Tutorial Article

Anaesthesia of donkeys and mules

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Introduction and definitions

Although donkeys are not widely used or commonly found in the USA, a 1994 Food and Agriculture Organisation (FAO) estimate put the world population of donkeys at over 44 million (Loew 1996), and there are approximately 15 million mules (Fielding 1991). Most of these animals reside in Asia and the developing nations of Central and South America and Africa. In many of these countries, because of drought and shifting populations, use of donkeys appears to be increasing (Starkey 1994), despite many myths and misconceptions about these animals (Starkey 1995).

When considering the horse, donkey and mule, it is important to know the definitions of the species. The **donkey** (*Equus asinus*), **ass** or **burro** (the term commonly used in the countries of the western and southern hemispheres) is a separate species from the **horse** (*Equus caballus*). The ass has been used for centuries as a beast of burden and has adapted to survive in variable climates, especially those desert or mountainous regions where the horse does not thrive naturally.

This evolution and a variety of uses by man have produced **great variety in types of donkeys**, from the **wild Somalian ass**, to the **Sicilian donkey** (originally miniaturised to work in mines; now known simply as the miniature donkey and registered by height) to the **Mammoth ass** (also registered by height and ranging from 137 to 142 cm at the withers); the **Mammoth ass** was originally bred in the United States from Spanish and French stock for production of large mules.

A **mule** is a sterile, hybrid product of a mare bred to a **jackass** (male ass), while the **hinny** is the hybrid **product of a stallion and a jenny** (female donkey). The mule combines traits of both its donkey and horse background, leading to **great diversity of size, temperament and body type** ranging from miniature mules to draft mules. During the 1920s 1930s and 1940s, the USA was one of the largest breeders of mules in the world; the animals were used for farmwork, logging and carting, and they were exported throughout the world. Although mules have been used extensively in the USA Europe and Mexico, many countries do not use or breed mules because of religious or cultural reasons.

Because of the worldwide importance of donkeys and mules, it is justified to consider anaesthetic management in these animals. **Our purpose is to review the physiological and behavioural differences in donkeys and mules, compared to horses, and to discuss how these differences affect anaesthetic management.**

Physiology and pharmacology

Donkeys physiology is significantly different from that of the horse. Many of these differences may be related to the fact that the donkey appears to be **desert-adapted**; the donkey may be able to conserve blood volume and maintain circulatory adequacy, allowing it to function after 20% dehydration (Yousef *et al.* 1970). Pituitary gonadotropins (Roser *et al.* 1984), skeletal muscle fibre types (Snow and Guy 1980), haemoglobin phenotypes (Osterhoff 1984), milk composition (Oftedal 1988) and circulating relaxin (Stewart *et al.* 1992) have been documented to differ betwen donkeys and horses.

These differences seem to produce disease in certain circumstances; neonatal isoerythrolysis appears to be more common in mule than in horse foals (McClure *et al.* 1994; Traub-Dargatz 1995) and donkeys may be more susceptible to hyperlipaemia than horses (Moore *et al.* 1994). While differences in subgroups of donkeys have been reported for haematological and biochemical values (Zinkl *et al.* 1990), these subgroups have not been investigated completely. With respect to exercise physiology and adaptation to altitude, donkeys appear to adjust similarly to horses after training (Yousef *et al.* 1971; Mueller *et al.* 1994; Foster *et al.* 1995).

Fig 1: Mammoth ass sedated with xylazine and butorphanol prior to injectable anaesthesia with ketamine.

Fig 2: Donkey recovering from inhalant anaesthesia: lying quietly in recovery stall.

Fig 3: Donkey restrained behind a swing gate prior to induction of anaesthesia

In addition, **differences in drug distribution and metabolism** have also been documented. Ampicillin (Horspool *et al.* 1992), amikacin (Horspool *et al.* 1994), oxytetracycline (Horspool and McKeller 1990), triclabendazole (Kinabo and Bogan 1989), gentamicin (Miller *et al.* 1994; Welfare *et al.* 1996) and phenylbutazone (Mealey *et al.* 1997) have been investigated. Although drug distribution may vary, there may be differences in drug metabolism; the donkey may possess an increased metabolic capacity for certain drugs, which may alter dosing intervals (Kinabo and Bogan 1989; Mealey *et al.* 1997). This may be related to differences in cytochrome P450 isoenzymes (Peck *et al.* 1997).

