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THE NEED FOR ASEPSIS IN LOCAL PENICILLIN THERAPY

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A study of the Preliminary Report to the War Office and Medical Research Council on Penicillin by Prof. Florey and Brig. Cairns (1943) reveals that Gram-negative organisms have been found in the discharge from penicillin-treated wounds. In some cases such organisms as *Bact. coli*, *Proteus vulgaris*, and *Ps. pyocyanea* have been grown from the aspirate from wounds receiving local injections of penicillin solution, and in others they have been cultured from pus issuing from similar wounds before healing was complete. Often enough the presence of such organisms, either in aspirated fluid or in purulent discharge, appeared to cause no serious complication or to delay healing unduly: on page 99, for example, it is stated: "Penetrating Brain Wounds.—The bacteriological results (Table II) usually showed that after two days' treatment of the brain cavity with penicillin Gram-positive cocci were no longer found in the fluid sucked or discharged from the wound; organisms of the coliform group were almost invariably present. In wounds which remained completely closed this state of affairs persisted until healing was complete." A further statement, on page 104, runs as follows: "For wounds more than a week old penicillin solution was usually used for 3 to 5 days. Though the end-result was satisfactory, and there was never any exacerbation of pre-existing infection as a result of closure, yet usually a sinus formed in some part of the wound and discharged pus for some days before it finally healed." Particular emphasis is laid upon *Ps. pyocyanea* as a common infective agent in such pus or wound aspirate in a paragraph on page 39: "In many wounds Gram-negative bacilli made their appearance during treatment. This was particularly so with *B. pyocyaneus*, which usually persisted until healing was complete"; and a more detailed description is given in the form of a brief case record (p. 102):

"July 27: Operation—Free pus beneath the scalp. Brain fungus projecting through a dural opening (2 cm. diameter). Five bone chips removed from the brain to a depth of 2.5 cm. The resulting brain cavity held 5 c.cm. of penicillin solution. Scalp closed in two layers by a plastic procedure. One tube for penicillin solution; 9,000 units in six days. Bacteriological examination showed *Staphylococcus aureus* in swabs from all levels of the wound. July 29: Fluid aspirated from the wound shows in films pus cells and no organisms; on culture *B. pyocyaneus*. Aug. 1: Wound edges moist at one point. On aspiration, 25 c.cm. of thin blood-stained pus (culture: '*B. coli*,' *B. pyocyaneus*). Aug. 3: Culture of aspirated fluid—'*B. coli*,' *B. pyocyaneus*, enterococci. Aug. 11: Wound intact. To base."

On the other hand, more serious results could readily be anticipated, and we find on page 100 a description of a death (one of three in a series of 23) which is attributed to "an error of surgical technique":

"At operation pus (*Staphylococcus aureus*) and necrotic material were found beneath the healing scalp, and the bone chips were removed. He was treated by local and intravenous or intramuscular penicillin for five days (5,000 units locally, 485,000 units parenterally). He became increasingly drowsy, and on the 10th day after operation his frontal wound was aspirated and 5 c.cm. of pus were obtained from beneath the skin. Films of this showed no organisms, and culture yielded only '*B. coli*.' He died on the following night.

"At necropsy, beneath the intact frontal wound was a button of firm granulation tissue 2.5 by 0.3 cm. Beneath that in the

right frontal lobe was a large thin-walled abscess 5 cm. in diameter and extending backwards above the right frontal horn for a distance of 12 cm. It was filled with pink pus. The ventricular wall was intact.

"Section of the abscess wall showed numerous Gram-negative organisms, and in one place, where there had been a tiny spicule of retained bone, clumps and chains of Gram-positive cocci. The cellular components of the abscess wall showed nothing remarkable."

It is true that the overlooking of one small bony spicule may be regarded as an "error," but it is a mistake very hard to avoid on occasion. No comment, however, is made upon the growth of *Bact. coli* from pus aspirated from beneath the scalp: the presence of this penicillin-resistant organism may have played no small part in the development of the abscess and the subsequent death of the patient.

A point of considerable importance arising out of the quotations given above is the time at which such Gram-negative organisms gain entry to the wound. The suggestion has been made that they are present in the wound initially but are overgrown by staphylococci and streptococci in first cultures, and only when the latter organisms have been removed or inhibited in growth by penicillin therapy can the Gram-negative organisms be obtained in culture media. This supposition may well be true and cannot be denied.

One can, however, postulate that the presence of these Gram-negative organisms is but another example of added hospital or cross-infection of wounds. In the quotation given above from page 102 of the Preliminary Report it will be seen that *Staph. aureus* was grown from swabs taken from all layers of the wound at operation: two days later fluid aspirated from the wound grew *Ps. pyocyanea*, five days afterwards the aspirate grew in addition *Bact. coli*, and on the seventh post-operative day *Bact. coli*, *Ps. pyocyanea*, and enterococci were cultured. In this case three different organisms appeared in the course of five days, during which time the wound was aspirated on three occasions, and, in view of the repeated aspirations, the possibility of cross-infection obviously existed.

