DENITROGENATION IN PREGNANT WOMEN

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ABSTRACT

Forty-five pregnant females were studied with respect to the effectiveness of denitrogenation by the 3, 5, 7 and 9 rapid vital capacity breaths, and 3 to 5 minutes of normal breathing. It was found that 3 to 9 vital capacity breaths cannot effectively denitrogenate a pregnant patient when a circle breathing system with a gas flow of 8 litres/min is used. At least 3 minutes of normal tidal volume breathing should be given for proper denitrogenation or preoxygenation if the circle system is used for such a purpose.

Keywords: Denitrogenation, Preoxygenation, Raman-laser-scattering spectrophotometer, Pregnancy, Rapid Vital Capacity Breaths Techniques.

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INTRODUCTION

The best way to preoxygenate a patient prior to the induction of anaesthesia for surgery has been controversial [1-3]. The recommendations for adequate preoxygenation ranged from normal breathing of 100% oxygen for 3 to 10 minutes [2-4] to taking four vital capacity breaths over thirty seconds [5]. Most studies measured oxygen saturation or arterial oxygen tension instead of the content of oxygen or nitrogen in the lungs. One clinical report by Carmichael et al [6] used end expiratory nitrogen content as a method of assessment of the adequacy of "denitrogenation". They suggested that "denitrogenation" serves as a more relevant term to represent the aim of all methods of "preoxygenation" previously proposed.

The functional residual capacity of a person serves as a store of oxygen, which can be drawn upon when need arises eg. during apnoea. The higher the concentration of oxygen in this space, the bigger will be the store. Therefore, the lower the concentration of nitrogen in this space during preoxgenation the larger the store for oxygen - hence the concept of denitrogenation.

Without a readily available monitor to ensure proper denitrogenation , all methods previously recommended are empirical at best. As suggested by Carmichael, mass spectrophotometry can be useful in this situation as it allows the accurate tracking of nitrogen washout during "preoxygenation" [6].

Raman light scattering is now an available technique for monitoring respiratory gases in the operation room in the form of the Raman laser scattering spectrophotometer- RASCAL [7, 8]. The response time of this analyser was about 250 ms with 366 cm of catheter and a flow rate of 150 ml/min. This is a patient-dedicated portable unit.

Denitrogenation or preoxygenation of a patient may reduce the chances of hypoxemia during a "difficult intubation" for general anaesthesia. Techniques such as the 4 vital capacity breaths and 5 minutes breathing methods have been earlier advocated. We wanted to know if these were suitable in the different clinical situations that we faced daily as anaesthetists in the operating room, with special reference to pregnant patients. Since it has been shown that desaturation of arterial oxygen occurs more rapidly in the pregnant woman during apnoea compared to non-pregnant controls [9], this can lead to serious consequences.

Preoxygenation is also a standard feature in the rapid sequence induction of general anaesthesia for Caeserean section and emergency surgery in the pregnant patient. Therefore we decided to test the various techniques of preoxygenation in three different groups of female patients with end-expiratory nitrogen as the basis of our assessment.

METHODS

Forty-five ASA I pregnant patients were studied. They were divided into 3 groups depending on the stage of pregnancy. There were 15 patients in each group. The 3 groups were 1) full term pregnant patients going for caesarean section who were uncomplicated singleton pregnancies; 2) patients scheduled for post-partum sterilisation within 3 days after delivery of ASA class I

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category; 3) patients who were scheduled for evacuation of uterus because of incomplete or missed abortions in first trimester pregnancies of ASA class I category.

The patients scheduled for elective surgery were studied for adequacy of denitrogenation after informed consent was taken.

The sampling catheter was mounted on the mask for the continuous measurement of the gases. The patients were allowed to breathe room air normally (tidal volume) via the mask to establish a respiratory pattern and baseline values for nitrogen and carbon dioxide for a period of time. Following this the mask was removed from the patient's face and the breathing system flushed with oxygen for several seconds to fill the tubings, reservoir bag and soda lime absorber with oxygen. The patients were then instructed to breathe through the snugly-fitted mask attached to the circle breathing system fitted with a 2 litre reservoir bag. The oxygen flow was set to 8 litres per minute. They were asked to exhale maximally and then take 10 rapid vital capacity breaths.

The end-expiratory nitrogen concentration was noted at 3, 5, 7 and 9 vital capacity breaths. This was followed with at least 5 minutes of breathing room air to enable the patients' end-expiratory nitrogen and oxygen to return to baseline values; following which the patients were asked to breathe normally (tidal volume breathing with 100% oxygen via the same breathing system). End tidal nitrogen was noted at 3 minutes and 5 minutes. The end-expiratory nitrogen concentration of the patients were measured using the RASCAL (Raman laser scattering spectrophotometer).

