A comparison of the v-gel® supraglottic airway device and non-cuffed endotracheal tube in the time to first capnograph trace during anaesthetic induction in rabbits

Abstract

Background: Rabbit anaesthesia can be a daunting prospect for many veterinary professionals. Their intubation can be difficult; because of this many rabbits are not intubated during major surgery.

Aim: To compare two methods of rabbit intubation and evaluate which achieved a reliable airway in the least time. This will in turn hopefully encourage veterinary nurses to take a more proactive role in rabbit anaesthesia.

Materials and methods: Eight rabbits that were admitted for elective neutering were randomly assigned either an endotracheal tube or a v-gel®. Using capnography the ease and success rate of intubation was assessed.

Results: The time taken to intubate a rabbit in the v-gel group was quicker than using an endotracheal tube.

Conclusion: The v-gel proved to be a reliable method to intubate a rabbit, reducing the risk of trauma to the patient.

Keywords: v-gel®, rabbit, anaesthesia, endotracheal tubes, intubation, capnography

Ideally all rabbits undergoing an anaesthetic procedure should be intubated. Visualising the larynx in rabbits is difficult, therefore intubation using an endotracheal tube (ETT) requires a careful technique and is often abandoned to avoid laryngeal trauma. Masking rabbits is unreliable as they can hold their breath at the smell of isoflurane and sevoflurane (Eatwell, 2011).

Phaneuf et al (2006) studied tracheal injury after endotracheal intubation in rabbits. Looking at a total of 26 rabbits, the study found that rabbits that had prolonged intubation, slight movement of the tube during repositioning or ventilation, and repeated intubation showed marked tracheal injury on histology. They also noted that many cases of tracheal damage go unreported with the potential for post-operative mucosal necrosis and death due to respiratory obstruction.

Deborah Richardson DipAVN, Veterinary Nurse at Cheshire Pet in Holmes Chapel, UK

Achieving a patent airway quickly with no trauma to the patient, and the ability to perform intermittent positive pressure ventilation (IPPV) with minimal isoflurane waste emission, is important for successful anaesthesia (Crotaz, 2013). Laryngeal Mask Airways (LMA), a type of supraglottic airway device (SGAD), are a suitable alternative for gas delivery in rabbits, but there is significant waste of anaesthetic gas (Smith et al, 2004). Nasal intubation is another alternative, especially in small rabbits where orotracheal intubation is even harder. Both Varga (2014) and Eatwell (2011) advise this should not be used in preference to oral intubation as it has the added risk of introducing pathogens into the trachea and subsequently the lung (Varga, 2014).

Upper respiratory tract anatomy of rabbits

Rabbits have a long narrow mouth, with limited mandibular and maxillary movement as well as a pair of large incisors and tongue. All these contribute to difficulty visualising the epiglottis for intubation. Rabbits are obligate nasal breathers; the tongue covers the epiglottis and has to be disengaged from the soft palate prior to intubation (Eatwell, 2011). Laryngospasm can occur during intubation as the glottis is small and ventrally situated, also making it difficult to see even with a laryngoscope (Tran et al, 2001).

Due to the small rima glottidis, ETTs sized between 2–4 mm are used depending on the size of the rabbit (Eatwell, 2011). Therefore rabbits can often breathe around the tube. O'Dwyer et al (2013) advises, in accordance with Poiseuille's equation, that ETTs create 16 times more resistance than v-gels.

Development of supraglottic away device (SGAD)

The v-gel® (Docsinnovent®) is a descendent of the i-gel, a second generation SGAD designed for use in humans. It provides a safe way to deliver and maintain anaesthesia without having to intubate and risk the potential trauma to the airways (Nasir, 2014). *Figure*

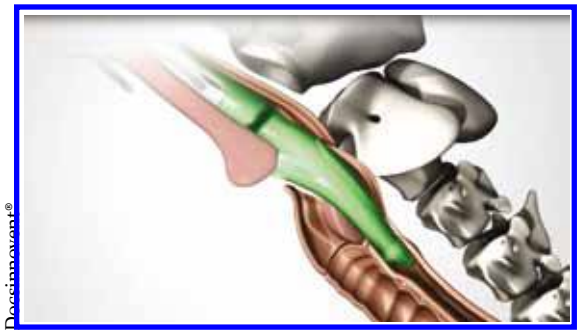

Figure 1. Showing the correct placement on the rabbit v-gel®.

