BRITISH MEDICAL JOURNAL

LONDON SATURDAY SEPTEMBER 29 1945

FURTHER REDUCTION IN HOSPITAL INFECTION OF WOUNDS

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Assessments of incidence of hospital infection of wounds in the World War of 1914-18 were made by Fleming and Porteus (1919) and by Stokes and Tytler (1918-19). The investigations of the former workers showed that 15% of all admissions were already infected with *Streptococcus haemolyticus* and that after a further stay in hospital of a week or more the incidence rose to 90%. Stokes and Tytler (1918-19) showed a rise in incidence of infection with *Str. haemolyticus* from 18.2% in the first seven days to 42.1% at the end of two weeks. The table below gives the incidence of infection with other organisms over the same period.

Swab	No. of Wounds	Str. haem.	Staph. aureus	Coliforms	Diphtheroids
Initial swab ..	165	18.2%	14%	23%	7.2%
1 to 7 days ..	60	21.6%	15%	10%	3.3%
4 to 14 days ..	19	42.1%	36.8%	26.3%	

After Stokes and Tytler (1919).

At the beginning of the Second World War the rate of hospital infection was still unpleasantly high. In 1940 Miles and others described 74 cases in which the percentage rate of cross-infection (or hospital infection) reached 58 for a combination of *Str. haemolyticus*, *Staph. aureus*, Gram-negative bacilli, and diphtheroids:

	Str. haem.	Staph. aureus	Gram-neg. Bacilli	Diphtheroids
Group 1 20 cases ..	40%	45%	15%	10%
" 2 30 " ..	13.3%	6.5%	10%	10%
" 3 24 " ..	25%	8.5%	33.3%	33.3%

Of the 74 wounds, 43 acquired new infecting bacteria, giving a total hospital infection rate of 58%. (After Miles *et al.*, 1940.)

In 1940 McKissock, Wright, and Miles found a cross-infection rate with *Str. pyogenes* of 15.4% in a series of air-raid casualties under routine local and systemic treatment with drugs of the sulphonamide group.

It would thus appear that relatively little abatement of the risks of hospital infection had taken place between the two wars in spite of the increase in experience during the intervening period, when certain reports, notably by Cairns and Cowan, indicated some of the more striking points in theatre and ward infection, all of them examples of hospital infection. It was in the light of this accumulated knowledge of cross-infection that McKissock, Wright, and Miles made the experiment which they recorded in 1941. They devised a dressing technique to reduce some of the more obvious risks of hospital infection. No attempt was made to block all channels of infection, but a serious assault was made upon the many channels which were laid open during the course of the dressing of wounds as ordinarily carried out in the hospital ward. The result of the adoption of an improved dressing technique over a four-months period, contrasted with a previous four-months period, showed a reduction of cross-infection with *Str. pyogenes* from 15.4 to 1.1%.

The present paper records the prophylactic effect of the improved dressing technique, which, since our 1941 report, has

been in continuous use over a period of three years. In the first four months of its trial *Str. pyogenes* was used as the sole indicator of hospital infection, but in view of the marked diminution of the streptococcal infection rate obtained in the original experiment the scope was subsequently widened to include all the potentially pathogenic aerobic bacteria commonly found in wounds.

Conditions of the Three-year Trial Period

The trial was made for 20 months in one hospital, after which the unit was transferred to another hospital, where the remaining 16-months trial was held. Neither building was in any way modern from the structural standpoint and no special facilities were available to render the conditions of the experiment unusually favourable. During the first 20 months the staff was composed mainly of voluntary aid detachments with a small number of civil nursing reserves, while in the second hospital the staff consisted mainly of nurses in general training. The theatre staff remained substantially unchanged throughout, and was composed almost entirely of voluntary aid detachments. One fully trained sister was in charge of the theatre and the 70 beds comprising the unit. Junior medical personnel changed at roughly yearly intervals.

No special precautions were taken to avoid airborne infection other than insistence upon the completion of bed-making and ward-cleaning at least half an hour before the performance of dressings and the closure of all doors and windows during dressings. The dressing technique demanded the employment of one doctor and three nurses at each dressing and followed exactly the routine laid down in the original paper, which was somewhat more elaborate than that recommended in the M.R.C. Memorandum on the subject.

