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# Anaesthesia

Journal of the Association of Anaesthetists of Great Britain and Ireland

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### Anaesthesia

Volume 56 Page 231 - March 2001

doi:10.1046/j.1365-2044.2001.01836.x

Volume 56 Issue 3

## Apparatus

### Retention of airborne latex particles by a bacterial and viral filter used in anaesthesia

apparatus

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We have developed a series of laboratory tests to evaluate the efficiency of a heat and moisture exchanger filter (Pall™ BB25) in retaining latex particles in order to protect allergic patients during anaesthesia. Latex particles were nebulised with cornstarch as a support and collected for assay in a flask, with or without the filter integrated into the experimental circuit. With the Pall BB25 filter in the circuit, no natural latex proteins were detected by measurement of either total protein or antigenic latex proteins. The Pall BB25 filter may represent a useful means of preventing inhalation of latex particles during anaesthesia in susceptible patients.

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#### Keywords:

- ☐ Equipment
- ☐ filters

The incidence of anaphylactic reactions during anaesthesia (general and regional) has been estimated as 1 : 13 000, with natural latex responsible for 16.6% of cases [1]. Every day in the operating theatre, staff use surgical equipment containing latex which exposes patients to the risk of potentially serious anaphylactic reactions [2]. The anaesthetised patient may inhale latex particles initially suspended in the air of the operating theatre or present in the anaesthetic breathing system derived from rubber components.

Natural latex is a milky fluid produced in the inner bark cells of the *Hevea*; it is a suspension of rubber particles dispersed through an aqueous serum. Natural latex proteins represent 1.5–2.8% of the whole suspension. They are extremely numerous and vary according to the *Hevea* species. Before being supplied, the natural latex material undergoes treatment such as addition of a gliding agent (talcum powder or cornstarch for gloves) [3]. Natural latex proteins may be adsorbed onto the starch powder and become airborne allergens in operating theatres [4–6]. Therefore, it is important to reduce or eliminate natural latex particle contamination, not only in operating theatres (i.e. by using non-powdered gloves), but also in anaesthetic breathing systems. Because a bacterial and viral filter introduced between the Y-piece and the patient is now used routinely in anaesthetic breathing systems to prevent cross-contamination, we studied the protective effect of such a filter (Pall BB25) in retaining natural latex protein-loaded starch powder.

Methods

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Starch powder nebulisation and collection

Nebulisation was performed in a 3-m<sup>3</sup> airtight cabin so that starch could not be nebulised into the surrounding air (Fig. 1a). Two grams of starch, either non-contaminated or contaminated with natural latex proteins, were introduced into a nebuliser (Misty-Neb Air Life, Allegiance) and nebulised for 10 min by means of compressed air (8 l.min<sup>−1</sup>) into a face mask. The latter device was used to nebulise the powder within a small volume to avoid losing a large quantity of it into the whole cabin volume. The face mask was fixed tightly to the cabin wall around a hole allowing a vacuum suction line to pass through. Outside the cabin, the suction line was connected to a flask containing 15 ml of distilled water, itself connected to the vacuum system equipped with a manometer preset to deliver a flow rate of 28 l.min<sup>−1</sup> (Fig. 1b). Experiments were conducted with or without the filter in this line upstream from the flask. Unused cornstarch (designated as latex-free starch) of industrial quality, intended for powdering gloves, was obtained from a glove manufacturer (Agenasorb 9020, Agrana Stärke GmbH, Wien, Austria). Excess cornstarch of the same type was also collected by the manufacturer at the end of the glove manufacturing process (designated as latex-loaded starch). The protein content of the latex-loaded cornstarch was 430 µg.g<sup>−1</sup>. Three nebulisation test series were carried out: (i) latex-free starch without filter (five tests), (ii) latex-loaded starch without filter (seven tests), and (iii) latex-loaded starch with the Pall BB25 filter (seven tests).

Cornstarch powder collected in the flask was obtained after extraction of total proteins and centrifugation of the sample (see below). The sedimentation base containing the starch was dried at 37 °C and the quantity weighed.

