EFFECT OF AGE ON THE SENSITIVITY OF UPPER AIRWAY REFLEXES

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SUMMARY
We have recorded the threshold concentration of inhaled ammonia vapour required to elic it reflex glottic closure \(\text{NH}_3\text{TR}\) in 102 healthy, non-smoking volunteers (39 female) aged 17–96 yr in order to assess the effect of age upon upper airway reflex sensitivity. A single measurement of sensitivity was made in each subject using a system delivering small concentrations of ammonia vapour for single intermittent breaths to the upper airway and recording glottic closure using an inspiratory pneumotachograph. We found a strong positive correlation between age and \(\text{NH}_3\text{TR}\), indicating a decrease in upper airway reflex sensitivity with increasing age. (Br. J. Anaesth. 1993; 70: 574–575)

KEY WORDS
Age factors. Airway: reflex sensitivity.

Reflex activity is thought to diminish with advancing age. Laryngeal reflexes in the elderly appear to be less active, both during induction of anaesthesia and in the recovery room, compared with the younger patient—suggesting that protection of the airway may be impaired in the elderly [1].

The protective reflex of the larynx is evoked by stimulation of receptors thought to be located in the hypopharynx and larynx. With concentrations of irritant vapour smaller than that required to produce cough, the response is glottic closure, and a brief pause in inspiration. The upper airway is sensitive to both chemical and mechanical stimuli, the former being both quantifiable and reproducible [2].

Using equipment described previously [2], we have measured the threshold concentration of ammonia vapour \(\text{NH}_3\text{TR}\) required to stimulate reflex glottic closure in patients. Previous workers [3] found a six-fold increase in the concentration of inhaled ammonia vapour required to produce a reflex stop in inspiration in patients between the second and eighth and ninth decades. However, that study population contained a large proportion of smokers and our early work [4] has shown that smokers have considerably more sensitive upper airway reflexes than non-smokers.

The aim of this study was to measure \(\text{NH}_3\text{TR}\) in non-smokers over a broad age range in order to assess the effect of age alone on upper airway reflex sensitivity.

METHODS AND RESULTS
After obtaining Ethics Committee approval and informed subject consent, we studied 102 healthy, non-smoking subjects aged 17–96 yr. The majority (85) were preoperative elective surgical patients, the remainder being members of our department, nursing staff and nine patients from geriatric wards. We excluded those with mental or neurological impairment, chronic bronchitis and asthma, a history of upper respiratory tract infection in the past month, and those receiving sedative medication. Two subjects had smoked in the past: one stopped 25 yr previously, the other stopped 4 weeks before the study.

Measurements were made either in our laboratory or on the ward, using the same portable equipment. A single measurement of \(\text{NH}_3\text{TR}\) was made in each subject, using the method described previously [2]. We have found that no significant difference exists between repeated measures made on the same day and on separate days in the same individual [2].

\(\text{NH}_3\text{TR}\) was plotted against age for each subject (fig. 1); there was an increase in \(\text{NH}_3\text{TR}\) with advancing age. The correlation coefficient was calculated as +0.85, indicating a strong positive correlation between age and \(\text{NH}_3\text{TR}\).

Mean \(\text{NH}_3\text{TR}\) for the age group 21–30 yr \((n = 14)\) was 571 (SEM 41.5) p.p.m., compared with a value of 1791 (52) p.p.m. for the group aged 86–95 yr \((n = 14)\).

COMMENT
Whilst loss of peripheral reflexes in the elderly may be of little anaesthetic significance, the reduction in the sensitivity of upper airway reflexes associated with age may be important, particularly after anaesthesia or sedation, when full airway protection may be delayed, with a consequent increased risk of aspiration [1].

In 1960, Pontoppidan and Beecher carried out a similar study using ammonia vapour [3]. They...
assessed 103 subjects aged 15–84 yr and found that the threshold increased more than six-fold from the second to the eighth and ninth decades, and that the between-subject variability in sensitivity increased with age. However, we have identified several factors that may have produced inaccuracies.

First, their breathing system contained a large canister into which the ammonia vapour was injected. This could have allowed streaming to occur and, depending upon inspiratory flow and the timing of inspiration, could have produced a variable concentration of ammonia. Also, depending upon the tidal volume and inspiratory flow rate of the subject, the stimulus may have been presented to the upper airway at differing times during the ventilatory cycle. The authors stated that the actual concentration of inhaled ammonia was unknown, but was assumed to be directly proportional to the absolute amount of ammonia used. Furthermore, seven subjects failed to respond to the maximum delivered stimulus of ammonia. Second, they used a metabolic spirometer to record the change in inspiratory flow, and not a pneumotachograph. Finally, their population contained a high proportion of smokers (85%), although this varied between 33% in the 70–79 yr group and 83% in the 50–59 yr group, but they could find no consistent influence of smoking upon airway irritability. In contrast, we have found that those subjects who regularly smoke more than 15 cigarettes per day have a significantly smaller NH3 TR than non-smokers of the same age [4], indicating that smokers have more sensitive upper airway reflexes. Therefore, in this study we have excluded smokers.

In essence, our results support Pontoppidan and Beecher’s work, indicating an increase in NH3 TR with increasing age, but we found the mean NH3 TR increased only three-fold from the third to the ninth and tenth decades—a change which was only 50% of that of their study. In addition, we found no increase in between subject variability in NH3 TR with age and, in general, our results were more tightly clustered in each age group. These differences between the earlier study and ours, in particular regarding distinction between smokers and non-smokers, may be explained by the improved design of our system, which delivers a more constant, known concentration of ammonia vapour [2].

The cause of this increased threshold in the elderly is unknown. The irritant receptors in the upper airway are thought to consist of free nerve endings ramifying among epithelial cells; they have been classified as type 1, rapidly adapting receptors, although no nervous end-organ has been identified histologically. Increasing age is associated with a reduction in the population of nerve endings and this, combined with the thickening that occurs in the mucosa of the upper airway thus reducing penetration of noxious chemicals, may lead to an increase in stimulation threshold. A decrease in amplitude of electrical potentials in pulmonary afferent vagal fibres with age (possibly caused by degenerative changes in sensory neurones of the Nodose (Vagal) ganglion) has been described in humans [5]. A similar mechanism may affect fibres from the superior laryngeal nerve. A histological study of age-related changes in the rat superior laryngeal nerve has demonstrated segmental demyelination and axonal degeneration in the elderly group and other ultrastructural changes associated with complete fibre dysfunction [6]. Several of these changes resemble those seen in aged human peripheral nerves, in which a decrease in fibre numbers is also a significant feature [5].

It is not possible to infer directly from our results that a progressively greater NH3 TR associated with advancing age implies a loss of protective reflexes and consequent increased risk of aspiration. However, the increased reflex stimulus threshold in the elderly may be a contributory factor, and emphasizes the need for increased vigilance during recovery from anaesthesia or sedation.

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REFERENCES