seems to be of particular importance not only in asthma but more especially in vasomotor rhinitis, and old foci in the antrum may be responsible for the exacerbation of symptoms in operations on the nose.

Treatment and Prophylaxis

It is clear that treatment of allergic conditions, especially of asthma, can and must start from several different aspects. When the specific allergen is the outstanding factor the discovery and removal of it may be followed by complete recovery. It may be very easy in one case and impossible in another.

As the complete range of allergens that are responsible can rarely be discovered in any one case, I make use of those specific allergens that have been detected mixed together with either peptone or small quantities of old tuberculin. Such a mixture is of great use in the treatment of a case in which any doubt remains as to the identity of all the responsible allergens. The treatment begins with a dose of a dilution that has been found, by means of titration in skin tests, to be considerably smaller than the smallest quantity producing a skin reaction. The course of injections, covering a period of ten to twelve weeks, should consist of doses of increasing size, and

until the patient has acquired a high degree of desensitization and consequent immunity.

Summary

The "threshold towards the allergen" varies not only in different persons but in the same person at different periods of life and under different conditions.

Hypersensitivity is consequently a variable factor not only in general but also in particular localized areas.

Thirdly, one has in these conditions to deal with a variety of causes changing the threshold of hypersensitivity. Treatment consists in dealing with septic foci, endocrine and metabolic changes, special physical conditions of the upper respiratory tract and chest wall, and with psychological factors influencing the sympathetic nervous system.

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The mask type of allergen-filtration apparatus connected to a high-pressure air supply in horizontal pipe behind chairs.

should not in any way be interrupted. Should, as the doses are increased, a severe reaction occur, the addition of 0.25 c.cm. of adrenaline 1 in 1,000 and/or the reduction of the quantity of the next dose to that of the preceding one will in most cases allow treatment to be continued. I have always tried to begin treatment in allergen-free surroundings. For hay fever it is usual to begin and finish the treatment before the start of the hay-fever season. With house allergens such surroundings may be obtained by means of an allergen-filter apparatus (see figure)—mask, sleeping bag, or cubicle—or by the careful removal of feathers and dust. In instances of food allergy the necessary conditions are obtainable by means of a special diet.

As has been shown before, the majority of cases in adults as well as in children are due to a hypersensitivity towards house allergens. Those next most responsible are the bacterial allergens, and I think it is for this reason that some asthma patients respond to vaccine treatment. The efficacy of such treatment depends very largely on the choice of the correct dose, on the type of bacterial vaccine, and on the time interval and the length of treatment. I prefer to use autogenous bacterial "allergens"

POST-HYSTERECTOMY AND PUERPERAL TETANUS

A STUDY OF THE BACTERIOLOGY OF OBSTETRICAL AND GYNAECOLOGICAL DRESSINGS *

BY

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The experiments related in this paper were undertaken to discover why a specific case of tetanus developed after hysterectomy, and they were extended to establish the reason why post-operative tetanus is peculiarly related to hysterectomy. It was apparent as a result that the dressings used before the operation contained tetanus spores and other anaerobic spore-bearing pathogens; they were made of "cellulose wadding."

Study of a Case

The clinical features of the case were as follows.

A woman of 51 suffered from intermittent loss of blood per vaginam. At operation an endometrioma of the posterior uterine wall was found attached to the pelvic colon. Total hysterectomy and bilateral salpingo-oophorectomy were performed. Four days later "tonsillitis" developed; and seven days later trismus, with spasms on deglutition. A diagnosis of tetanus was made by two clinicians experienced in the condition. She died twelve days after the operation.

At the post-mortem examination the operation site was found in fair condition, although less union of tissue was present than normal; there was no definite naked-eye sepsis. The spleen was soft and diffused, little evidence of tonsillitis was found, and nothing explaining death.

Material from the wound site was collected, and also a sample of faeces. The tissue cultures yielded morphologically typical tetanus bacilli and spores; the faeces did not. A guinea-pig injected with a mixed culture died with signs of tetanus.

The catgut used at the operation had also been used on the same day on two other cases, which had a normal con-

* From the John Burford Carll Laboratories, Westminster Hospital Medical School.

valescence. A sample was tested and gave no aerobic or anaerobic growth. It was reissued for general use, and the whole batch, a large one, was used over a period of months with no untoward results.