1 shows the tip of the device lying in the opening of the oesophagus, closing off the oropharyngeal inlet; the device shape can then form a seal over the laryngeal inlet (Kannaujia et al, 2009). The v-gel is species specific, and includes a bite block and to minimise rotation, and a buccal stabiliser (this adapts to fit the natural curve of the patient's oropharynx, which ensures a seal is maintained even with a small amount of rotation).

Use of the supraglottic airway device in cats

Brodbelt (2010) found that healthy cats were nearly twice as likely to die under anaesthesia compared with dogs. They concluded that respiratory problems caused by endotracheal intubation, inadequacy of ventilation, and trauma to the upper airway were some of the major causes. In a study of 79 178 healthy cats and 8209 rabbits undergoing anaesthesia, Brodbelt et al (2008) calculated that the risk of death in cats was 1:419 (0.24%) compared with the risk of death in rabbits at 1:72 (1.39%), with the risk increasing to 1:14 (7.37%) in sick rabbits. They also concluded that compared with a study carried out by Clarke and Hall in the mid-1980s, anaesthetic risk had greatly reduced over the last 20 years. These results show that rabbits are the small animal at the highest risk of death intra and post operatively encouraging the advancement of safer anaesthetic techniques.

V-gels do not fully protect against regurgitation, which is a concern when v-gels are used in feline patients likely to have an endoscopy or where emesis is a risk (Dorfelt and Hecker, 2013). This is not a concern in rabbits as they cannot regurgitate (Varga, 2014), however the mouth must be clear of any food before inserting the SGAD or ETT. A study by Bateman et al (2005) compared using a facemask and a LMA in 16 large rabbits during isoflurane anaesthesia. The study found that the LMA was advantageous over the facemask, but the LMA with intermittent positive pressure ventilation (IPPV) created gastric tympanism in four of the rabbits. This study used LMAs that were not species specific as v-gels are, however as v-gels become more widely used for IPPV this is an area that requires further investigation.

It is likely that using v-gels in rabbits will allow quicker and easier insertion, resulting in less reliance on masked anaesthetics and reduced environmental leakage, protecting the anaesthetist and surgical team. A study in cats comparing the v-gel SGAD with cuffed ETT for airway management in 20 cats found that the time taken to the first reading was significantly shorter in the v-gel group (van Oostrom et al, 2013).

ETT

ETTs should be measured before insertion to the level of the larynx, if inserted too far endobronchial intubation occurs, this can cause hypoxia and cyanosis as the other lobe of the lung cannot assist with respiration (Bryant, 2009). Watney (2003) advises that ETT are usually supplied too long and are meant to be cut down to the correct length, in the author's experience this rarely happens. In addition, caution should be used with a cuffed ETT; over-inflation of the cuff, such as above 30 mmHg, can cause ischaemia risking serious mucosal damage in rabbits (Nordin et al, 1977), therefore it is not recommended to inflate the cuff above 20 mmHg. This is supported by a more recent study in human medicine by Sengupta et al (2004). Rabbit v-gels are designed without a cuff to prevent trauma and displacement if the cuff is over inflated (*Figure 2*).

Figure 2. The non-cuffed v-gel®, the open port is where the side stream capnograph is attached to reduce dead space.

Safe rabbit anaesthesia

In 1963 The American Society for Anaesthesiologists (ASA) created a framework across human and veterinary medicine. The framework categorised

what a patient's preoperative health status was in order to allow professionals to uniformly assess the anaesthetic risk (Daabiss, 2011) (*Table 1*).

The rabbit's ability to conceal an underlying illness means that the health of the rabbit can be difficult to assess. Varga (2014) supports this and asks anaesthetists to consider environmental stress such as loud noises, a strange environment, the presence of possible predators, and physical restraint, which could cause the release of catecholamines that may lead to cardiac arrhythmias. Preoperative gut stasis caused by illness or pain must be stabilised prior to any anaesthetic. Therefore Eatwell and Mancinelli (2013) suggest rabbits should be graded between II and IV.

