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RESEARCH PAPER

# The effect of experience, simulator-training and biometric feedback on manual ventilation technique

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## Abstract

**Objective** To determine the frequency of provision and main providers (veterinary surgeons, nurses or trainees) of manual ventilation in UK veterinary practices. Furthermore, to determine the variation in peak inspiratory (inflation) pressure (PIP), applied to a lung model during manual ventilation, by three different groups of operators (inexperienced, experienced and specialist), before and after training.

**Study design** Questionnaire survey, lung model simulator development and prospective testing.

**Methods** Postal questionnaires were sent to 100 randomly selected veterinary practices. The lung model simulator was manually ventilated in a staged process over 3 weeks, with and without real-time biometric feedback (PIP display), by three groups of volunteer operators: inexperienced, experienced and specialist.

**Results** The questionnaires determined that veterinary nurses were responsible for providing the majority of manual ventilation in veterinary practices, mainly drawing on theoretical knowledge rather than any specific training. Thoracic surgery and apnoea were the main reasons for provision of manual ventilation. Specialists performed well when manually ventilating the lung model, regardless of feedback training. Both inexperienced and experienced operators showed significant improvement in technique when using the feedback training tool: variation in PIP decreased significantly until operators provided manual ventilation at PIPs within the defined optimum range. Preferences for different forms of feedback (graphical, numerical or scale display), revealed that the operators' choice was not always the method which gave least variation in PIP.

**Conclusions and clinical relevance** This study highlighted a need for training in manual ventilation at an early stage in veterinary and veterinary nursing careers and demonstrated how feedback is important in the process of experiential learning. A manometer device which can provide immediate feedback during training, or indeed in a real clinical setting, should improve patient safety.

***Keywords*** bagging, IPPV, manometer, manual ventilation, simulation.

## Introduction

Artificial ventilation techniques, both manual and mechanical, can be used to either support or completely replace spontaneous ventilation, for example during anaesthesia or cardiopulmonary resuscitation. Whilst manual ventilation may be most appropriate for the short-term support of ventilation, for example during postinduction apnoea, mechanical ventilators are more convenient for the provision of prolonged ventilatory support. Mechanical ventilators, however, may not always be available in veterinary practices, or staff may be unfamiliar with their use, such that manual ventilation ('bagging') may be required (Redondo et al. 2007).

The potential problems associated with the provision of artificial ventilation are manifold, and range from macroscopic and microscopic lung damage to impairment of cardiovascular function and fluid retention (Leroy 1827; Sladen et al. 1968; Clare & Hopper 2005). The correct degree of lung inflation when performing manual ventilation is usually judged by watching how far the animal's chest rises, although, if there is a manometer within the anaesthetic breathing system, then PIPs of 10−25 cm $H_2O$ are usually advocated for animals with a healthy respiratory system (Dugdale 2007a,b). Most small animal breathing systems, however, at least of the nonrebreathing type (T-piece, Bain, Magill and Lack), do not have integral manometers, making objective assessment of manual ventilation impossible.

A study in premature lambs where physicians were asked to provide manual ventilation using a self-inflating (resuscitation-type) bag, demonstrated large variations in applied peak inspiratory (inflation) pressure (PIP) and tidal volumes; and the large inflation pressures commonly delivered were considered potentially harmful (Resende et al., 2006). Although Karsdon et al. (1989) demonstrated that inclusion of a manometer decreased the variation in PIP during manual ventilation of a human baby mannequin, this has yet to been demonstrated across different species, different operators and under differing circumstances; this formed the basis of this study.

The use of simulation devices in medical and veterinary training can help to develop clinical skills whilst ensuring that actual patients are not put in danger (Ziv et al. 2003; Scalese & Issenberg 2005). Simulation-based medical education can provide context-sensitive learning and promote the development of competence in a technical, practical or clinical skill (Epstein 2007; Kneebone & Baillie 2008). Whilst simple simulators risk promoting the development of technical expertise in isolation, i.e., without integrating other skills such as team-work and communication, the best simulators recreate the characteristics of routine clinical practice (Kneebone & Baillie 2008).

The initial aim of this study was to produce a simulator device which could provide the operator with immediate biometric feedback of their manual ventilation technique in terms of the PIP applied to a model lung. The main aim was then to test this simulator in a 'familiar/recognisable' clinical environment, on three different groups of operators (inexperienced, experienced and specialist), to determine whether exposure to real-time feedback improved their technique and, upon withdrawal of that feedback, whether their training/skill was maintained over time.

The hypotheses were: 1) that specialist operators would out-perform less experienced operators; 2) that less experienced operators would attain rapid training; and 3) that this training would be retained for the period of the study (3 weeks). This study also incorporated a survey of manual ventilation procedures at practices across the UK.

## Materials and methods

### Questionnaire design and implementation

After ethical approval by the University of Liverpool Ethics Committee, the questionnaire (Appendix S1) was sent out to 100 small animal veterinary practices across England, Wales and Scotland. These were chosen by randomly selecting towns and cities from a list (Wikipedia contributors, 2008), using random numbers. The place was then typed into a search engine (Yell Ltd., UK) with 'small animal veterinary practice' and again random numbers were used to select the practice. The questionnaire consisted of three open-ended questions and seven close-ended questions. The questions within it aimed to obtain information about when, why, how and by whom manual ventilation was provided, plus any training received, and how often patients required manual ventilation. The responses were anonymous so other questions were included to establish the size of the practice and to identify if bigger practices provided manual ventilation more often compared to smaller practices.

### Construction of the simulator

A lung model (Fig. 1) was made from a 2 L reservoir bag (Intersurgical Ltd., UK) and a 5 L plastic container as follows. The 2 L reservoir bag was used as the lung. The 5 L container was used to simulate the chest; the side of the container was cut away and a 0.5 mm thick latex rubber sheet was stretched and fixed across the open side to act as a diaphragm. The side of the container was used instead of the base so that when the reservoir bag 'lung' was inflated, the diaphragm would rise and therefore appear to be like the animal's chest rising underneath a drape. The

 

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