Discussion

It is not easy to reconcile these findings with those obtained in the early days of diphtheria immunization when F.T. was extensively used with definite clinical success. It is possible that the reason for the poor immunizing action of the present-day F.T. is the fact that it is prepared in a highly purified form, whereas the F.T. used in the early days undoubtedly contained many impurities which might well have exerted an adjuvant effect.

There is also a discrepancy between our findings and those reported by Bousfield and Holt (1954), who obtained better Schick-conversion rates in children after two spaced doses of 30 Lf of F.T. This discrepancy can, however, be explained on the basis of the difference in immunizing procedures. Whereas Bousfield and Holt always Schick-tested the children before immunizing them this was not done in our trials. Recently Bousfield and Holt (1962) have shown that better Schick-conversion rates can be obtained if children are Schick-tested before being immunized, particularly if the testing is done four weeks rather than one week before the injection of F.T. This effect is presumably due to the additional antigenic stimulus provided by the Schick-test dose.

From the results of our study it is concluded that diphtheria plain F.T. as prepared at the present time in a highly purified form is not suitable for primary immunization against diphtheria. In order to obtain adequate primary immunization with such a purified antigen it is essential that it should be combined with an adjuvant such as pertussis vaccine or a mineral carrier. It would thus seem desirable to give young children a combination of pertussis vaccine with diphtheria and tetanus toxoids (triple vaccine), and to older persons who have not previously been immunized a combination of diphtheria and tetanus toxoids containing a mineral carrier such as aluminium hydroxide or phosphate. Although it might be argued that such combinations carry a slight risk of provocation to poliomyelitis, now that vaccination against poliomyelitis is practised on a wide scale the risk is much less than in past years and will not become more frequent if the prevalence of poliomyelitis in the population remains low. If the triple vaccine is given after immunization with the poliomyelitis vaccine, as in Schedule Q of the Ministry of Health's Circular (1961), the risk should be almost negligible.

Summary

Field trials of diphtheria plain formol toxoid (F.T.) in children 6 to 12 months of age have shown that the highly purified material prepared at the present time is not suitable for primary immunization against diphtheria.

The Committee is grateful to those parents in Leeds who consented to have their children take part in this study.

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SKIN PREPARATION AND TOWELLING IN PREVENTION OF WOUND INFECTION

BY

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Records of sepsis in wounds after clean surgical operations have been kept in a uniform fashion in this unit since the beginning of 1955. Certain changes in antiseptic methods have been made from time to time, keeping as far as possible other factors constant, so that the effect of the changes on the sepsis rate might be observed. In a previous publication (Kinmonth *et al.*, 1958) the effects of changes in theatre ventilation on the bacterial content of the air and on wound sepsis were described. In that publication it was recorded that 10% of our patients were found to carry hospital staphylococci on their skin. This finding was based on swabs taken from the skin on the operation area just before the final skin preparation was made in the theatre. It was suggested that skin carriage such as this might be a cause of wound sepsis.

This is a report of the results of changes in techniques designed chiefly to reduce infection of clean wounds by organisms on the skin. The changes consisted, firstly, of more thorough preparation of the skin in the ward and in the theatre before operation, and, secondly, of measures taken during the operation to prevent transfer of organisms from the surrounding skin into the wound itself.

Methods

Records.—These were kept in the same way as in our previous studies. The particulars of the surgical operations, all of which were performed in the North Theatre of St. Thomas's Hospital, were entered in a wound book, which was reviewed monthly. The same criteria for grades of sepsis were used as in the previous study. It was classed as grade 1, or minor sepsis, if merely low-grade inflammation in the surface of the wound or the skin around it existed or if stitch infection occurred. Grade 2, or major sepsis, comprised those cases in which definite suppuration, delay in wound-healing, and fever occurred. Swabs were taken of all infected wounds, and records were kept of the organisms grown and of their sensitivity to antibiotics.

Changes in Antiseptic Methods.—The changes made in January, 1959, were as follows:

Before January, 1959	From January, 1959
<i>In Ward</i>	
Bath : ordinary soap Spirit paint-up and sterile towel covering	Bath : hexachlorophane ("cidal") soap. Hexachlorophane wash and sterile towel covering
<i>In Theatre</i>	
2% Iodine tincture ± Muslin skin towels Hand-dips : saline	5-minute wash with hexachlorophane soap 2% Iodine tincture Plastic skin towels Hand-dips : chlorhexidine ("hibitane")

The changes were chiefly towards the greater use of antiseptics to prevent infection from the skin. These were new and probably more effective than had been available in the past. The plastic skin towels were made of "denlar" semitransparent plastic sheeting,* and were sewn to the skin margins with a good overlap into the wound. "Vidrape"† adhesive surgical film has been used for some of these cases. It has the advantages of simplicity and ease of use, of being large enough to cover any operative area, and of excluding the patient's skin from the wound more thoroughly. These materials are waterproof. They cannot act like the conventional muslin cloth, which soon becomes wet and bloody and is a ready wick or depot for organisms. Chlorhexidine digluconate 1 in 2,000 aqueous solution has been used in the surgeon's hand-dips and also to rinse the wound at the end of operation or from time to time during longer operations. The plastic towels were often wiped clean with chlorhexidine solution at intervals during the operations, and the gloved hands were washed at intervals in the hand-dips to counteract spread of infection into the wound from the surroundings. No problems of healing followed the use of chlorhexidine solution.

