Comment

Antinuclear antibodies and the rheumatoid factor in cases of asbestosis probably result from the pulmonary lesions and are not evidence of an autoimmune mechanism in the pathogenesis of the disease. Another probable explanation of the negative finding in our cases is that antophyllite, owing to its different physicochemical structure, causes less destruction of lung tissue than other asbestos materials.

¹ Pernis, B, *et al*, *Folia Allergologica*, 1963, **10**, 396.

² Turner-Warwick, M, and Parker, W R, *British Medical Journal*, 1970, **3**, 492.

³ Merchant, J A, *et al*, *British Medical Journal*, 1975, **1**, 189.

⁴ Nurminen, M, *Work-Environment-Health*, 1972, **9**, 112.

⁵ Meurman, L, *Acta Pathologica et Microbiologica Scandinavica*, 1966, suppl 181.

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Errors in using clinical thermometers

Anecdotes of febrile patients with normal tracings on their temperature charts are not uncommon. Probably many of these errors occur because the thermometer is left under the tongue for an insufficient period. In 1944, from a study in which eight thermometers were tested in each of 32 individuals, De Nosaquo *et al*¹ concluded that a minimum of three minutes sublingual exposure is required. More recently, on the basis of a smaller study, a group of student nurses recommended a time of at least four minutes.²

Despite such results, we found in a survey of popular textbooks that most authors advise that thermometers need be kept in the mouth for only two minutes. In practice, where there is a high pressure of work, this time is often reduced to a minute or even less. We have re-examined the effect on readings of leaving thermometers in place for different periods.

Methods and results

Three clinical thermometers, each with a differently shaped bulb, were used. Two were calibrated in °C and read to the nearest 0.1°C. The third, which was calibrated in °F, was read to the nearest 0.2°F. The accuracy and rate of equilibration of the thermometers were tested in a thermostatically controlled water bath against a standard thermometer reading to 0.01°C. It was shown that each thermometer was accurate to within 0.1°C (0.2°F), and attained its maximum within 10 seconds. Thirty-two people took part in the study. Nineteen were healthy volunteers (mostly medical students) and 13 were inpatients. We performed 37 experiments. In each experiment one person and one thermometer were used, and 10 readings of the thermometer were recorded. These readings were taken after leaving the thermometer in the mouth for each of the 10 insertion times: ½, 1, 1½, 2, 2½, 3, 3½, 4, 4½, 5 minutes. These 10 measurements were made in random order. For five minutes before starting, and then throughout the duration of an experiment, the subject was kept in an environment with a temperature constant to 1°C. He was required not to drink or smoke during this period and conversation was kept to a minimum. Before taking each temperature the thermometer was cooled for at least 30 seconds in a beaker of water at room temperature, and the mercury shaken down to below the scale. Subjects were asked to ensure that the thermometer stayed well under the tongue while temperatures were being taken.

In each experiment a note was made of the highest temperature recorded. The difference between this maximum and each reading in the experiment was deemed the "error" of that reading. The figure shows the mean error, when averaged over all experiments and expressed in °C, plotted against insertion time. Also shown is the percentage of individual errors of 0.3°C or more.

Mean errors (continuous line) and percentages of errors $\geq 0.3^{\circ}\text{C}$ (broken line) in relation to insertion time.

Comment

The criteria by which a satisfactory insertion time is defined are arbitrary. We feel, however, that two minutes, after which 27% of temperatures recorded in our study had "errors" of 0.3°C or more, is not sufficient. On the basis of our results we would join De Nosaquo and his colleagues in recommending a time of at least three minutes. It is important that temperatures should be measured accurately, so that low-grade fevers are not missed and that the pattern of a fever may be followed, both as an aid to diagnosis and as a guide to the efficacy of treatment.

We would like to thank Dr A J Honour and Dr B E Juel-Jensen for their advice and encouragement.

¹ De Nosaquo, N, *et al*, *Journal of Laboratory and Clinical Medicine*, 1944, **29**, 179.

² *Nursing Times*, 1971, **67**, 1139.

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Explosion during halothane anaesthesia

Halothane is popularly regarded as a non-explosive anaesthetic. Quotations from published work state "[fluothane] is not inflammable when mixed with oxygen at normal pressure." "Mixtures of fluothane, oxygen, and nitrous oxide are non-flammable in the proportions used in anaesthetic practice." "Fluothane ignites at 1% v/v in 99% nitrous oxide and 4% v/v in 24% oxygen and 72% nitrous oxide." ICI Ltd state that the energy required to produce this would not normally be found in anaesthetic practice.

I therefore wish to report a case of halothane explosion during dental anaesthesia. After induction of the tenth case of the morning, say, after 45 minutes' continuous anaesthesia, a loud bang occurred; simultaneously a spark and a blue flame was seen inside the halothane vaporiser. The flame did not appear at the nose piece, which was

held above the patient. The patient was unharmed and there was no damage. Subsequently a smell of fluorine and burning was noticed.

The apparatus used was a 1956 Mckesson, model 880, modified to take gases via long flexible hoses from 3273 l (720 gal) cylinders mounted on a wheeled trolley. The wheels of the machine and connecting hoses are not electrically conductive. A Mckesson halothane vaporiser was employed. Before the explosion the gases were being administered in the usual proportion of 20% oxygen and 80% nitrous oxide at 7 mm pressure.