Table 1. ASA Physical Status Classification System

Grade	Risk specification
I	Normal healthy patient
II	Patient with mild systematic disease
III	Patient with severe systematic disease
IV	Patient with severe systematic disease that is a constant threat to life
V	Moribund patient that is not expected to survive without the operation
VI	A declared brain dead patient whose organs are to be removed for donor purposes

(Eatwell and Mancinelli, 2013; ASA, 2014)

Capnography

Pulse-oximetry (PO) and capnography allow the anaesthetist to assess patient ventilation noninvasively. PO measures the percentage of oxygen saturation in haemoglobin (SPO_2) and pulse rate. The results have limitations as there can be a delay in reported hypoxia without identifying a cause.

Capnography measures the concentration of carbon dioxide (CO_2) in respiratory gases, assesses lung perfusion and ventilation (Chitty, 2008). There are two types of capnograph, a mainstream and a sidestream, the latter being better suited to smaller weight patients as it uses smaller sampling volumes. An infrared beam projects through the sample of expired air, the beam is absorbed by the CO_2 molecules present, a photodetector then calculates how much light is not absorbed, and so measures the end tidal CO_2 concentration ($ETCO_2$) (Bilborough, 2006). The $ETCO_2$ reflects arterial CO_2 levels very closely, making capnography a reliable, real time monitor, which reacts faster than PO in an emergency (Eatwell, 2011).

Materials and methods

Animals

Eight rabbits that came into the practice in a 2 week period were included in this study. They were of mixed breeds, one male and seven female, weighing between 2–3.5 kg, aged between 8 months to 5 years old, and individually requiring elective neutering. They all were classified as ASA II to III as six of the rabbits were from rescue organisations, which had limited information regarding their background; however there were no apparent health issues. The owners gave consent to the study and a specific research consent form was signed. The owners were aware that they could withdraw from the study at any time. Harper Adams University provided such forms of consent to the owners and for the practice. The study was passed by the Harper Adams University Ethics Committee.

The rabbits were randomly assigned into one of two groups by a third person, who was not attached to the study. The first group were intubated with the v-gel, and the second group were intubated with the ETT. In group 2 the technique used to intubate was one recommended by Eatwell (2011) using an otoscope to visualise the epiglottis. This technique was used in favour of the blind method and the number of attempts to intubate was limited to three in order to reduce risk of causing tracheal trauma.

Procedure

The anaesthetic and surgical procedures were carried out each time by the same veterinary surgeon and veterinary nurse; the veterinary surgeon was more practised with the ETT than the v-gel. All rabbits were weighed and given a premedication of medetomidine (Domitor, Elanco Companion Animal Health) 0.2 mg/kg, combined with ketamine (Ketamidor, Chanelle Vet UK) 10 mg/kg given intramuscularly (IM). Once sedation was observed, the patient was pre-oxygenated using a mask for 3 minutes. The right ear was clipped exposing the lateral ear vein and butorphenol (Torbugesic, Zoetis UK LTD) 0.05 mg/kg administered intravenously (IV). All rabbits were given Meloxicam (Boehringer Ingelheim LTD) 1.5 mg/kg subcutaneously (SC) for post-operative analgesia and a 40 ml subcutaneous bolus of a crystalloid to aid maintenance of hydration.

Assessment of a suitable depth of anaesthesia was made by: loss of palpebral reflex; loss of pedal withdrawal; and lack of gag reflex. The time was recorded from this point to the first acceptable wave on the capnograph (a small castle-shaped wave). Patients were placed in sternal recumbency while the larynx was desensitised using a lidocaine spray (Intubeaze Oromucosal Spray; Dechra Veterinary Products LTD). This was dribbled down the inside of

the otoscope cone after checking the mouth was free of food. Both the ETT and the v-gel were connected to the capnograph prior to insertion. The v-gel was lubricated with a water-based spray immediately prior to insertion, all rabbits were held with their head and neck extended, and using tissue forceps the tongue was pulled to the side so the incisors did not cause any trauma. The device was inserted diagonally until the incisors had been bypassed, then slid freely back in a straight line until resistance was met. At this point it was found that the rabbit's breath could be clearly heard. Once a reading was seen on the capnograph, it was ensured there was no rotation of the device and the incisors lined up with the bite guard. Once intubated both devices were secured with a white open weave bandage, tied behind the ears and then positioned in dorsal recumbency for surgery. Patients were connected to a ventilator (Vetronics SAV03) used as an open T-piece, which provided mechanical ventilation if necessary.

