*J. Hyg., Camb.* (1977), **79**, 417
*With* 1 *plate*
*Printed in Great Britain*



# The potential for contamination of intravenous infusions by airborne skin scales

By C. J. HOLMES and M. C. ALLWOOD
*Department of Pharmacy, The University, Manchester* 13

(*Received* 19 *May* 1977)

SUMMARY

Skin scales may be attracted onto the surface of administration set connector needles before insertion into infusion containers. Viable microorganisms associated with skin scales may therefore gain access to the infusion by this route. A technique is described for creating an environment of airborne skin scales. This environment is used to examine the attraction of skin scales onto the surface of administration set connector needles and three other materials. After exposure, skin scales are found adhering to the surface of each material examined. The attraction of skin scales onto administration set connector needles is dependent on the time of exposure to the environment. Results suggest that intravenous infusions can be contaminated by this route when the infusion and administration set is assembled.

## INTRODUCTION

The microbial contamination of intravenous infusions in hospital wards during their assembly and subsequent administration has been widely studied (see Maki, 1976). Such investigations provide an indication of the proportion of infusions that become contaminated with microorganisms during use but cannot necessarily establish the source of such contamination. Precautions are seldom taken to avoid contamination of the intravenous infusion by all recognized causes. Microorganisms may gain access to an infusion system during the influx of unfiltered air (Percival, 1966; Arnold & Hepler, 1971), the addition of drugs (Kundsin, Walter & Scott, 1973; D'Arcy & Woodside, 1973), by migration of microorganisms from the cannula of the administration set (Maki, Goldman & Rhame, 1973) and during the insertion of the administration-set needle through a contaminated infusion bottle plug (Holmes & Allwood, 1976). Careless manipulation of an infusion system, particularly during assembly, may also lead to its microbial contamination (Maki, 1976; Meers, 1976). Investigations by Hansen & Hepler (1973) which attempted to eliminate these sources of contamination during infusion have revealed, however, that some microorganisms may still gain access to infusion systems. The routes by which such microorganisms enter an intravenous infusion system are still open to conjecture. Meers (1976) has proposed that skin scales shed from the body surface may be attracted onto the surface of the administration-set connector needle and consequently be introduced into the infusion during insertion of the needle. Viable microorganisms present on skin scales would thus also gain access to the infusion container.

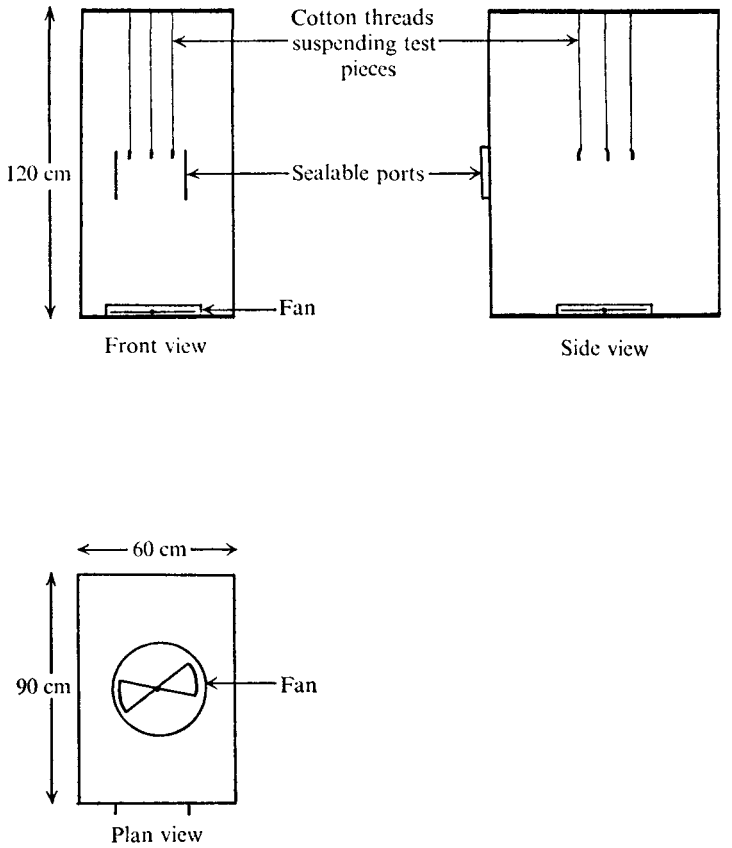



Fig. 1. Diagram of the chamber used to measure the attraction of skin scales onto administration set connector needles and other materials.