Material

There were in the whole period 1,129 wounds at risk, of which 882 were clean surgical incisions and 247 traumatic wounds. Of the latter, 231 already contained pathogens at the time of admission, while in 16 cases cultures from the initial wound swab were sterile. It is probable that in the later months of the three-year trial period the risk of hospital infection was less grave than in the earlier period by reason of the smaller number of septic cases admitted to the wards. During this period, however, there were nearly always some infected wounds to swell the reservoir of infection permanently pro-

TABLE I.—Details of Wounds

Surgically Inflicted				Traumatic			
Ventriculography ..	..	..	433	Head and back ..	..	..	220
Craniotomy ..	..	..	251	Arm ..	..	..	12
Laminectomy ..	..	..	92	Leg ..	..	..	10
Burr-holes ..	..	..	60	Trunk ..	..	..	5
Leucotomy ..	..	..	12				
Trigeminal sensory-root section ..	..	..	10				
Arteriography ..	..	..	9				
Miscellaneous ..	..	..	15				
Total ..	..	..	882				247

vided by the respiratory tracts of medical and nursing personnel, the patients, and their visitors.

Technique of Investigation

Bacteriological Method.—Wound swabs were taken from all surgically inflicted wounds wherever there was a moist surface, gaping of the wound, eversion of a skin edge, or obvious clinical infection. A swab was taken from traumatic wounds at the time of the first dressing after admission to our department and again at every subsequent dressing (on an average about thrice weekly) until healing was complete. The initial swabs were cultured aerobically and anaerobically, but if no anaerobes were obtained on this occasion further anaerobic cultures were omitted.

Chemotherapy.—All patients with traumatic wounds were given a five-day prophylactic course of sulphapyridine, sulphathiazole, or sulphamezathine, amounting to 30 g. in all. Open traumatic wounds were dusted with sulphanilamide powder, and a small number of the clean surgically inflicted wounds were similarly dusted in layers as they were closed. Penicillin was not given to any patient in the series.

"Hospital" or Cross Infection.—Infection has been classed as "silent" or "clinical," according to the following criteria: *Silent infection* was indicated by the growth of organisms from a bacteriological swab taken from a healed or healing wound where no evidence of clinical infection could be found; *clinical infection* was considered present if there were local signs such as stitch abscess, purulent discharge, swelling and oedema, etc., or where there was general constitutional disturbance. An attempt has also been made to separate true theatre infection from ward infection, as will be seen in Table II. Theatre infection was presumed: (1) where organisms or evidence of infection was found beneath the silver-foil seal applied at the end of the operation; (2) where infection occurred within the first four days after operation; (3) where infection started in the deep layers of the wound, the superficial layers being healed.

Results in Surgically Inflicted Wounds

There were 18 cases of infection (silent and clinical) in the 882 wounds—an incidence of 2.4%.

TABLE II

Case	Where Infected	Day of Infection	Organism Infecting	Comments	Type of Infection
1	Ward	3rd	Staph. aur.	Bandage removed by patient	C.I.
2	"	10th	Staph. alb.	Constantly scratching wound	C.I.
3	"	34th	Staph. aur.	Incision penetrated by comb tooth	C.I.
4	Theatre	4th	Staph. aur.; Str. faecalis	Bone flap removed	C.I.
5	"	7th	Staph. alb.	Healed in 36 days	C.I.
6	"	1st dressing 4th	"	" 6 "	S.I.
7	"	1st dressing 4th	"	" 7 "	S.I.
8	"	1st dressing 7th	Not swabbed	" 18 "	C.I.
9	"	1st dressing 7th	"	" 16 "	C.I.
10	"	2nd	Staph. alb.; Bact. coli	" 11 "	C.I.
11	Ward	9th	Staph. alb.; diphtheroid	" 10 "	S.I.
12	"	10th	Staph. aur.; non-haem. strep.	" 75 "	C.I.
13	"	7th	Staph. aur.	" 100 "	C.I.
14	"	10th	Staph. alb.; diphtheroid	Not healed on discharge; C.S.F. leak	S.I.
15	"	8th	Staph. aur.; diphtheroid	Healed in 3 days; C.S.F. leak	S.I.
16	"	5th	Staph. alb.	Healed in 37 days	C.I.
17	"	10th	"	" 26 "	C.I.
18	"	7th	"	" 5 "	S.I.