Total protein assay

Total protein content was measured using the modified Lowry method according to the European standard EN 455-3 for total protein measurement on medical glove extracts [7]. After each nebulisation test, proteins were extracted by gentle shaking of the water contained in the flask for 2 h at room temperature. The extracts were centrifuged at 4000 r.p.m. (2000g) for 20 min at 4 °C, and the supernatants were then filtered using a syringe filter (PES filtering membrane; 0.2 µm pore size, Whatman® Puradisc™ 25AS). The assay was carried out on the filtrates. The filtrates and solutions for each point of the standard curve underwent a triple precipitation with 72% deoxycholic acid, 0.15% trichloroacetic acid and 72% phosphotungstic acid (Sigma). After centrifugation at 4000 r.p.m. for 20 min at 4 °C, the pellets were dissolved in 0.1 n sodium hydroxide. The colorimetric assay was carried out on a microplate using a total protein measurement kit (BioRad Protein Assay Kit). The total protein concentrations were obtained by using an ovalbumin (grade V, Sigma) standard curve.

Antigenic natural latex protein assay

Quantitative analysis was carried out using CIAIP (competitive immunoassay for antigenic latex proteins). The method, described previously [8],

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Accepted: 8 September 2000

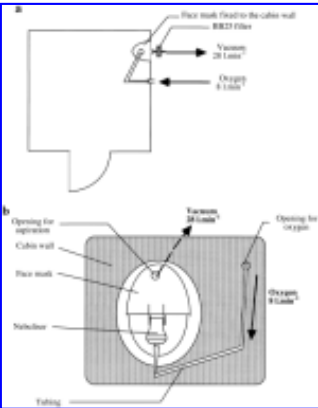
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Figure 1 Diagram of the apparatus for nebulising and collecting cornstarch: (a) upper view of the test...

Data were compared by using the Mann–Whitney rank-sum test. A value of  $p < 0.05$  was considered statistically significant.

## Results

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The results of the cornstarch and protein assays are presented in [Table 1](#). After nebulisation of latex-free starch without the filter, the quantity of collected starch was 11–44% of the quantity initially introduced in the device with no detection of total or antigenic proteins. With latex-loaded starch without the filter, the mass of starch and total protein collected was 36–54% and 28–36% of the nebulised amount, respectively; antigenic proteins were detected in six tests out of seven. With the Pall BB25 filter between the nebulisation system and the flask, the mass of starch collected in the flask was 0–0.6% of the nebulised amount, with no total protein detected and antigenic latex proteins either undetectable or equal to the lower detection limit (the latter in two tests).

## Discussion

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Prevention of anaphylactic reactions due to latex particles is an important concern in anaesthesia, hence the need for more efficient protective methods. For many years, bacterial and viral filters have been routinely inserted into the anaesthetic breathing system in order to prevent cross-contamination. The French Society for Anaesthesia (Société Française d'Anesthésie Réanimation, SFAR) recommends for each patient the use of a hydrophobic bacterial and viral filter with a retention efficiency > 99.9999% when tested with a monodispersed aerosol of small microorganisms [9].

We therefore thought it interesting to test one of these filters (Pall BB25) for its ability to retain latex particles and possibly prevent potentially serious allergic reactions to latex particles generated in the anaesthetic equipment. This hydrophobic bacterial and viral filter has been specially developed for anaesthesia. It is indicated in adults and, owing to its small volume (35 ml), children over 10 kg. It retains small airborne bacterial and viral contaminants [*Brevundimonas diminuta* (0.3 µm) and Bacteriophage MS2 (0.02 µm)] with a retention efficiency > 99.999% and larger particles [*Serratia marcescens* (0.45 µm) and *Bacillus subtilis* (0.8 µm)] with a retention efficiency > 99.999% [10–12]. Moreover, owing to its hydrophobic membrane, it prevents the passage of *Mycobacterium* [13] and hepatitis C virus [14] through its membrane.

To set up the experimental procedure, a great number of preliminary tests consisting of solubilising the starch and nebulising it as microdroplets proved fruitless; because of their weight, the microdroplets sedimented too rapidly after nebulisation and suction through the vacuum line was uncertain and minimal. In contrast, direct nebulisation of the starch powder allowed us to avoid dispersion in the cabin and nebulisation was carried out directly into the face mask.