In this study we have established a technique for creating an environment artificially contaminated with airborne skin scales. This environment was used to examine the attraction of skin scales onto the surface of connector needles and three other materials.

## MATERIALS AND METHODS

It has been shown that dust collected from undisturbed surfaces in hospital areas and 'household dust' is largely composed of skin scales (Davies & Noble, 1962; Clark, 1974). Microscopic examination of dust collected in our laboratory shows that this also consists largely of flake-like particles morphologically resembling skin scales. Therefore, such dust from undisturbed surfaces in the laboratory provided an accessible and plentiful source of skin scales.

### *Production of an environment of airborne skin scales*

An enclosed area of dimensions $60 \times 90 \times 120$ cm was used as a chamber in which an atmosphere of skin scales could be produced (Fig. 1). Two sealable ports in the front of the chamber permitted the manipulation of apparatus within the enclosed area. A fan was placed in the bottom of the chamber to

provide an upward flow of air which was used to create and maintain skin scales in an airborne state.

At the start of each experiment the fan was switched on and a small stoppered container containing *ca.* 150 mg of dust introduced through the ports into the chamber. This container was opened approximately 20 cm above the fan and slowly inverted, allowing the dust to circulate in the chamber. The container was then removed and the ports closed.

*Preparation of apparatus and solutions*

All apparatus and solutions were cleaned before use in particular, to remove any skin scales. Solutions were filtered through Millipore membrane filters (45 mm, 0·45 nm pore size). Apparatus was rinsed 6 times with the detergent solution (0·1 % (v/v) Triton X100, B.D.H. Chemicals Ltd, Poole, U.K.) and all manipulations outside the chamber were performed under a laminar flow hood using clean P.V.C. gloves (Arbrook Ltd, Livingstone, U.S.A.).

*Sampling of chamber air for skin scales*

The air in the chamber was sampled with a Porton raised impinger (May & Harper, 1957); 5·5 litres of air were drawn through the impinger and the airborne skin scales collected in 10 ml of 0·1 % (v/v) Triton X100 placed in the impinger vessel. Skin scales entrained in the inlet tube of the impinger were removed by washing with two 5 ml quantities of 0·1 % (v/v) Triton X100 which were combined with the collecting solution. Two ml of the bulked suspension was then placed in a Millipore filter unit (25 mm, 0·45 nm pore size), 0·1 ml of 0·5 % (w/v) crystal violet solution added, the suspension filtered and the unit rinsed twice with 5 ml of 0·1 % (v/v) Triton X100. The filter was transferred to a glass Petri dish and dried in an oven at 60 °C. The dry filters were made transparent by the addition of immersion oil and the number of skin scales on the filter surface counted microscopically ( × 100 magnification). The total area of the filter surface to be viewed for counting consisted of the area stained with crystal violet. The dye also aided the identification of skin scales on the filter surface.

*Preparation of test pieces before exposure to skin scales*

Connector needles (manufactured from polymethyl methacrylate) removed from blood administration sets (Travenol Laboratories Ltd, Thetford, Norfolk, U.K.), and pieces of borosilicate glass, natural rubber and aluminium of similar size, were selected as materials to be examined. A length of cotton thread was attached to one end of each test piece by which they could be suspended. The test pieces were washed 6 times with 0·1 % (v/v) Triton X100 (the detergent was required to remove skin scales from solid surfaces), rinsed 3 times with distilled water and then suspended in the laminar flow hood to dry. Preparation by this method ensured that the test pieces were free from skin scales and surfactant solution, which might influence the attraction of airborne skin scales to their surfaces. Microscopic examination of test pieces confirmed that skin scales were absent (Plate 1A). After drying each test piece was placed in a stoppered tube with

the attached cotton threads extending outside the tube. This tube was now transferred to the skin scale chamber. The cotton threads were attached to the top of the chamber so that when the tube was opened and the pieces exposed they would be readily suspended (Fig. 1).