Numerous reports document the return to sedation following the antagonism of etorphine with diprenorphine in donkeys. This may be due to the donkey's unique ability to metabolise the N-alkyl substituent of diprenorphine, converting the antagonist into an agonist (Dobbs 1972).

Behavioural and anatomical differences

With this background, it is not surprising that physiological variations among equids contribute to differences in responses to individual drugs and combinations of drugs. However, it is also important to recognise behavioural differences between the donkey and horse (Taylor and Matthews 1997). **The donkey is not driven by the same 'fight or flight'** instincts as the horse. It is by nature much more inclined to stop and face frightening objects, accept restraint (e.g. head ties or manual restraint) and **not panic under unknown conditions (including recovery from anaesthesia)**. The donkey also does not appear to show pain as graphically as the horse; it is much more stoic (which may be detrimental in donkeys with gastrointestinal disease). Donkeys generally do not appear to be as responsive to the use of a nose 'twitch' as the horse; immobilisation is best accomplished with stocks or by 'snubbing' the donkey to a stout object.

It is also best to use a different technique for injections in donkeys and mules; **press the needletip lightly against the skin and gradually increase the pressure until the needle penetrates the skin.** Unlike the horse, which will move away from this pain, the donkey will generally lean into the needle. Donkeys' and mules' skin is thicker than horses' skin; therefore hypodermic injections and placement of i.v. catheters are facilitated by positioning the needle slightly more perpendicular in relation to the skin surface.

Given the widespread distribution of the donkey population in the world and the length of time that they have been utilised by man, it is not surprising that many combinations of tranquilisers and anaesthetics have been employed. **Table 1 summarises some of the older drugs and drug combinations which have been used in donkeys**, for sedation as well as general anaesthesia. Acupuncture meridians have been investigated in donkeys (Yu *et al.* 1994) and reported to be 'largely coincident' with those of the horse.

Pre-anesthetic and injectable anaesthetic agents

With the introduction of xylazine and ketamine, a combination of the 2 drugs rapidly became favoured for equine anaesthesia. Reports of poor results in donkeys and mules (Short 1987) led us to investigate this combination and **Table 2** summarises the doses which have been evaluated. Several factors appear to contribute to poor results:

1) The pharmacokinetics of ketamine differ in the donkey and mule from the horse (Matthews *et al.* 1994). Clearance of ketamine is most rapid in the Mammoth ass, followed by the mule and horse.

2) Recumbency time is probably influenced by sedation produced by xylazine. Clinically, mules appear to require approximately 50% more xylazine (and probably other alpha-2 agonists) than donkeys or horses. However, the pharmacokinetics of xylazine have not been investigated in the donkey and mule.

3) The animal's background must be considered and

TABLE 1: Drug combinations used for sedation, standing surgery local and regional anaesthesia, and general anaesthesia in donkeys

Drug	Dose	Procedure	Reference
Lignocaine HCl	20 ml, 2%	Regional limb block	Al-Badrany et al. (1989)
Procaine HCl	8–10 ml 1% 30 ml 2%	Posterior epidural Anterior epidural	Shoukry et al. (1975)
Propionyl-phenothiazine and local	Not reported	Standing laparotomy	Nassef (1983)
Acepromazine and chloral hydrate	Not reported	Standing procedures	Hays (1977)
Triflupromazine and procaine	80 mg i.m. 7 ml, 2%	Canker debridement	Pratap (1987)
Acepromazine and xylazine	0.04 mg/kg bwt i.v. 1.0 mg/kg bwt i.v.	Sedation	Kalhoro et al. (1991)
Acepromazine and chloral hydrate	0.1 mg/kg bwt i.m. 10% to effect	Intestinal anastomoses	Singh et al. (1988)
Propionyl-phenothiazine and pentobarbitone and ether/chloroform (2:1)	Not reported	Not reported	Madani and Adams (1976)
Chloral hydrate	Not reported	Ventral abdominal hernia	Nigam and Misk (1984)
Propionyl-phenothiazine and chloral hydrate	0.023 mg/kg bwt 4 g/50 kg bwt	Various	Tantawy (1980) Samy et al. (1986)
Dipyrone and chloral hydrate	20% 1 ml/10 kg bwt 4 g/50kg bwt	Anaesthesia alone	Samy et al. (1986)
Chloral hydrate and thiopental	Not reported 10 mg/kg bwt	Anaesthesia alone	Samy et al. (1986)
Lidocaine and thiopental	2%, 2 mg/kg bwt Not reported	Not reported	Youssef et al. (1991)