Attention was then directed to the dressings. After operation the vulval pads used were made of cotton-wool, autoclaved according to a routine found satisfactory by test. No organisms were found in sampling a typical dressing tin. Before operation, however, a pad of unsterilized cellulose wadding had been used. A specimen was taken and placed in a wide-mouthed jar, boiling broth was poured on to it, and the culture was examined after seventy-two hours. Morphologically typical tetanus bacilli were found; the culture was purified by subculture, and on injection into mice typical tetanus developed.

The position, therefore, was that a woman not harbouring tetanus spores in her faeces developed tetanus after an operation in which catgut was almost certainly not to blame, and that the pads employed prior to operation were conclusively shown to contain tetanus spores. It would scarcely be possible to obtain a better *a priori* case for the aetiology of this particular tragedy.

Consideration of the Literature

An admirable account of the literature of catgut tetanus is given by Dalrymple-Champneys. The difficulty of proving a chain of events which had their origin some days or weeks back is obvious; the specific catgut used is rarely if ever obtainable, and it is not surprising that proof of the contamination is rarely to hand. Although the material used is made from the relatively sterile small intestines of lambs, it is obviously a possible cause of post-operative tetanus. But there are a very large number of other possible sources; tetanus spores are everywhere. There are, indeed, strong reasons to suppose that post-operative tetanus is due most often to causes other than catgut.

In the first place, if catgut were to blame as a rule we should expect a general operative incidence, or perhaps an incidence varying only with the amount of catgut used. But, broadly considered, tetanus is found to follow minor operations where no catgut is used more often than major operations involving much catgut. Such conditions as tetanus neonatorum, due to the knife used, tetanus following vaccination and corn-cutting, due to the dressings, and a series recently reported by Godwin where several cases after circumcision were found to be due to dressings applied by a Cypriot quack, indicate that it is unreasonable to blame catgut, in whose preparation at least some care is taken, rather than dressings and apparatus, in whose preparation far less care is taken.

The observation that post-operative tetanus has a peculiar incidence following hysterectomy was made by Fildes, who stressed the difficulty of proving a relationship between the catgut used and the infection. He quoted cases recorded by Koch, Audebert, and Dyke. Four further cases have been reported to me privately.

Apart from cases following hysterectomy a large number of cases after abortion, either criminal or natural, and after childbirth are recorded. Le Doze collected nineteen cases of puerperal tetanus, and stated that puerperal tetanus accounted for 3.5 per cent. of all cases of tetanus. The literature of tetanus has recently abounded in references to this condition; cases have, for example, been recorded by Rossi and Bernardbeig. Moreover, the female genital tract is a possible source of contamination in tetanus neonatorum; and the case of tetanus developing after rupture of prepuce in coitus recorded by Kuzmin may perhaps have been of similar aetiology. The importance of the condition in obstetrical and gynaecological

practice must not, however, be exaggerated. Reference to the literature indicates its development after compound fractures, where the dressings or direct wound contamination by dirt may be the cause, after operations on the gut, where the organism is possibly derived from the faeces, and after extraction of teeth. In the case of dental extractions, again, the possibility of infection from the plug inserted into the socket must not be overlooked, although tetanus bacilli have been grown from saliva. Enough has, however, been said to show that tetanus is a disease sooner or later likely to bring itself to the attention of gynaecologists and obstetricians, and that any explanation of its development in such practice deserves consideration on its merits.

Tetanus Spores in Cellulose Wadding

The discovery of the unsuspected presence of tetanus spores in cellulose wadding dressings was made by Fildes; and two cases developing in orthopaedic practice from splints packed with this were described by him at a meeting of the Pathological Section of the Royal Society of Medicine in 1935. The cases were not published. The technique used by him makes the isolation of tetanus, previously difficult, exceedingly simple. Cellulose wadding produces a "reduction potential" which makes anaerobic culture easy without further elaboration, and the climbing properties on agar slopes of the organism render purification again a simple matter. No other anaerobe is so easily obtained pure.

In view of the apparent relationship of the case here described to "sanitary towels," a number of different types of British make were examined. They were made of bleached or unbleached, coloured or non-coloured, cellulose wadding, or of cotton-wool, or of mixtures of both. Some were advertised as hygienic, aseptic, or antiseptic. No British towel is actually sold with a guarantee of sterility, though some have a vague certificate.

It is difficult for the pathologist to see any difference of importance between the various makes, though of course the wearer may find preferences.