All rabbits were maintained with isoflurane and oxygen, and monitored using a capnograph (Vetronics, Impact III) which included a PO and mini temperature probe. The patient was kept warm with a heat mat and insulation wrap. Once the surgery was finished all rabbits received 2 minutes of post-oxygenation, followed by atipamazole (Antisedan; Elanco Companion Animal Health) 0.2 mg/kg IV to antagonise the medetomidine. As advised by Eatwell and Mancinelli (2013) the intubation device was removed when pedal withdrawal reflexes began to return.

Results

The results for the data collected are shown in *Table 2* (the rabbits were operated on in the order given in the table). All v-gel placements were successful first time except for Alfie — the correct v-gel was chosen based on the weight of the rabbit, however he was a brachycephalic type and the R2 could not be positioned correctly without using force; no force should be used, if resistance is met a smaller v-gel should be chosen. The R2 was removed and the patient oxygenated with a mask while the R1 was prepared.

Lingual cyanosis was noted in Beatrice and Alfie; however the PO and capnograph readings remained normal. This was resolved once the device was repositioned. Breath sounds were clearly audible in rabbits intubated using the v-gel compared with ETTs where heavy reliance on the capnograph was needed to confirm intubation.

Intubation time was dramatically longer in group 2 than group 1. It was noted that the first two rabbits, once intubated, held their breath and had to be mechanically ventilated for 5 minutes. Further investigation showed that the patients had not reached the appropriate level of anaesthesia required to intubate. To rectify this the veterinary surgeon and veterinary nurse carrying out the procedure ensured that the gag reflex was totally absent before commencing intubation.

Discussion

There appears to be a difference that is clinically significant between v-gels and ETTs. The v-gels reduced the time taken in this study to achieve an

Table 2. The time taken for successful intubation from desensitisation of the larynx to the first appropriate wave on the capnograph using endotracheal tubes (ETT) and v-gels®

Rabbit	Procedure	Group	V-gel / ETT	Time to 1st capnograph wave (mins/secs)	Notes
Beatrice	Spay	1	V-gel	0.30	Lingual cyanosis — repositioned
Alfie	Castration	1	V-gel	1.30	Swapped from R2 to R1 Lingual cyanosis — repositioned
Lulu	Spay	2	ETT	3.14	2nd attempt
Fudge	Spay	2	ETT/v-gel	6.00/0.18	3 attempts failed/ swapped to v-gel
Leah	Spay	1	V-gel	0.27	
Paloma	Spay	2	ETT	5.07	2nd attempt
Jane	Spay	2	ETT/v-gel	5.00/0.30	3 attempts failed/ swapped to v-gel
Desdemona	Spay	1	V-gel	0.30	

adequate airway compared with ETT. The small sample size meant that statistical analysis was not suitable, and further study with larger numbers is required to determine statistical significance. Group 2 had a 50% success rate, the failed attempts to place an ETT could have been due to the otoscope cone length being too short, as the veterinary surgeon struggled to visualise the epiglottis in two of the rabbits.

Two rabbits in group 1 experienced lingual cyanosis, these were the first two in the study. This could have been due to user error. Slade (2012) suggests over-insertion or not enough lubrication could cause this; repositioning of the v-gel resolved the problem. The monitoring equipment did not alert at this time to suggest the rest of the patient was affected. This supports Kazakos et al's (2007) conclusion that the lingual compression was localised. Lingual cyanosis is caused by compression of the lingual vein at the base of the tongue. Therefore slight adjustment of the v-gel can relieve this pressure and resolve the cyanotic effect.

The main problem encountered in this study was preventing the anaesthetic equipment from pulling on the intubation device. The ETT were of such small diameter that there was a risk of the tube kinking and causing respiratory obstruction; Phaneuf et al's (2006) study on tracheal injury post endotracheal intubation suggested that rabbits may be predisposed to developing serious tracheal injury and clinically significant sequelae in association with routine intubation. Rabbits have been used extensively as a model for human tracheal injury; mild mucosal injury in humans, such as microscopic lesions or focal loss of cilia, took 7 to 10 days to return to normal, in more severe cases 2 to 6 weeks (Phaneuf et al, 2006). Anatomically humans and rabbits have the same number of tracheal layers, however rabbits may be more susceptible to injury than humans because of an increased reperfusion response to potential pressure caused by the ETT. This is relevant because rabbits may have an underlying illness hence the ASA recommendation of II to IV using the Physical Status Classification System. If there is underlying illness that reduces the patient's healing ability, or if the rabbit has to have multiple intubations, the end result could be serious trauma.