Staph. aureus refers to coagulase-positive staphylococci, and *Staph. albus* to coagulase-negative staphylococci. C.I. indicates "clinical infection." S.I. indicates "silent infection."

Analysis of these 18 cases of added infection revealed that the patients themselves were responsible on three occasions. Two patients removed their bandages and scratched their own wounds, and one penetrated her healed incision with a comb on the 34th day after operation. Thus 15 cases only, of

which 7 occurred in the theatre and 8 in the ward, may be considered as true examples of hospital infection of wounds—an incidence of 1.7%. The theatre infection rate is 0.8% and the ward cross-infection rate 0.9%.

None of the 18 cases cross-infected contained *Str. pyogenes*, and of the 8 cases infected in the ward 3 were silent infections and only 5 showed clinical evidence of sepsis. The high incidence of *Staph. albus* (5 out of 8 cases) was presumably due to the prevalence of this organism on the human scalp and hair.

Results in Traumatic Wounds

In the series of 247 traumatic wounds—most of which were due to enemy action and were of the heavily contaminated variety familiar to those who have had the care of air-raided casualties—231 were already infected on admission. *Str. pyogenes* was present on admission in 11.3% (28) of the infected wounds. A total of 27 of the 247 wounds later yielded additional organisms (of some type) as a result of hospital infection—an incidence of cross-infection of 10.9%. Of the 27 cases only 4 became cross-infected with *Str. pyogenes*—an incidence of 1.6%.

Comparing the figures with those of Stokes and Tytler, it can be seen that the increase in incidence of *Str. haemolyticus* in wounds from 18.2% to 42.1% in their series has not been in any way approached in ours. The rise, in our series, of infection with *Str. pyogenes* is only from 28 patients (whose wounds contained *Str. pyogenes* on admission) to 32 during the whole period of stay in hospital—i.e., a percentage rise from 11.3 to 12.5.

We can thus show complete protection from *Str. pyogenes* in 882 clean surgical wounds. In traumatic wounds the incidence was reduced from 1.6% from our own "pre-dressing technique" incidence of 15.4%. The total incidence of cross-infection of 11.3% shows a considerable reduction when compared with the figure of Miles *et al.* of 58% obtained in the early stage of the war.

Conclusions

A strikingly low rate of cross-infection of wounds has been maintained during the use of the improved dressing technique in our department over a three-year period. As no material alterations in the conditions of the experiment have taken place during the three years it is fair to assume that the improved dressing technique is alone responsible for the lowering of the rate of cross-infection. The continuation of the technique over so long a period of time, under the conditions of war, with all its shortages of material and man-power, proves that there is no essential difficulty in observing the rules laid down by us in our original paper.

As to the intensely practical value of this reduction of hospital infection one has but to consider the saving in hospital-bed days. A wound which breaks down as a result of added infection may easily lead not only to days but to many weeks or months of additional stay in hospital, with all its cost in food, bedding, drugs, dressings, and the time of nurses and doctors, apart from the unfortunate and sometimes lethal effect upon the patient.

Summary

An improved dressing technique designed to avoid cross-infection has been in use for a period of three years, during which time 1,129 wounds have been treated.

882 wounds were surgically inflicted, while 247 were traumatic and mainly the result of enemy action.

The total incidence of cross-infection in the 882 clean cases was 2.4% and in the 247 traumatic wounds 10.9%.

Str. pyogenes has been eliminated as a cross-infecting agent in the 882 clean surgical wounds and its incidence in traumatic wounds reduced to 1.6%.

The improved dressing technique is considered to be the sole factor in these striking reductions upon previously published figures for hospital (or cross-) infection of wounds.

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