Results of Cultures

The results of anaerobic cultures are tabulated below. It will be seen that *Cl. tetani* and *Cl. welchii* are consistently present, and that in some cases death from tetanus followed in mice injected. In many cases mild tetanus developed, but the mice recovered.

No.	Composition of Towel	Description of Towel	Anaerobic Bacteria	Litmus Milk	Mice Tests
1	White cellulose wool; white cotton-wool	Nil	<i>Cl. tetani</i> <i>Cl. welchii</i> <i>Cl. sporogenes</i>	Acid Storm clot	Negative
2	White cellulose wool; coloured cellulose wool	Nil	<i>Cl. tetani</i> <i>Cl. welchii</i> <i>Cl. sporogenes</i>	Acid Storm clot	Positive
3	White cellulose wool	Certificate of Hygiene	<i>Cl. tetani</i> <i>Cl. welchii</i> <i>Cl. sporogenes</i>	Acid Storm clot	Positive
4	White cellulose wool	Nil	<i>Cl. tetani</i> <i>Cl. sporogenes</i>	Acid	Negative
5	White cellulose wool	Nil	<i>Cl. tetani</i> <i>Cl. welchii</i> <i>Cl. sporogenes</i>	Acid Storm clot	Negative
6	White cellulose wool	Certificate of Hygiene	<i>Cl. tetani</i> <i>Cl. sporogenes</i>	Acid	Positive
10	Brown and white cellulose wool; white cotton-wool	Nil	<i>Cl. tetani</i> <i>Cl. welchii</i> <i>Cl. sporogenes</i>	Acid Storm clot	Slight spasms.
11	Brown and white cotton-wool	Nil	<i>Cl. tetani</i> <i>Cl. welchii</i> <i>Cl. sporogenes</i>	Acid Storm clot	Negative
12	White cellulose wool; white cotton-wool	Nil	<i>Cl. welchii</i> <i>Cl. sporogenes</i>	Acid Storm clot	Negative
13	White cotton-wool	Antiseptic, recommended by medical profession	<i>Cl. welchii</i> <i>Cl. sporogenes</i>	Acid Storm clot	Negative
14	White cellulose wool; brown and white cotton-wool	Antiseptic	<i>Cl. welchii</i> <i>Cl. sporogenes</i>	Acid Storm clot	Negative

Aerobic cultures were then made on the same products ; a much more difficult task, since spreading air organisms were constantly present. Results may be again tabulated, haemolytic staphylococci, non-haemolytic streptococci, and *B. coli* were identified.

No.	Description of Towel	Aerobic Bacteria	B. CcLi Test
1	Nil	Haemolytic staphylococci Coliform bacilli	Positive
2	Nil	Staphylococci Streptococci	Negative
3	Certificate of Hygiene	Staphylococci Streptococci	Negative
4	Nil	Staphylococci	Negative
5	Nil	Coliform bacilli Pneumococci	Positive
6	Certificate of Hygiene	Haemolytic staphylococci Coliform bacilli	Positive
10	Nil	Streptococci, Coliform bacilli, <i>B. subtilis</i>	Positive
11	Nil	Staphylococci Coliform bacilli	Positive
12	Nil	Haemolytic staphylococci Coliform bacilli	Negative
13	Antiseptic, recommended by medical profession	Haemolytic staphylococci Coliform bacilli	Negative
14	Antiseptic	Staphylococci, Coliform bacilli, <i>B. subtilis</i>	Positive

In France several brands of towel are sold with vague certificates of sterility ; one type was found with a clearly phrased guarantee specifying the autoclave temperature. The results of cultures were as follows :

No.	Composition of Towel	Description of Towel	Anaerobic Bacteria	Litmus Milk	Mice Tests
7	White cotton-wool	Aseptic and Antiseptic	<i>Cl. welchii</i>	Acid storm clot	Slight spasm. Negative
8	White cellulose wool Coloured ..	Aseptic	<i>Cl. tetani</i> <i>Cl. sporogenes</i>	Acid	Negative
9	White cotton-wool	Aseptic and Antiseptic Sterilized 130° C.	<i>Cl. tetani</i> <i>Cl. welchii</i>	Acid storm clot	Negative

No.	Aerobic Bacteria	B. Coli Test
7	Coliform bacilli	Positive
8	Haemolytic staphylococci	Negative
9	Coliform bacilli, <i>B. subtilis</i>	Negative

In America greater importance is attached to sterility of towels, and one at least is sold with a specific guarantee of sterility. It is a tampon of white cotton-wool which lies in the vagina. It was the only towel examined which proved sterile. No "towel" of this vaginal type is sold in Great Britain, though, of course, dancers among others use such methods of absorbing menstrual flow.