TABLE 2: Recumbency times (min) with various injectable anaesthesic combinations in donkeys, mules and horses

Drug combination	Donkeys[†]	Mules[†]	Horses[‡]
Xylazine (1.1 mg/kg bwt i.v.) Ketamine (2.2 mg/kg bwt i.v.)	24.0	14.0	23.0
Xylazine (1.1 mg/kg bwt i.v.) Butorphanol (0.04 mg/kg bwt i.v.) Ketamine (2.2 mg/kg bwt i.v.)	37.0	25.1	23.5
Xylazine (1.1 mg/kg bwt i.v.) Telazol* (1.1 mg/kg bwt i.v.)	43.0	21.1	30.7
Detomidine (0.02 mg/kg bwt i.v.) Ketamine (1.1 mg/kg bwt i.v.)	?	?	26.8

*Telazol is a combination of tiletamine and zolazepam (50 mg/ml of each drug). [†]Matthews et al. 1992; [‡]Matthews et al. 1991.

TABLE 3: Anaesthetic regimens for donkeys and mules

	Donkeys (mg/kg bwt i.v.)	Mules (mg/kg bwt i.v.)
Preanaesthetics		
Xylazine or	1.1	1.6
detomidine with	0.02	0.03
butorphanol	0.033–0.04	0.033–0.04
or diazepam	0.033	0.033
Induction		
Ketamine	2.2	2.2
Maintenance		
Additional injectables	1/4–1/2 original dose	1/4–1/2 original dose
Inhalants	halothane isoflurane sevoflurane	halothane isoflurane sevoflurane

although we have had good success sedating **domesticated donkeys** with doses of xylazine suitable for horses, untamed or feral equids of all types require significantly, 2 or 3 times, more xylazine than tamed or domesticated equids. Therefore, one should not expect to sedate a wild burro satisfactorily with a typical dose of xylazine for a horse. Administration i.m. xylazine (2 mg/kg bwt) and ketamine (4.4 mg/kg bwt) has been shown to be effective for producing anaesthesia in donkeys (Mbiuki and Mogoa 1991).

Sedation produced by **detomidine** has been investigated in donkeys (Mostafa et al. 1995). Doses of 5 and 10 µg/kg bwt produced effective sedation, while 20 µg/kg bwt produced deep sedation. These doses are similar to those used in the horse. Again, our clinical experience is that mules require approximately 50% more detomidine for effective sedation than donkeys or horses (**Table 3**).

Donkeys require approximately 40% less **guaifenesin** to produce recumbency than do horses (Matthews et al. 1996). Although they clear guaifenesin faster than horses,

they remain recumbent longer.

Mixtures of guaifenesin and thiamylal or thiopentone can be used for donkey and mule anesthesia but caution should be used to avoid overdepression. The mixture of **guaifenesin-xylazine-ketamine** (GKX) has been widely used and evaluated in horses and ponies (Lin *et al.* 1993; Young *et al.* 1993). In our experience, when the mixture contains 1 mg/ml of ketamine, it has been less satisfactory in donkeys and mules than in horses. Since the distribution and metabolism of guaifenesin and ketamine differ from the horse (Matthews 1994), donkeys and mules may require a different 'recipe' for this mixture. We have yet to evaluate the more recent GKX mixture, with 2 mg/ml of ketamine.