*Exposure and collection of test pieces*

Preliminary experiments showed that the concentration of skin scales in the chamber air rapidly decreased during the first 5 min after the creation of the skin scale environment to *ca.* $10^3$ skin scales per l. This was followed by a much slower decrease during the next 20 min. After creating an environment of skin scales as previously described, 10 min was allowed to elapse before each tube containing the test pieces suspended in the chamber was removed and the test pieces exposed to the skin scale environment.

For the first study, a combination of 5 connector needles and 5 pieces of either glass, rubber or aluminium were used. For the second study, 8 connector needles were used. In each case, five replicate experiments were performed.

At the end of the exposure time the cotton threads suspending the test pieces were cut and the pieces collected in clean stoppered tubes. The chamber air was sampled and counted at the beginning, and after exposure; the mean was taken as the concentration of airborne skin scales in the chamber air.

*Recovery of skin scales from test pieces*

The stoppered tubes were transferred to the laminar flow hood where 5 ml of 0·1 % (v/v) Triton X100 was added to each tube, shaken for 30 s, and the suspension transferred to a Millipore filter unit (25 mm, 0·45 nm pore size). This was repeated twice and each rinsing added to the same filter unit to which 0·3 ml of 0·5 % (w/v) crystal violet solution was then added. Three 5 ml rinses of the test piece were shown to remove 97 % (S.D. 2·3) of skin scales as shown by microscopic examination after washing. The solution was filtered and the unit rinsed with 5 ml of the surfactant solution. The filter was then placed in a glass Petri dish, dried and examined as previously described. A small number of skin scales found on the membrane filters (3–12 per filter) were derived from the recovery and counting procedure. This number was determined for each experiment by repeating the procedure of preparation, suspension, exposure and washing of a separate batch of test pieces, except that aerosolization of the skin scale material was omitted. This number was subtracted from the number of skin scales recovered from test pieces after exposure to the skin scale environment.

## RESULTS

The first study consisted of exposing the different materials to the skin scale environment for 5 min. Statistical analysis of the results revealed that a significant correlation existed between the number of skin scales in the chamber air and the number recovered from the connector needles ($r = 0{\cdot}65$; tabulated = 0·88 for $n = 3$; $P = 0{\cdot}05$) (Table 1). Microscopic examination of connector needles

Table 1. *The attraction of skin scales onto the surface of administration set connector needles and other materials*

| Experiment | Test piece material | Skin scales per litre of chamber air | Skin scales recovered per cm² of test piece* |
|---|---|---|---|
| A | Connector needle | 1825 | 63·1 |
| | Rubber | | 35·9 |
| B | Connector needle | 836·4 | 15·1 |
| | Glass | | 12·6 |
| C | Connector needle | 1364 | 32·2 |
| | Aluminium | | 29·7 |
| D | Connector needle | 1678 | 37·8 |
| | Aluminium | | 24·8 |
| E | Connector needle | 1198 | 58·0 |
| | Aluminium | | 41·8 |

* Mean of 5.