Movement or rotation of the v-gel could cause, the seal to be inadequate or respiratory obstruction. Docsinnovent have tried to combat this problem by advising that v-gels should always be used with capnography, and also that they are used with the purpose designed D-grip (*Figure 3*). However, the D-grip is not suitable to support a ventilator therefore there is scope for further products to be designed for this purpose.

Figure 3. Displays how the d-grip helps to prevent rotation and pulling on the intubation device.

The ventilator on an open setting was chosen over the T-piece which had a low resistance adjustable pressure limiting valve (APL), because patients showed improved ventilation when a capnograph was used. The ETCO2 should be kept between 35–45 mmHG and using the ventilator over the T-piece kept the expired CO_2 levels within this range. Hofland et al (2006) discussed Keuskamp's development of the Amsterdam infant ventilator. His concerns were the high pressure that develops at the 'Y' connector in the Ayres T-piece when using high gas flows. This high pressure facilitates inspiration, but hinders expiration; this could tire the small spontaneously breathing patient easily. Keuskamp's infant ventilator is still used in experimental animal studies today. Stanford (2004) recommends either using a mini T-piece to reduce dead space or mechanical ventilation, both in conjunction with capnography.

Conclusion

Rabbits have always been popular companion animals, with professionals succeeding in educating owners about their pet's physical and emotional needs. Veterinary care has to evolve to meet these needs by providing the safest method of anaesthesia for a challenging species. Striving to reduce risks and improve safety records encourages owners to neuter

their pets or proceed with routine procedures, which in turn bonds that client to the practice.

Achieving an effective patent airway in rabbits without harm, and with ease has been the main objective in this study. The v-gel does achieve this and the device will aid the veterinary profession to bring gold standard care to rabbit anaesthesia. On evaluation the v-gel is well designed, the main issues identified are respiratory obstruction if over inserted, lingual cyanosis due to lingual vascular compression and malpositioning resulting in inadequate ventilation. All these issues have been identified by the manufacturer and the user is provided with solutions to overcome the potential problems.

Veterinary nurses are an essential part of the surgical and anaesthetic team; they make a promise to constantly endeavour to ensure the health and welfare of their patients. Many nurses may feel that intubating a rabbit with an ETT is out of their comfort zone as it is with many veterinary surgeons. The v-gel allows for veterinary nurses to secure an airway in rabbits and start taking more of a lead role in rabbit anaesthesia under the direction and supervision of a veterinary surgeon. **VN**

Acknowledgments: A massive thank you to the fabulous team at Cheshire Pet. Also to North West Rabbit Rescue, RSPCA Local and vet student Tim for allowing their rabbits to take part in this study.

References

American Society of Anesthesiologists (2014) ASA Physical Status Classification System. [On-line] Available from: https://www.asahq.org/resources/clinical-information/asa-physical-status-classification-system (accessed 20th December, 2014)

Bateman L, Ludders JW, Gleed RD, Erb HN (2005) Comparison between facemask and laryngeal mask airway in rabbits during Isoflurane anaesthesia. *Vet Anaesth Analg* **32**: 280–8

Bilborough G (2006) A practical guide to capnography. *In Practice* **28**(6): 312–19

Brodbelt D, Blissett K, Hammond RA et al (2008) The risk of death: A confidential enquiry into perioperative small animal fatalities. *Vet Anaesth Analg* **35**: 365–73 doi: 10.1111/j.1467-2995.2008.00397.x.

Brodbelt D (2010) Anaesthetic deaths in cats in practice. *Veterinary Ireland Journal* **2**(3): 151–6

Bryant S (2009) Capture that airway: Everything you need to know about endotracheal tubes and difficult intubations. [On-line] CVC. http://veterinarycalendar.dvm360.com/capture-airway-everything-you-need-know-about-endotracheal-tubes-and-difficult-intubations-proceedin?rel=canonical (accessed on 8th November, 2014)

Chitty J (2008) The use of capnography in conscious rabbits. [On-line] Association of Avian Veterinarians. Annual Conference & Expo with the Association of Exotic Mammal Veterinarians. Available from: http://www.aemv.org/members_only/AAV%202008%20Small%20Book.pdf#page=75 (accessed 29th November, 2014)