In order to simulate the most extreme conditions, we challenged the filters with large amounts of latex proteins ( $\approx 239\text{--}308\text{ }\mu\text{g}$  were collected in the experiment, representing  $\approx 1000\text{ }\mu\text{g.m}^{-3}$ ). Baur *et al.* [15] reported that exposure to a latex aeroallergen level of  $0.6\text{ ng.m}^{-3}$  induces hypersensitivity symptoms in healthcare workers. In our experiment, the quantity of latex proteins was  $> 1000$  times higher. The definition of a threshold limit value for natural latex proteins in medical latex gloves is the subject of an intense debate within the European Commission. Furthermore, because of the use of different methods and reference standards extracts, different results may be obtained from the same sample. For example, when submitting subjects particularly allergic to natural latex proteins to ocular provocative tests with the reference extract,  $1\text{--}10\text{ ng}$  natural latex proteins induce a strong local reaction. However, our findings suggest that the Pall BB25 filter provides adequate protection of the anaesthetised patient when placed between the anaesthetic breathing system and the patient's tracheal tube.

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Table 1 Amount of cornstarch, total protein and antigenic latex proteins collected after passage of ne...

### To cite this article

Barbara, J., Chabane, M. H., Leynadier, F. & Girard, F. (2001)

Retention of airborne latex particles by a bacterial and viral filter used in anaesthesia. *Anaesthesia* **56** (3), 231-234.

doi: 10.1046/  
j.1365-2044.2001.01836.x

## Acknowledgment

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We thank Ms M. Legoy for her excellent technical assistance.

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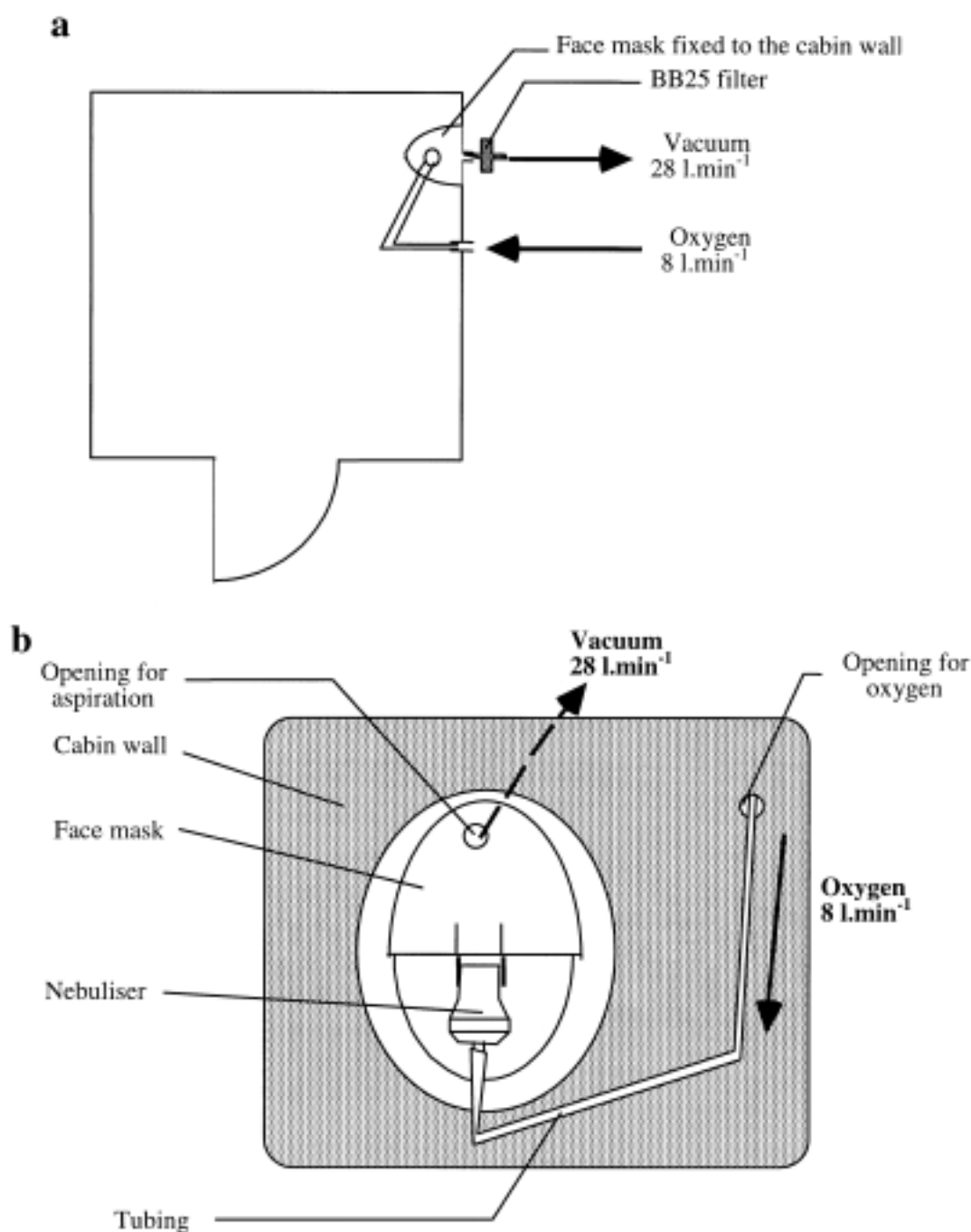
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Figure 1 Diagram of the apparatus for nebulising and collecting cornstarch: (a) upper view of the test cabin; (b) view of the cornstarch nebulising system.





