could be a causative factor, arterial blood pressure was measured in elephants immobilized with etorphine alone \((n = 71)\) and with etorphine/azaperone \((n = 109)\) and carfentanil/azaperone \((n = 26)\) mixtures. Arterial blood pressure was found to be significantly lower in the groups immobilized with azaperone mixtures than in the group immobilized with etorphine alone \((p < 0.05)\). In addition, no cases of lung oedema were observed in animals immobilized with etorphine/azaperone and carfentanil/azaperone mixtures. It is strongly recommended, therefore, that azaperone be added to immobilization mixtures when elephants are subjected to herding prior to darting.

Keywords: Blood pressure, elephant, stress

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Introduction

The African elephant *Loxodonta africana* culling programme of the Kruger National Park includes the immobilization of young animals with a shoulder height less than 2 m for translocation purposes. In previous years, these elephants were immobilized in the veld using either etorphine HCl (M99, HMC Manufacturing Chemists Ltd., Dundee, Scotland) or carfentanil (Wildnil, Janssen Pharmaceutica, Beerse, Belgium), crated and transported to bomas in Skukuza where they were kept for several weeks before translocation. Some animals developed lung oedema, observed as a pink frothy discharge from the external nares, sometimes resulting in death either within 24 h of capture or at some stage during the subsequent 3–4 weeks. This phenomenon is possibly caused by an elevation in systemic blood pressure which increases afterload and culminates in left ventricular failure. The rise in blood pressure may be secondary to the various stressors encountered during the capture process, namely, effects of drugs, forced exercise and/or postural changes.

The \(\alpha_1\)-adrenergic antagonist azaperone (Stresnil, Janssen Pharmaceutica, Beerse, Belgium) was added to the immobilization mixture in subsequent capture operations with the aim of overcoming possible blood pressure elevation and reducing the incidence of lung oedema. The purpose of this study was to report blood pressure values obtained in elephants immobilized with etorphine alone and also with etorphine/azaperone and carfentanil/azaperone mixtures.

Method

Animals

All elephants used in the study were juveniles ranging in mass from about 200 to 1300 kg which were immobilized during the 1992 and 1993 culling programmes in the Kruger National Park. The procedure involved herding the animals by helicopter and darting them from the air. As soon as the elephants were laterally recumbent which, in most cases, occurred within several minutes of darting, each animal was clinically examined for the possible presence of lung oedema, presumed to manifest itself as a pink, frothy discharge from the external nares.

Immobilization

The following groups of animals were investigated:

- **Group 1:** Immobilized with 4,0–8,0 mg etorphine \((n = 71)\);
- **Group 2:** Immobilized with a mixture of 4,0–8,0 mg etorphine and 50–90 mg azaperone \((n = 109)\);
- **Group 3:** Immobilized with a mixture of 4,0–8,0 mg carfentanil and 50–90 mg azaperone \((n = 26)\).

Since body mass was estimated from the air at darting, dosages for individual elephants, expressed on a mg/kg basis, were approximate. Therefore, total dosages of etorphine, carfentanil and azaperone are given.

Blood pressure measurements

As soon as possible after recumbency, a 14-gauge needle connected to a mercury manometer by a 0,9% saline-filled
tube was placed into a vessel of the external ear. Using a
two-way tap, the manometer was zeroed to atmospheric
pressure and then connected to the blood vessel to measure
arterial pressure. Due to the small calibre of the connecting
tube used, no pulsatile movement of the mercury in the
manometer was observed and, therefore, all pressures
measured were assumed to approximate mean blood press-
ure. Measurements for Groups 1 & 2 were taken during
1992 and those for Group 3 during 1993. Differences in
arterial pressures between Groups 1, 2 & 3 were tested
using analysis of variance and regarded as significant at the
5% level.

Results

Incidence of lung oedema

The number of elephants developing lung oedema and the
mortality rate (expressed as a percentage of the total number
of animals captured in that year) observed in capture opera-
tions carried out from 1989 to 1993 are shown in Table 1.
During 1989, 1990 and 1991, some elephants were immobi-
lized with etorphine alone and others with carfentanil alone.
However, lung oedema did develop in certain animals
regardless of the immobilization drug used.

Etorphine immobilization

Arterial pressure (mean, standard deviation and range)
obtained for Group 1 elephants, irrespective of whether they
developed lung oedema or not, is shown in Table 2. A total
of 13 elephants in this group developed lung oedema at
capture, and had a mean arterial blood pressure of 182 ±
15 mm Hg. This figure was higher than that of the remaining
group of elephants in which no oedema was observed
(172 ± 19 mm Hg; n = 58).

Etorphine/azaperone and carfentanil/azaperone
immobilization

Also shown in Table 2 are the blood pressure values
obtained for Groups 2 & 3. Mean arterial blood pressure in
both these groups was found to be significantly lower (p <
0.05) than that obtained in Group 1. No cases of lung
oedema were observed in either Group 2 or Group 3.