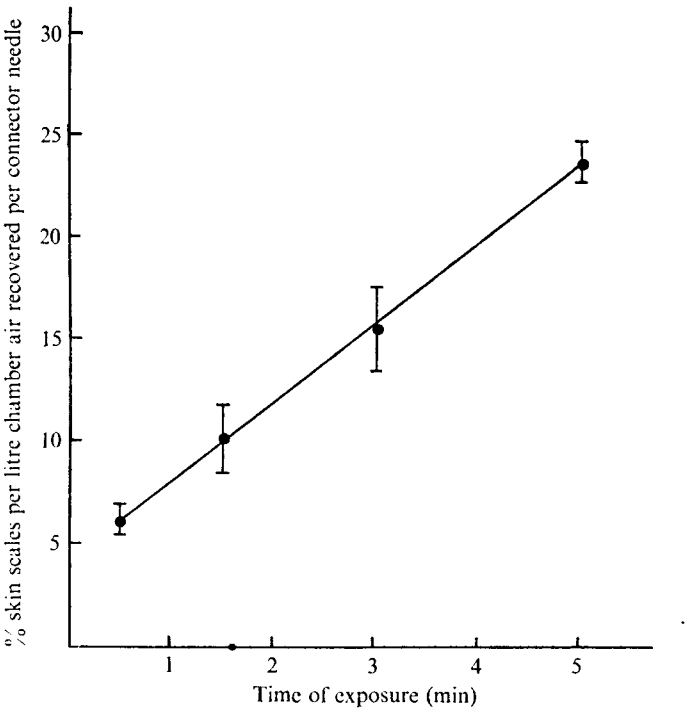



Fig. 2. The influence of the time of exposure in the number of skin scales recovered from administration set connector needles (mean ± standard error of the mean).

clearly revealed the presence of skin scales (Plate 1 B). The results showed that the mean number of skin scales recovered from connector needles ranged from *ca.* 100 to 400. The mean number of skin scales recovered per cm² of connector needle surface was greater in each experiment than for the other materials employed. However, a 2-way analysis of variance of individual experiments

https://doi.org/10.1017/S0022172400053274 Published online by Cambridge University Press

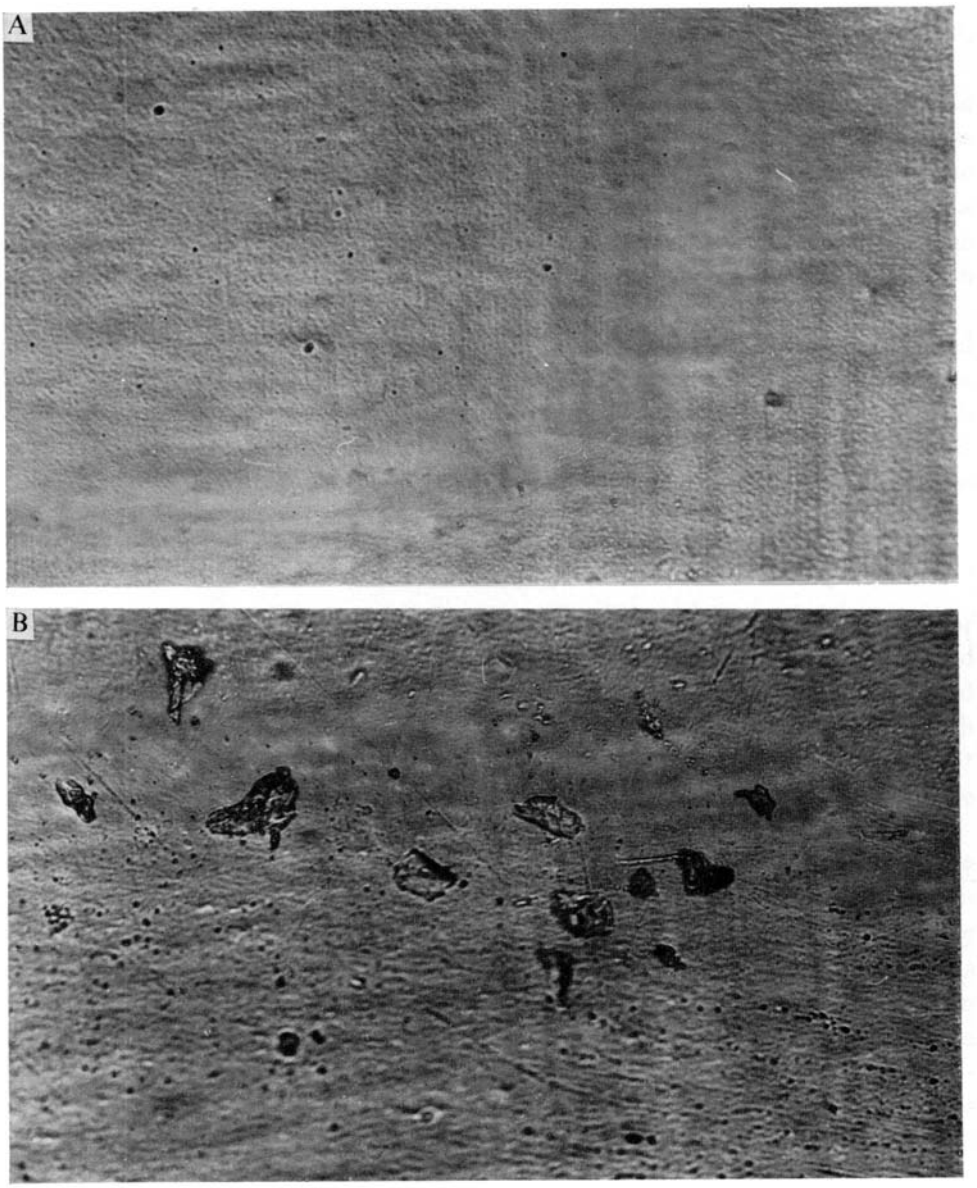
A–E showed that these differences were not significant ($f^1_{A4} = 0{\cdot}49$, $f^1_{B4} = 0{\cdot}88$, $f^1_{C4} = 0{\cdot}76$, $f^1_{D4} = 0{\cdot}54$, $f^1_{E4} = 0{\cdot}04$; tabulated value = 7·71, $P = 0{\cdot}05$).