Dressings.—No change was made in dressing technique. Dry gauze was stuck on to the wound with mastisol and, except for the smallest wounds, then covered with "elastoplast" adhesive strapping. The dressings were left in place, unless there was some particular indication, until the stitches were removed.

Results

The sepsis rates (Table I) show some fluctuation from year to year, but it is evident that a downward trend appearing in 1959 is continued in 1960 and 1961. If this fall were a random variation or due to changes in

TABLE I.—Comparison of Sepsis in All Cases Done in North Theatre (Excluding Dirty Cases)

Year	Cases	Grade 1 Sepsis		Grade 2 Sepsis		Total Sepsis	
		No.	%	No.	%	No.	%
1955	320	25	7.8	15	4.8	40	12.6
1956	384	22	5.7	17	4.4	39	10.2
1957	352	19	5.4	10	2.8	29	8.2
1958	501	34	6.8	21	4.2	55	11.0
1959	485	21	4.3	16	3.0	37	7.4
1960	482	12	2.5	9	1.9	21	4.4
1961	431	7	1.6	12	2.8	19	4.4

type of case then this should become evident in Table II. Here an analysis of the sepsis rate by operation shows that in fact there is a fall in rate in almost all types of case. This is very good evidence that the fall is a real one and of significance.

Certain operations carried a high risk of sepsis (Table II). In fact, 54% of the sepsis occurred in 21% of the cases. In high-risk operations various factors may increase the likelihood of infection. They are: longer operating-time, the use of foreign materials, extensive dissection, poor blood-supply, large flaps with resulting haematomas, and collections of fluid where bacteria may multiply. But in all cases, no matter how suitable the site of operation may be for the growth of pathogens, these must be introduced into the wound for infection to take place.

*Made by Denlar Ltd., 134 Curtain Road, London E.C.2.

†Obtainable from Aeroplast Corp., 420 Dellrose Avenue, Dayton, Ohio, U.S.A., or Samoora, Standard Works, Lawrence Road, London N.15.

TABLE II.—Comparison of Sepsis Rates in Different Operations (Grade 2 Only)

	1955-8			1959-61		
	At Risk	Septic	% Sepsis	At Risk	Septic	% Sepsis
Low-risk operations :						
Thyroid	33	0	0	36	0	0
Varicose veins	278	7	2.5	289	4	1.4
Hernia	187	2	1.1	90	1	1.1
Sympathectomy	107	3	2.8	99	1	1.0
Mastectomy	51	3	5.9	47	2	4.3
Abdominal (excluding re-section)	166	6	3.6	141	5	3.5
Superficial tumours	181	6	3.3	151	1	0.7
Others	268	5	1.9	200	1	0.5
High-risk operations :						
Amputation	49	4	8.2	44	1	2.3
Prostatectomy	32	3	9.4	24	3	12.5
Arterial	76	5	6.7	137	9	6.6
Abdominal (resection)	80	8	10.0	61	3	4.9
Cardiac	0	0	0	49	4	8.2
Renal	19	3	15.8	11	1	9.1
Incisional hernia	15	3	20.0	7	0	0
Block dissection	15	5	33.0	12	2	16.7

Discussion

The new techniques were introduced chiefly to combat infection from the skin and would be expected to act in this way, but they may possibly have affected other means of infection as well. The use of antiseptic solution in the hand-dips could, for example, have helped to cut down contamination by aerial fall-out of bacteria into the hand-dips and thence into the wounds during long operations. Rinsing the wound with chlorhexidine solution might perhaps have made some slight difference to the sepsis rate, but we think this to be unlikely. It was not possible to show a difference between controls and treated cases in a previous study (Kinmonth, unpublished data, 1954) when chlorhexidine was instilled into the wound at the end of operation.

After the innovations there has been a fall in sepsis maintained over three years. The composition of the series as regards numbers and types of operation before and after the change in methods is very similar. There is one exception. The later group contains a number of open cardiac operations, and the earlier does not. However, these operations had a relatively high (8.2%) sepsis rate, and so their inclusion cannot be said to have artificially lowered the total sepsis rate; rather the reverse.

An interesting confirmation that the fall in sepsis observed is a meaningful one comes from Table II, where the sepsis rate is analysed according to type of operation. It is seen that it is consistent for the different operations. Those with higher sepsis rates before the change have relatively higher ones after. For example, block dissection is the operation with the highest risk both before and after the changes in aseptic technique.

While the reservoir of infection is in the hospital and the ultimate source infected patients, how and when is the infection transmitted to the wound? Many possible routes exist both in theatre and in ward. It is suggested that the fall in sepsis rate in this surgical unit is the result of the new methods adopted, by removing one route of infection. No other major changes have been introduced. There has been no change in ward-dressing techniques.