The regimen of **detomidine and propofol** has been evaluated for use as an i.v. anaesthesic in horses and donkeys. In donkeys, premedication with detomidine (0.015 mg/kg bwt i.v.) was followed by induction of anaesthesia with a bolus of propofol (2 mg/kg bwt i.v.) (Hartsfield *et al.* 1994). Anaesthesia was maintained with a propofol infusion (mean infusion rate; 0.21 ± 0.03 mg/kg bwt/min). Surgical conditions were satisfactory for carotid artery exteriorisation and the anaesthesia time was 102 ± 17 min (mean ± s.d.). After stopping the propofol infusion, time to standing was 43.5 (mean ± s.d. 13 min), and the quality of recovery was always excellent.

In horses, premedication with detomidine (0.015 mg/kg bwt i.v.) was followed by induction of anaesthesia with propofol (2.0 mg/kg bwt i.v.) (Matthews *et al.* 1997). Anaesthesia for abdominal exploratory was maintained with a propofol infusion (0.18 mg/kg bwt/min). Mean anaesthesia time was 61 ± 19 min and time to standing was 67 ± 29 min. We have not investigated the use of propofol in mules.

Inhalant anaesthesia

Inhalant anaesthesia in donkeys and mules appears to be quite similar to that in the horse, although our clinical impression is that the size of the trachea in a donkey may be slightly smaller than in a comparably-sized horse; and the donkey may therefore require a slightly smaller endotracheal tube. The donkey's nostril size also appears to be smaller, which makes nasotracheal intubation when indicated, difficult. The MAC-values for halothane and isoflurane in the donkey are 1.51% (s.d. 0.25) and 1.29 (s.d. 0.02) respectively (Mercer and Matthews 1996). Although the halothane MAC-value is somewhat higher than reported for horses, it is very similar to that reported in ponies (mean 1.4% ± 0.11) (Matthews and Lindsay 1990). We are not aware of any MAC studies in mules.

Monitoring depth of anaesthesia in donkeys and mules is somewhat different than in the horse, in which 'eye signs' (e.g. nystagmus, corneal and palpebral refexes and rotation of the globe) are usually reliable indicators of the depth of anaesthesia. **In donkeys, the eye tends to remain very quiet even when the animal is in a very light plane of anaesthesia.**

The use of blood pressure monitoring is strongly advised, since it seems to provide a more reliable indicator of anaesthetic depth. It would be interesting to know if the donkey's stress response to anaesthesia is similar to that seen in the horse. Our clinical impression and examination of anaesthetic records do not indicate any differences in mean blood pressures between anaesthetised donkeys, mules, and horses. Fluids i.v., support of blood pressure (e.g. use of cardiotonic or vasoactive drugs) and appropriate padding should be used in all anaesthetised equids. Size and age of the equid influence 'normal' variables, such as, heart rate and blood pressure, while, **in the case of large Mammoth asses or draft mules, particular care to provide good padding and support of limbs is important.** Our clinical observation is that respiratory rate and character are different in donkeys than in horses and mules; respiratory rate tends to be higher, with less excursion of the rib cage.

Our usual, clinical regimen for anaesthesia in mules and donkeys is presented in **Table 3**. Doses are guidelines and are modified based on the clinical status of the animal and the values of physiological variables monitored during the procedure. The clinician should keep in mind that, because of behavioral differences discussed above, the donkey or mule presented for emergency surgery may be more ill than expected.

Anaesthetic recovery

Recovery from anaesthesia tends to be smoother and somewhat longer in donkeys and mules than in horses. Mules show greater variation, which seems to depend on the type of horse from which they are derived (e.g. 'hot' or 'cold'-blooded). Sedatives for recovery are generally not necessary; and donkeys almost always lie quietly until they are coordinated enough to stand. Occasionally, they may need assistance on the tail to facilitate standing and they frequently stand rear limbs first, similar to a cow.

Summary

Great variabilities in the sizes and types of donkeys and mules affects the choice of drugs and anaesthetic management of these equids. Most of the difference between donkeys, mules and horses is apparent when using injectable anaesthetic regimens, since these drugs are distributed and metabolised at rates different from the horse. With inhalant anaesthesia few differences are seen between equids. However, it is helpful for the clinician to recognise behavioural differences between donkeys, mules and horses which impact on anaesthetic management.

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