No.	Composition of Towel	Description	Anaerobic Bacteria	Litmus Milk
16	White cotton-wool	American. Nil	Nil	Sterile
			Aerobic Bacteria	B. Coli Test
16	"	"	Nil	Negative

An accouchement set put up by a reputable maker was next examined. It was, of course, sold as sterile. The superficial wool was charred, suggesting that dry heat was used for sterilization. Results were as follows. The anaerobic staphylococci may be neglected ; they were probably introduced during culture.

"Sterile" Accouchement Set

No.	Composition of Material	Description of Material	Anaerobic Cultures	Litmus Milk	Mice Tests
X	Brown and white cotton-wool towel	Sterile	<i>Cl. tetani</i> <i>Cl. sporogenes</i>	Acid	Slight spasm.
Y	Brown cotton-wool	"	Staphylococci <i>B. subtilis</i>	No change	Negative
Z	White cotton-wool	"	Staphylococci <i>B. subtilis</i>	No change	Negative
			Aerobic Cultures	B. Coli Tests	
X	Ditto	"	Sterile		Negative
Y	Ditto	"	<i>S. subtilis</i>		Negative
Z	Ditto	"	Sterile		Negative

An accouchement set was next arbitrarily selected from the labour ward of a general hospital. The vulval pads were made of cellulose wadding. When cultured they were found sterile.

A similar set sold by a private firm and issued under strict supervision and regular bacteriological test by an enlightened medical officer of health in London was next examined. It had a closely fitting lid, which is often not the case. All the pads were made of cotton-wool. Three out of four were sterile. *B. subtilis* was obtained in one case, almost certainly a cultural contamination. The practice of this medical officer of health appears not to be universal ; in some districts at least no control or supervision of accouchement sets exists.

It would appear from these findings that cellulose wadding is peculiarly apt, as Fildes showed, to harbour anaerobic spores. The reason is not obvious, since cotton-wool also consists of cellulose.

The method of manufacture of cellulose wadding is as follows :

1. Selected tree trunks, mainly red spruce and pine, are mechanically ground into chippings and then heated under pressure in an autoclave at a temperature of above 100° C. with a strong aqueous solution of sodium hydrogen sulphite containing an excess of sulphur dioxide. This treatment converts the lignin into lignone sulphonic acid, which, being soluble in water, is removed by washing, leaving behind the pure cellulose. The latter is then suspended in water, bleached with strong calcium hypochlorite solution, and then run out on a machine and converted into fairly thick boards.

2. The sulphite wood pulp is taken as required, macerated with water in a beating engine until it disintegrates into its constituent fibres, and then treated again with calcium or sodium hypochlorite solution. The pulp is then diluted with water and run on to a machine, where it is made into plied wadding.

These processes would be calculated to kill any spores, and in fact material after stage 1 and stage 2 was found free from *Cl. tetani* and *Cl. welchii* by bacteriological tests. The contamination therefore follows later.

Measurement of the electrical charge and rate of leak by a Lindeman electrometer did not show a material difference between cotton-wool and cellulose wadding ; nor does either of them attract lycopodium when rubbed with vulcanite or other rods. A sterilized pad hung up in a room for seven days was not found on later culture

to contain either *Cl. tetani* or *Cl. welchii*, whether its composition was cellulose wadding or cotton-wool. However, cellulose wadding is known to have characteristics which make it peculiarly useful in industry; it is used in filtering solutions in artificial silk manufacture, and in gas masks, where cotton-wool is much inferior. The characteristics which make it of value in industry render its use, unsterilized, dangerous in medicine.

Discussion of Results

There is a danger that results such as those here described may be given grossly exaggerated importance. Tetanus spores are everywhere; and in this work such things as artificial and real silk handkerchiefs were found to contain them. It is not the presence of the spores but the use which is made of the products containing them which matters. No one has ever contracted or is ever likely to contract tetanus during the use in menstruation of these towels. Equally obviously, they should not be used before or after parturition or pelvic operations, even if they have been "sterilized."