It is not always clear how the patient's skin may become contaminated, but there are various possibilities. The patient may be a nasal carrier, and the transfer of bacteria from nose to skin occurs easily. Hare and Ridley (1958) found that 4 out of 15 nasal carriers of *Staph. aureus* carried the organism on the abdominal

skin. Williams *et al.* (1960) quote several studies in which it was shown that the wound sepsis rate was higher in patients who were nasal carriers.

Adequate skin-cleansing with antibacterial agents may sterilize the skin surface, but organisms exuded from sweat and sebaceous glands may in time contaminate porous skin towels and the wound. Only careful exclusion of the patient's skin surface will prevent this route of entry. Lowbury and Lilly (1960) have shown that preparation of the skin with antiseptics may reduce the number of bacteria but not eliminate them completely. It is therefore important to attempt to protect the wound from the entry of organisms from the surrounding skin even though it may have been thoroughly prepared.

While we do not deny that wounds may be infected from many sources within and without the theatre, demonstration of the route and source of specific infections is most difficult. All possible sources of organisms should therefore be eradicated or excluded. This paper focuses attention chiefly on one source, one that is often neglected—the patient himself at operation.

Summary and Conclusions

New techniques of skin preparation and skin towelling were introduced into the Surgical Professorial Unit at St. Thomas's Hospital in January, 1959. In the ensuing three years a fall in wound sepsis rate was observed compared with the previous four years.

It is suggested that one of the important sources of organisms infecting surgical wounds may be the patient's own skin. Good exclusion of the skin surface from the wound can be obtained with modern methods.

We are grateful to Professor R. Hare and Professor R. A. Shooter for help and suggestions during this work, and to Mr. M. P. Curwen, of the Department of Medical Statistics of St. Bartholomew's Hospital, for his advice.

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SILICONE SPRAYS IN PREVENTION AND TREATMENT OF DECUBITUS SKIN DISORDERS IN DOMICILIARY NURSING

BY

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Silicone fluids have been incorporated into ointments and barrier creams since their properties became generally known. Their main uses have been as vehicles for medicaments (Laumanns, 1958) and to protect the skin against discharges such as around colostomy wounds, napkin areas in infants, and folds of skin macerated by intertrigo (Wigley, Calnan, Meara, and Seville, 1952). Smith, Day, and Zimmerman (1953) found a silicone cream more effective than other barrier creams against eczematogenous contact allergens. M. A. Cooke (personal communication, 1961) also found a delayed and reduced area of reaction in a procaine-sensitive patient by applying a silicone and methyl cellulose emulsion to the skin for four days prior to the application of 2% procaine, compared with control sites similarly treated with a standard barrier cream or left unprotected.

Silicone fluids were chosen because they are inert: they protect the skin and permit normal healing to take place (Morrow, 1954). They were found particularly valuable against aqueous systems whether from body discharges or in protecting the skin from outside contact, as in hydrotherapy (Accart, 1957).

Other workers (Bateman, 1956; James, 1956; Roberts, 1959) have used silicone creams in the prevention of decubitus ulcer, claiming not only that they were effective but that they also saved the nurses' time. Roberts and Williams (1957) first described silicone barrier creams in domiciliary nursing and found them so successful that they instituted them throughout the nursing services for which they were responsible.

Since nearly all the work on decubitus ulcers had been with silicone barrier creams, although Brusca (1956) and Roberts (1962a) had used a spray with success, we thought it might be valuable to compare the use of

barrier creams and silicone sprays with the traditional method in domiciliary nursing.

Materials and Methods

Silicone fluids are linear polymers based on the siloxane (R_2SiO) unit. The polymers can be of varying length, and as the molecular weight increases so does the viscosity. The reference numbers MS 200 and MS 555 which are used to describe the fluids we used are a commercial convenience. The B.P.C. designation for polydimethylsiloxane fluids suitable for pharmaceutical application is dimethicone, and these are available as MS 200 fluids. The repeating polymer unit is Me_2SiO , and all the organic groups attached to the silicone are methyl groups. The fluid MS 555, which has both phenyl and methyl substituent groups in its molecule, has the unusual property among silicone fluids of being soluble in alcohol, while the dimethicone fluids are not. MS 555 fluid was used in two strengths, 2% and 5% in ethanol, and sprayed from "freon" (dichlorofluoromethane)-operated canisters: the two were distinguished by colour of the label only, and neither G. S. W., who directed the trial, nor the nurses knew which strength of silicone they used.

The Middlesex County Council organizes its home-nursing service through ten local area committees. The superintendents of home nursing from the areas met us to discuss the nature and objects of the trial, and their co-operation was readily given. It was pointed out that if silicone sprays were as effective as more-established methods two advantages might accrue: first, saving of nursing-time, and, second, a spray might be used by the patients' relatives in domiciliary nursing in the nurse's absence, where a more difficult or more time-consuming method would either not be undertaken or be under-