Data were subjected to analysis of variance and t-test where appropriate. Statistical significance was taken to be $p < 0.05$.

RESULTS

All subjects were ASA I, patient volunteers from age 21 to 42 years (see Table I). There were no differences in age distribution. Weight differences were obvious and need no explanation.

Table I
Age and weight distribution of patients
*** (n = 45)**

Group	Age (years)#	weight (kg)
Full term pregnancy	30.9 (5.3)	67.5 (10.5)
Range	21 -41	
Post-partum	29.5 (3.9)	61.8 (10.0)
Range	24 -36	
Early pregnancy	29.9 (5.6)	60.4 (10.6)
Range	22 - 42	

Values given as mean with standard deviation in parentheses.
* n ≐ 15 in each group
\# No significant differences at p< 0.05 by ANOVA for age distribution
(Weight differences in the groups need no further elaboration)

RESULTS OF DENITROGENATION STUDY

The results are shown in the Table II and Figs 1 - 4.

Comparison between Techniques

Three or 5 minutes normal breathing of 100% oxygen for denitrogenation was significantly better than 3, 5, 7 and 9 vital capacity breaths ($p < 0.05$) (See Table II and Figs 1-3).

Table II
End expiratory nitrogen concentration (%) with the different methods of denitrogenation.

	Full term pregnancy (n = 15)	Post partum patients (n = 15)	First Trimester pregnancy (n = 15)	Mean
3 VC	25.6 (6.5)	24.9 (9.5)	20.2 (4.9)	23.6
5 VC	18.4 (5.4)	15.7 (6.1)	14.2 (3.9)	16.1
7 VC	15.4 (6.5)	11.9 (5.1)	10.3 (3.1)	12.5
9 VC	13.9 (5.9)	10.0 (4.4)	7.4 (2.3)	10.4
3 MINS	3.5 (3.1)	3.5 (1.9)	3.2 (1.5)	3.4
5 MINS	1.6 (0.5)	1.7 (1.2)	1.3 (0.6)	1.5

VC = vital capacity breaths
3/5 mins= 3 or 5 minutes of normal tidal volume breathing of oxygen.
Values given as mean with standard deviation in parentheses where appropriate

Fig 1
Denitrogenation in term parturient using different vital capacity breaths

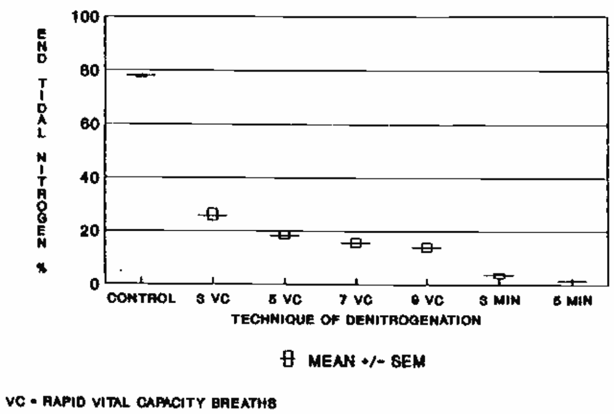


Fig 2
Denitrogenation in First Trimester Pregnancies using different vital capacity breaths

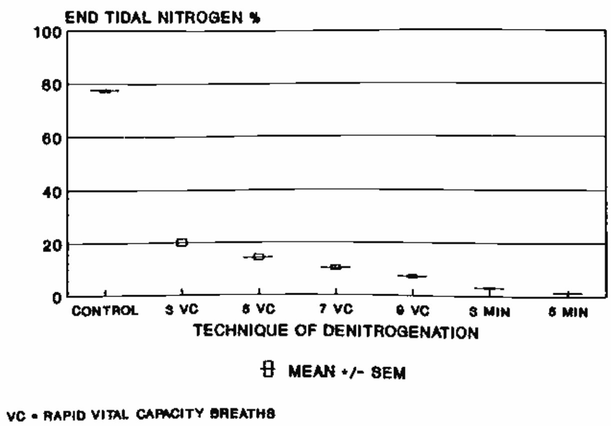
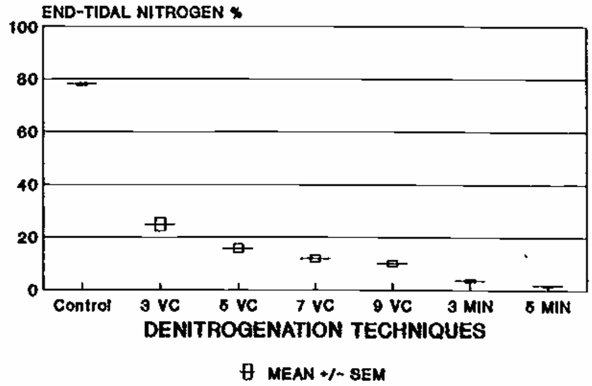
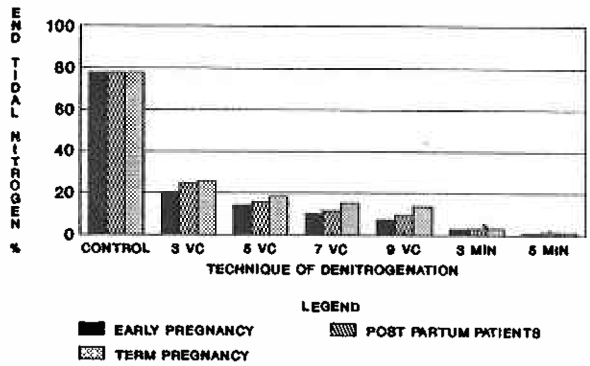