The influence of time of exposure on the attraction of airborne skin scales to connector needles was examined. Five experiments were performed, in each case the concentration of airborne skin scales in the chamber varied. Therefore, the mean number of skin scales recovered per connector needle was expressed as a percentage of the number present per litre of chamber air. It was found that the number of skin scales attracted to the connector needles was directly related to the time of exposure (Fig. 2). A constant increase in the number of skin scales recovered from the connector needles was observed corresponding to an increased time of exposure to the environment of skin scales. Connector needles were exposed to environments of *ca.* 1150–1750 skin scales per litre and up to 130 skin scales were recovered from the connector needles on exposure for 30 s. This number increased with time, resulting in the recovery of up to 350 skin scales after 5 min exposure

## DISCUSSION

Results indicate that airborne skin scales are attracted onto the connector needles of intravenous infusion administration sets. Meers (1976) has suggested that this attraction may be due to electrostatic forces since it has been established that skin scales carry a negative surface charge (Lees & Brighton, 1972). Although the nature of this attraction is yet to be determined, the results of the present study show that no difference was found in the attraction of skin scales onto the surfaces of several different materials.

A complete layer of skin cells is shed from the human body approximately every 4 days (Halprin, 1972; Jansen, Hojyo-Tomoko & Kligman, 1974). Consequently, a large number of skin scales are constantly liberated from the body surface. May & Pomeroy (1973) recorded counts of between 237 and 17,000 scales liberated per minute. The abrasive action of clothes aids the detachment of skin scales from the body surface allowing these particles to be transported by the natural air convective boundary layer of the body and therefore into the environment (Clark & Cox, 1973). It has been estimated that 10% of such skin scales carry viable microorganisms (Noble & Davies, 1965). Davies & Noble (1962) observed concentrations of skin scales ranging from *ca.* 350 to 2000 per litre of air sampled from hospital ward environments (figures not dissimilar from those used in the present study) but only a small proportion (0·1–0·25%) carried viable microorganisms. The likelihood of contaminating intravenous infusions by skin scales attracted on to the connector needle will depend on the number of skin scales carrying viable microorganisms. Skin scales shed from the body of the person assembling or manipulating an infusion system will possess a greater proportion of skin scales carrying viable microorganisms than the environmental air (Noble & Davies, 1965). The longer the connector needle is exposed to an environment of skin scales in a hospital ward, the greater is the number that become attached to the connector needle. During the assembly of an intravenous infusion system, the connector needle is unavoidably exposed to the environment




C. J. HOLMES AND M. C. ALLWOOD (*Facing p.* 423)

https://doi.org/10.1017/S0022172400053274 Published online by Cambridge University Press

on removal of the protective sheath before insertion into the infusion container. Thus, to eliminate this source of intravenous infusion contamination, the assembly of the infusion system would have to be performed in a clean environment such as that provided by a laminar flow hood.