The morning was warm and humid, the surgery well ventilated (the door and window open). The gases are, of course, passed over the halothane; no estimate can be given of the halothane percentage within the vaporiser, but it was set to administer at "full," giving approximately 2% halothane v/v at the point of delivery. The sucker, chair, and hot air steriliser were all live and in the vicinity but none was in use or in contact with the Mckesson apparatus or its appurtenances (in other words, no motors, heater, etc were in use). There were no naked flames, and the only volatile liquids on the premises were halothane and surgical spirit. The floor is a rubberised compound and non-conductive.

The machine is wheeled between surgeries (about 8 metres) between cases. After the explosion the machine was examined and no faults were found. The session continued for another six cases but the precaution was taken of earthing the machine to the plumbing between cases.

Subsequent analyses of the nitrous oxide and halothane showed no contaminants.

Possible causes

Local atmospheric conditions were thundery, so that atmospheric induction or induction by nearby equipment (such as the sucker or chair motor) must be considered together with the rubberised floor as a possible factor. ICI has subsequently reported that the possibility must be accepted of a potentially explosive mixture of halothane and nitrous oxide being present in the vaporiser and that a build-up of static in the bowl fired the halothane. Conceivably the motion of the liquid in the bowl during frequent moving of the anaesthetic trolley or mixing of gases at different temperatures may have accounted for static build-up which produced the explosion. The AC type glass bowl is electrically isolated by cork washers above and below. The question must be asked whether these should be made of conductive rubber.

Anaesthetics with halothane have been carried out in vast numbers and no other explosive incident has been reported. Moreover, at this surgery the same conditions have existed for many years. Nevertheless, I believe that this case is worth recording as it would appear that the possibility of an explosion with halothane cannot be ignored, provided the circumstances so combine as to produce the necessary static discharge. Hence earthing of the machines should be considered and anaesthetists should be reminded that halothane is not a non-explosive anaesthetic.

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Diaphragmatic paralysis after supraclavicular puncture of subclavian vein

Supraclavicular subclavian venepuncture, originally described by Yoffa,¹ has been accepted as a safe procedure for routine use. The method offers a means of rapid entry into the central venous system and cardiac chambers. It has been used for the administration of fluids, measurement of central venous pressure, insertion of pacing electrodes,² and for trans-septal puncture of the left atrium.³ Complications of the technique include inadvertent arterial puncture, entry of air into the venous system,⁴ and pneumothorax.⁴ We could find no

previous report of diaphragmatic paralysis and wish to report two cases of this complication after subclavian venepuncture.

Case reports

Case 1—This 69-year-old man presented with Stokes-Adams attacks due to intermittent complete heart block. A temporary pacing catheter was passed via the right subclavian vein, using the Seldinger technique and a Desilet-Hoffman introducer. No difficulty was noted. A chest radiograph before the procedure showed normally placed diaphragms, but a routine radiograph three days later showed a raised right hemidiaphragm. Since the patient had extensive varicose veins, pulmonary embolism was considered the most likely diagnosis and anticoagulant treatment was begun. Later fluoroscopy, however, showed the right hemidiaphragm to be paralysed. Permanent endocardial pacing was established, and follow-up over three years has been uneventful apart from a pacemaker generator replacement. The right hemidiaphragm, however, remains raised and shows paradoxical motion on fluoroscopy.

Case 2—A 57-year-old man with long-standing mitral and aortic valve disease presented with pyrexia and anaemia. Blood cultures were negative, but infective endocarditis seemed probable. To facilitate intravenous antibiotic treatment a polyethylene catheter was inserted into the right subclavian vein using the Seldinger technique and supraclavicular approach. The catheter was removed after 10 days and the treatment continued through a peripheral vein. There was a little discomfort in the site of subclavian venepuncture but no local swelling or tenderness and a chest radiograph at this time showed normally placed diaphragms. Two weeks later an attempt was made to catheterise the right subclavian vein again but was abandoned after several unsuccessful punctures. A routine chest radiograph four days later showed a raised right hemidiaphragm and fluoroscopy confirmed the presence of paradoxical movement. This finding raised the possibility of bronchial neoplasm or subphrenic abscess as an underlying cause for the whole clinical picture. Nevertheless, bronchoscopy and radiography of the abdomen with artificial pneumoperitoneum showed nothing abnormal. There was complete clinical response to continued antibiotic treatment. The right hemidiaphragm remained raised for almost two years of follow-up before returning to its normal position radiologically, and the motion on fluoroscopy was not entirely normal. Although the right hemidiaphragm descended on inspiration paradoxical motion remained present when he sniffed.

Comment

No cause other than supraclavicular subclavian venepuncture emerged to explain the paralysis of the right hemidiaphragm in these two patients, and it must be assumed that trauma to the phrenic nerve in the root of the neck was responsible. The right phrenic nerve is closely related to venous structures as it enters and passes through the thoracic cavity. It crosses immediately behind the subclavian vein close to the subclavian-jugular junction and comes to lie on the lateral surface of the right brachiocephalic vein (see fig). The nerve could be damaged by a needle which transfixes the vein or is directed too far posteriorly behind the first rib. The complication could be avoided by directing the needle as anteriorly as possible, but the anatomy of the subclavian vein is variable⁵ and deeper or multiple punctures are occasionally required. Paralysis of a hemidiaphragm occurred only

Anatomical relations of right phrenic nerve in thoracic inlet. Clavicle and sternomastoid muscle have been omitted for clarity. SVC=Superior vena cava.