Certain considerations, however, present themselves to a pathologist who studies for the first time the apparently neglected subject of the "hygiene of menstruation," and the "accouchement set." Sanitary towels are a recent development of civilization. They are not towels; are they sanitary? Is it really desirable to retain the menstrual flow at the vulva, particularly in pads apparently selectively impregnated with most of the better-known anaerobic and aerobic pathogens? Does this increase the "carrier rate" of the individual; and even if tetanus is a curiosity in the puerperium or after operation, is *welchii* infection so rare? Can women become carriers of virulent streptococci from this source, especially since so many women wear pads during pregnancy? Is the American technique of the sterile vaginal tampon preferable, whatever its aesthetic or other objections?

Moreover, it certainly seems strange that in these days of extreme care in the management of the puerperium no regulations exist for the sterilization or control of accouchement sets. A patient who contracts a *welchii* infection will get a serum which must comply with elaborate regulations; but the dressing which gave her the infection need comply with none. Yet the necessary regulations are few: autoclaving and occasional bacteriological testing are all that is needed. At present the sale of a tin of sardines is the subject of more official control than a tin of accouchement dressings. All the resources of preventive medicine are making little impression on the incidence of puerperal infection. The aboriginal, who uses no menstrual pad and no accouchement dressing tin, is safer from infection than her civilized sister.

It is not intended to exaggerate the importance of these views; there are unfortunately only too many known ways in which infection may occur in pregnancy. It is just possible, however, that changes in the hygiene of menstruation and more care in sterilization of dressings might be of benefit.

Technique of Examination

The bacteriological examination of a large object such as a vulval pad presents many difficulties. Spore-bearing organisms are, of course, very numerous in the air, and are apt to adhere to the pad during manipulation. Moreover, where wide-mouthed jars are used in culture, spores may drop in during manipulation, or might even survive in a cotton-wool plug after autoclaving. Control tests were therefore done with pads known to contain tetanus spores, and pads were autoclaved, impregnated with *Cl. sporo-*

genes, which has a typical morphology, and again autoclaved and then cultured. To avoid the risk of contamination from unsafe plugs the culture jars were fitted with screw caps.

These preliminary control tests showed that autoclaving for fifteen minutes at 130° C. killed *Cl. tetani* and *Cl. sporogenes* in vulval pads.

Such objects as the bristles of test-tube brushes used in the laboratory and the dust of the laboratory floor were found to contain tetanus spores. A rigid technique involving the minimum of manipulation was therefore followed. In no case were any pathogenic spore-bearing organisms found in material sterilized in the laboratories or the theatre sterilizer of Westminster Hospital.

On the other hand *B. subtilis* grew, usually after a lapse of some days, in about one control test in four, and occasionally *Staphylococcus albus* was grown. The laboratory air, filtered through powdered sugar, was found to contain these organisms. Even when manipulations are performed behind a glass screen complete sterility is difficult to ensure.

It is wise, therefore, to examine at least four pads from a dressing tin, and to neglect an occasional contamination with staphylococci or *B. subtilis* in criticizing an accouchement set.

The pad, when placed in a sterilized jar, is immediately covered with boiling lemco broth (about 500 c.cm.) and left for seventy-two hours. Subcultures are made into Robertson's medium, and from this subcultures were made into litmus milk and on to the bottom of a tube of Fildes's medium, which should be dry and horny at the top. Subcultures are again made into Robertson's medium from the horny part of the slopes, and after seven days mice are injected. Even if the animal does not die with signs of tetanus mild cases may be recognized by holding the animal up by the tail and placing a pencil between the hind legs. The animal clutches the pencil with its legs; but if there be a mild tetanic intoxication the injected leg soon goes into spasm.

A storm clot in litmus milk is taken as evidence of *Cl. welchii*.

For aerobic culture pads are soaked in sterile saline filtered through a sterile Gouch filter; the filtrate is centrifuged and the deposit cultured on appropriate media.

It may here be added that pads soaked in lochia have been examined by a similar technique. Vast numbers of bacteria in great variety are present, even when the pads are sold as impregnated with strong antiseptics. This, however, is a separate problem.

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On the occasion of the celebration of the centenary of the Medical Association of Vienna there will be a special festal "week" of medical meetings, receptions, and excursions in Vienna from May 19 to 29, during which addresses will be given by leading authorities in various European countries. The preliminary programme may be obtained from the Kursbüro der Wiener Medizinischen Fakultät, 4, Alserstrasse, Vienna, IX.