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Table 1 Amount of cornstarch, total protein and antigenic latex proteins collected after passage of nebulised cornstarch either contaminated with latex or latex-free, with or without the Pall BB25 filter. Figures relate to individual experiments.

|                                     | Cornstarch only,<br>no filter | Cornstarch plus<br>latex, no filter | Cornstarch plus<br>latex, with filter |  |
|-------------------------------------|-------------------------------|-------------------------------------|---------------------------------------|--|
| Cornstarch (mg)                     | 742                           | 847                                 | 2                                     |  |
|                                     | 881                           | 938                                 | 4                                     |  |
|                                     | 340                           | 1021                                | 2                                     |  |
|                                     | 555                           | 722                                 | 1                                     |  |
|                                     | 226                           | 992                                 | 5                                     |  |
|                                     |                               | 824                                 | 0                                     |  |
|                                     |                               | 1071                                | 0                                     |  |
| Median                              | 555                           | 938*                                | 2                                     |  |
| Total proteins ( $\mu$ g)           | < 30                          | 308                                 | < 30                                  |  |
|                                     | < 30                          | 281                                 | < 30                                  |  |
|                                     | < 30                          | 298                                 | < 30                                  |  |
|                                     | < 30                          | 243                                 | < 30                                  |  |
|                                     | < 30                          | 286                                 | < 30                                  |  |
|                                     |                               | 239                                 | < 30                                  |  |
|                                     |                               | 284                                 | < 30                                  |  |
| Median                              | < 30                          | 284*                                | < 30                                  |  |
| Antigenic latex proteins ( $\mu$ g) | < 0.42                        | 2.13                                | 0.42                                  |  |
|                                     | < 0.42                        | 1.16                                | < 0.42                                |  |
|                                     | < 0.42                        | 1.92                                | < 0.42                                |  |
|                                     | < 0.42                        | 1.07                                | 0.42                                  |  |
|                                     | < 0.42                        | 0.80                                | < 0.42                                |  |
|                                     | 0.66                          | < 0.42                              |                                       |  |

|                                                                            |        |        |        |  |
|----------------------------------------------------------------------------|--------|--------|--------|--|
|                                                                            |        | < 0.42 | < 0.42 |  |
| Median                                                                     | < 0.42 | 1.07†  | < 0.42 |  |
| *p < 0.002 and †p < 0.01 compared with cornstarch plus latex, with filter. |        |        |        |  |



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