Discussion

Numerous studies describe the successful immobilization of
both African and Indian elephants with etorphine (Wallach
& Anderson 1968; Jainudeen, Bongso & Peraera 1971;
Alford, Burkhart & Johnson 1974; Tamas & Geiser 1983;
Byron, Olsen, Schmidt, Copeland & Byron 1985; Sale,
Rishi, Singh & Verma 1986; Heard, Kolliaas, Webb, Jacob-
son & Brock 1988) or carfentanil (Dunlop, Hodgson,
Steffey & Fowler 1985). However, quantitative information
regarding blood pressure in elephants immobilized with
these drugs is limited. In particular, no data are available for
elephants immobilized with etorphine or carfentanil subse-
quent to being herded by helicopter as was the case in this
study. Dunlop, Hodgson, Cambre & Kenney (1988) record-
ed an ear arterial blood pressure of 190 mm Hg immediately
after the immobilization of an elephant with etorphine.
Similarly, arterial pressures between 150 and 220 mm Hg
were measured in unherded elephants (n = 8) immobilized
with etorphine (Hattingh, Knox & Raath, unpub. data).
These observations, although made on adult animals which
were not herded prior to immobilization, cannot be assumed
to represent control values (i.e. obtained in resting,
conscious elephants). To date, the only arterial blood
pressure measurements obtained under conditions which
approximate the resting state in elephants come from
Honeyman, Pettifer & Dyson (1992) who reported a mean
arterial blood pressure of 145 ± 3 mm Hg in conscious,
standing animals (n = 15). It would appear from these data
that elephants in this study immobilized with etorphine
alone (i.e. Group 1) were hypertensive.

Of interest in this study was, firstly, that elephants
immobilized with azaperone mixtures (Groups 2 & 3) dis-
played lower arterial blood pressures than those given
etorphine alone (Group 1) and, secondly, that all cases of
lung oedema were Group 1 animals. The current hypothesis,
which tends to be supported by these observations, is that
the development of lung oedema (revealed by histopatho-
lological examination of lung tissue) is related to changes in
blood pressure. One suggestion is that a rise in arterial blood
pressure in response to various stressors experienced during
capture increases afterload and leads to left ventricular
failure (pers. com., Dr Roy Bengis). On the basis of this
suggestion, an attempt was made to overcome possible

Table 1

<table>
<thead>
<tr>
<th>Year</th>
<th>Drug</th>
<th>Total number of animals caught</th>
<th>Lung oedema (%)</th>
<th>Mortality (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989</td>
<td>Etorphine alone</td>
<td>109</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>1990</td>
<td>Etorphine alone</td>
<td>94</td>
<td>14</td>
<td>2</td>
</tr>
<tr>
<td>1991</td>
<td>Etorphine alone</td>
<td>135</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>1992</td>
<td>Etorphine alone</td>
<td>71</td>
<td>18</td>
<td>6</td>
</tr>
<tr>
<td>1992</td>
<td>Etorphine alone</td>
<td>71</td>
<td>18</td>
<td>6</td>
</tr>
<tr>
<td>1993</td>
<td>Carfentanil</td>
<td>109</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>1993</td>
<td>Carfentanil</td>
<td>109</td>
<td>10</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 2

<table>
<thead>
<tr>
<th>Group</th>
<th>Drug/s</th>
<th>N</th>
<th>Arterial pressure (mm Hg)</th>
<th>Range (mm Hg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Etorphine alone</td>
<td>71</td>
<td>174 ± 16</td>
<td>137 - 212</td>
</tr>
<tr>
<td>2</td>
<td>Etorphine and azaperone</td>
<td>109</td>
<td>120 ± 29*</td>
<td>56 - 184</td>
</tr>
<tr>
<td>3</td>
<td>Carfentanil and azaperone</td>
<td>26</td>
<td>131 ± 17*</td>
<td>116 - 164</td>
</tr>
</tbody>
</table>

* Value significantly lower (p < 0.05) than that of Group 1.
blood pressure elevation by using azaperone which has antago-

nistic peripheral $\alpha_1$-adrenergic receptor properties (Melt-

tzer & Swan 1988).

A number of stressors experienced by the elephants dur-
ing capture may result in increased arterial blood pressure,
thereby playing an important role in the development of
lung oedema. Firstly, etorphine itself may be responsible;
hypertension associated with the use of this drug has been
documented in the horse (Daniel & Ling 1972; Lees & Hill-
didge 1975; Bogan, MacKenzie & Snow 1978). Secondly, the
study carried out by Honeyman et al. (1992) suggests
that postural changes during immobilization may be im-
portant. These authors recorded arterial blood pressure in
elephants at various times after the animals had assumed
lateral recumbency and observed a gradual increase between
1.7 minutes (162 $\pm$ 7 mm Hg) and 16.5 minutes (180 $\pm$
9 mm Hg) after they initially became recumbent. It was con-
cluded that the animals developed a positional hypertension
due, in part, to catecholamine release. Finally, the stress of
herding and forced exercise is probably a major factor con-
tributing to the development of lung oedema observed in
some individuals. The culling procedure has been shown to
result in increased plasma cortisol and catecholamine
concentrations in elephants (Hattingh, Wright, De Vos,
McNairn, Ganhao, Silove, Wolverson & Cornelius 1984),
which reflects mass sympathetic nervous system discharge.
While the majority of elephants appear to tolerate the effects
of herding and immobilization, certain individuals succumb
to the various stressors involved. The reason for this
apparent susceptibility and subsequent development of lung
oedema is not clear and requires further investigation.

Although further studies are indicated to elucidate the
causative factors in the development of lung oedema, the
observation that its incidence is eliminated by the use of
azaperone is significant. It is thus recommended that this
drug be added to immobilization mixtures when elephants
are being captured in the manner described above.

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