## REFERENCES


Arnold, T. R. & Hepler, C. D. (1971). Bacterial contamination of intravenous fluids opened in unsterile air. *American Journal of Hospital Pharmacy* **28**, 614–19.

Clark, R. P. (1974). Skin scales among airborne particles. *Journal of Hygiene* **72**, 47–51.

Clark, R. P. & Cox, R. N. (1973). Dispersal of bacteria from the human body surface. In *Airborne Transmission and Airborne Infection* (ed. J. F. Ph. Hers and K. C. Winkler), p. 413. Utrecht: Oesthoek Publishing Company.

D'Arcy, P. F. & Woodside, W. (1973). Drug-additives – a potential source of bacterial contamination of infusion fluids? *Lancet* ii, 96.

Davies, R. R. & Noble, W. C. (1962). Dispersal of bacteria on desquamated skin. *Lancet* ii, 1295–7.

Halprin, K. M. (1972). Epidermal 'turnover' times: a re-examination. *British Journal of Dermatology* **86**, 14.

Hansen, J. S. & Hepler, C. D. (1973). Contamination of intravenous solutions by airborne microbes. *American Journal of Hospital Pharmacy* **30**, 326–31.

Holmes, C. J. & Allwood, M. C. (1976). Intravenous infusion bottle plugs as a source of microbial contamination. *Journal of Hygiene* **77**, 315–20.

Jansen, L. H., Hojyo-Tomoko, M. T. & Kligman, A. M. (1974). Improved fluorescence staining techniques for estimating turnover time of the human *stratum corneum*. *British Journal of Dermatology* **90**, 9.

Kundsin, R. B., Walter, M. D. & Scott, J. A. (1973). In-use testing of sterility of intravenous solutions in plastic containers. *Surgery* **73**, 778–81.

Lees, J. & Brighton, W. D. (1972). Simulated human skin scales. *Journal of Hygiene* **70**, 559–64.

Maki, D. G. (1976). Sepsis arising from extrinsic contamination of the infusion and measures for control. In *Microbiological Hazards of Infusion Therapy* (ed. I. Phillips, P. D. Meers and P. F. D'Arcy), p. 99. Lancaster, England: MTP Press Ltd.

Maki, D. G., Goldman, D. A. & Rhame, F. S. (1973). Infection control in intravenous therapy. *Annals of Internal Medicine* **79**, 867–87.

May, K. R. & Harper, G. J. (1957). The efficiency of various liquid impingers in bacterial aerosols. *British Journal of Industrial Medicine* **14**, 287–97.

May, K. R. & Pomeroy, N. P. (1973). Bacterial dispersion from the body surface. In *Airborne Transmission and Airborne Infection* (ed. J. F. Ph. Hers and K. C. Winkler), p. 426. Utrecht: Oosthoek Publishing Company.

Meers, P. D. (1976). Intravenous infusions: the potential for and source of contamination. In *Microbiological Hazards of Infusion Therapy* (ed. I. Phillips, P. D. Meers & P. F. D'Arcy), p. 59. Lancaster, England: MTP Press Ltd.

Noble, W. C. & Davies, R. R. (1965). Studies on the dispersal of staphylococci. *Journal of Clinical Pathology* **18**, 16.

Percival, A. K. (1966). Contamination of parenteral solutions during administration. *Medical Journal of Australia* **2**, 954.


## EXPLANATION OF PLATE

### Plate 1

Microscopical appearance of the outer surfaces of administration connector needles (A) before exposure and (B) after exposure to the skin scale environment for 5 min (magnification × 100).