Crotaz IR (2010) Initial feasibility investigation of the v-gel airway: an anatomically designed supraglottic airway device for use in companion animal veterinary anaesthesia. *Vet Anaesth Analg* **37**: 579–80

Crotaz IR (2013) An observational clinical study of cats and rabbits in anatomically designed supraglottic airway device for use in companion animal veterinary anaesthesia. *Vet Rec* **172**: 606

Daabiss M (2011) American Society of Anaesthesiologists physical status classification. *Indian Journal of Anaesthesia* **55**(2): 111–15

Docsinnovent (2010) D-grip tube holder. [On-line] Docsinnovent. Available from: http://docsinnovent.com/products/product/d-grip-tube-holder (accessed on 3 rd January, 2015)

Dorfelt R, Hecker K (2013) Laryngeal tubes: Innovation in small animal anaesthetics. Specialist Article, 3. [On-line] Docsinnovent. http://www.docsinnovent.com/studies (accessed 8th November, 2014)

Eatwell K (2011) Secrets of safe anaesthesia in rabbits. [On-line]. Webinar Club. Available from: http://www.veterinarywebinars.com/membership/assets/webinars/2011-06/webinar_SAA_studynotes.pdf (accessed 19th September, 2014)

Eatwell K, Mancinelli E (2013) Anaesthesia guidelines for airway management in rabbits. *Veterinary Times* 18th March: 14–17

Hofland J, Leendertse-Verloop K, Rupreht J (2006) Keuskamp and the Amsterdam infant ventilator. *Anaesthesia* **61**: 705–12

Kannaujia A, Srivastava U, Saraswat N, Mishra A, Kumar A, Saxena S (2009) A preliminary study of I-Gel: A new supraglottic airway device. *Indian Journal of Anaesthesia* **53**(1): 52–6

Kazakos GM, Anagnostou T, Savvas I, Raptopoulos D, Psalla D, Kazakou IM (2007) Use of the laryngeal mask airway in rabbits: placement and efficacy. *Laboratory Animal* **36**(4): 29–34

Nasir MA (2014) From the pen of the inventor. *Difficult Airway Society* **Summer**: 15–7

Nordin U, Lindholm CE, Wolgast M (1977) Blood flow in the rabbit tracheal mucosa under normal conditions and under the influence of tracheal intubation. *Acta Anaesthesiologica Scandinavica* **21**(2): 81–94

O'Dwyer L, Slade L, Pickup S (2013) Safe delivery of anaesthetic agents in cats and rabbits. *The Veterinary Nurse* **4**(7): 422–8

Phaneuf LR, Barker S, Groleau MA, Turner PV (2006) Tracheal injury after endotracheal intubation and anaesthesia in rabbits. *J Am Assoc Lab Anim Sci* **45**(6): 67–72

Sengupta P, Sessler DI, Maglinger P et al (2004) Endotracheal tube cuff pressure in three hospitals, and the volume required to produce appropriate cuff pressure. *BMC Anaesthesiology* **4**: 8

Slade L (2012) Supraglottic airway devices in cats undergoing routine ovariohysterectomy. *The Veterinary Nurse* **3**(1): 30–5

Smith JC, Robertson LD, Auhll A, March TJ, Derring C, Bolon B (2004) Endotracheal tubes versus laryngeal mask airway in rabbit inhalation anaesthesia: Ease of use and waste gas emissions. *J Am Assoc Lab Anim Sci* **43**(4): 22–5

Stanford M (2004) Practical use of capnography in exotic animal anaesthesia. *Exotic DVM* **6**(3): 57–60

Tran HS, Puc MM, Tran J-LV, Del Rossi AJ, Hewitt CW (2001) A method of endotracheal intubation in rabbits. *Laboratory Animals* **35**: 249–52

van Oostrom H, Krauss MW, Sap R (2013) A comparison between the v-gel supraglottic airway device and the cuffed endotracheal tube for airway management in spontaneously breathing cats during Isoflurane anaesthesia. *Vet Anaesth Analg* **40**(3): 265–71 doi: 10.1111/vaa.12015

Varga M (2014) *Textbook of Rabbit Medicine*. Second Edition. Butterworth Heinemann Elsevier, London

Watney G (2003) Anaesthesia Equipment Resource. [On-line]. ASE. http://asevet.com/resources/ettubes.htm (accessed 20th December, 2014)