Fig 3
Denitrogenation in Post-partum patients with different techniques



VC = Rapid vital capacity breaths

Fig 4
Denitrogenation in Pregnancy, First Trimester, Term pregnancy and post-partum.



VALUES GIVEN AS MEAN

Five minutes of normal breathing gives a significantly lower end tidal nitrogenation concentration than 3 minutes of normal tidal volume breathing ($p < 0.05$).

Comparison between groups

There were no statistical differences ($p < 0.05$) with respect to the effectiveness of denitrogenation at 3 and 5 minutes of normal tidal volume breathing (Fig 4). However, there were significant differences between the patients in first trimester and full-term pregnancy with regards to end expiratory nitrogen concentrations when the different vital capacity breaths were analysed ($p < 0.05$).

There were no significant differences between full-term pregnancy and post-partum patients, with regards to adequacy of denitrogenation, when the vital capacity breaths techniques were compared ($p > 0.05$). See Fig 4.

DISCUSSION

It was obvious from our study that 3 to 9 "rapid vital capacity breaths" techniques will not effectively denitrogenate the patients as compared to 5 minutes of normal tidal breathing of oxygen. We could not achieve the same results as Carmichael et al [6] probably because our subjects were different. Their subjects achieved 3.6 ± 0.8% at end of 5 rapid vital capacity breaths compared to ours of 15.9% (range: 14.26 to 18.4%.) Our subjects were patient volunteers, who received instructions on the techniques of rapid vital capacity breaths just prior to our evaluation. (We wanted to simulate the emergency situation). On the other hand, Carmichael's subjects were healthy volunteers properly instructed in the techniques of rapid vital capacity breathing.

Secondly, they flushed the bag with 100% oxygen every time it was empty. We thought that this was clinically not practical as it was both inconvenient to us and uncomfortable to the patients and excluded it in our study. Additionally the standard 2 litre reservoir bag used with our breathing system may have prevented the attainment of a lower end expiratory nitrogen concentration with the 5 to 9 rapid vital capacity breaths method of denitrogenation. (The 2 litre bag in the circle system not meeting the inspiratory needs of a rapid vital capacity breath.) Most anaesthetic machines do not deliver more than 8 litres/min of oxygen without using the emergency oxygen flush.

Thirdly, our subjects were females patients at three different stages of pregnancy whereas theirs were a mixture of both sexes. The changes of respiratory function during pregnancy may or may not have contributed to this difference.

Another possible explanation for not achieving the same degree of denitrogenation could be due to airleaks which are invariable during the procedure of rapid vital capacity breathing. Rapid breathing may entrain atmospheric air around the mask, giving rise to higher nitrogen levels in the systems.

We conclude that even with 9 rapid vital capacity breaths, we were unable to achieve adequate denitrogenation of pregnant patients. Therefore we continue to believe that at least 3 minutes of normal tidal breathing of 100% oxygen to be better than having the patients take rapid vital capacity breaths of 100% oxygen during preoxygenation.

It was also reported by Russell et al [10] that denitrongenation in the parturient, by measurement of end expiratory oxygen level by mass spectrophotometry, was more rapid than the non-pregnant control. They used either a Magill's circuit or a demand valve type of breathing system. We do not routinely use this type of system in our operation theatre. They also found that 4 rapid vital capacity breaths is not as effective as 120 seconds of normal breathing in preoxygenating the parturient.

Finally, we restate the fact that probably the most optimal way to denitrogenate is to monitor the end expiratory nitrogen concentration, in the light of the availability of a portable patient dedicated nitrogen analyser. The possibility of detecting incorrect mask holding (leading to air leak) is an advantage, as one of the causes of inability to properly denitrogenate the patient is a poorly fitted mask.

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