The emphasis laid upon the presence of *Ps. pyocyanea* is rather unusual, for this organism is not commonly grown, in our experience, from swabs taken pre-operatively from traumatic wounds. In a period of over three years, for example, preliminary wound swabs were taken from a series of 247 patients with traumatic lesions, and in only 2 cases was *Ps. pyocyanea* grown—once in pure culture and once associated with haemolytic streptococci and micrococci.

Bact. coli, *Proteus vulgaris*, and *Ps. pyocyanea*, however, are well known as infecting agents in hospital or cross-infection of wounds (McKissock, Wright, and Miles, 1941), and it is more reasonable to assume, therefore, unless or until proof to the contrary is forthcoming, that the appearance of these Gram-negative organisms in a post-operative wound is due to added or hospital infection.

The opportunity for cross-infection of a wound undergoing treatment with penicillin solution is particularly good. A rubber tube runs from the outside air to the depths of the wound, and through this channel injections of the penicillin solution are made, usually twice daily, for from 3 to 5 days. Unless

Table of Results: First Series

Name	Wound	Pre-operative Wound Swab	X-ray	Time of Operation after Wounding	Operation	Penicillin Units	Sulphur Drug	Wound Healing	Stab Wound Healing	Hospital or Cross-infection (Potential)	Complications
PE.	3 mm. frontal	S. albus —	1 cm. defect. Bone fragments 3 cm. deep. Metallic F.B. much deeper	96 hours	Total excision except for metallic F.B. Closure in 2 layers	44,000 local 20,000 thecal in 5 days	36 g. in 5 days	2 days	8 days	None	None
ME.	7 cm. L. frontal	None	Metallic F.B.s in scalp. No fracture	98 hours	Total excision	10,000 local in 5 days	34 g. in 5 days	4 "	5 "	"	"
AM.	13 cm. L. fronto-parietal	"	8 cm. defect L. fronto-parietal. Bony F.B.s. Metallic F.B.s in brain	*72 (1) hours 107 (2) hours 136 (3) hours	(1)*Partial exc. and suture in 1 layer (2) Clot removed P. tube inserted (3) Removal of clot. Reclosure in 2 layers	39,000 local 19,000 thecal in 5 days	36 g. in 5 days	7 "	7 "	B. coli	"
SC.	8 cm. R. supra-orbital; brain extending	Str. pyog.; S. albus; diphtheroids; spore-bearer	3 cm. defect R. frontal. Entering frontal sinus. Bony and metal F.B.s in frontal lobe	84 hours	Total excision. Closure in 2 layers	51,000 local 24,000 thecal in 5 days	37 g. in 5 days	5 "	3 "	"	"
KE.	1 cm. tri-radiate at vertex	None	4 × 3 cm. depressed fracture over longitudinal sinus	71 hours	Total excision. Closure in 2 layers	21,000 local in 5 days	36 g. in 5 days	2 "	7 "	None	"
WA.	10 cm. from R. side nose through eye to R. zygoma	S. albus —; B. coli	Comminuted fracture roof, lateral wall, and floor R. orbit. In-driven bone fragments	*24 (1) hours 82 (2) hours	*Partial excision. Wound left open Total excision. Dura not closed. Closure in 1 layer	43,000 local in 5 days	36 g. in 5 days	2 of wound in 5 days; rest granulating still at 18 days 3 days	7 "	S. aureus +	None
DO.	Puncture L. supra-orbital	None	0.5 cm. defect L. frontal. 4 cm. penetration by bone. 8 cm. penetrating metal F.B.	34 hours	Total excision, except metal F.B. Closure in 2 layers	44,000 local in 5 days	37 g. in 5 days		9 "	None	Penetrating chest wound
AT.	2 cm. L. temporal	S. albus —	2 cm. bony defect. Metal F.B.s at 4-5 cm.	96 hours	Total excision, except deep metal F.B. Closure in 2 layers	37,000 local in 5 days	38 g. in 5 days	3 "	8 "	"	S. albus meningitis. 13 days after op. further penicillin intrathecally
LY.	Puncture L. frontal	None	Metal F.B. in scalp	77 hours	Total excision. Removal F.B. Closure in 2 layers	22,000 local	27 g. in 5 days	2 "	7 "	"	None
HO.	Puncture R. parietal	"	1 cm. defect R. parietal. Bony F.B.s 3 cm. deep; metal F.B. 6 cm.	120 hours	Total excision except metal F.B. Closure in 2 layers	27,000 local	35 g. in 5 days	2 "	7 "	"	"
WR.	10 cm. across ant. parietal regions	S. aureus +; S. aureus —	3 cm. defect over meatus extending to L. Bony F.B.s in brain to 2 cm.	192 hours	Total excision. Closure incompletely in 2 layers	51,000 local in 5 days	35 g. in 5 days	5 "	10 "	"	—
LU.	1 cm. R. ant. parietal	None	1 cm. defect. Bony F.B.s to 2 cm.; metal F.B. 10 cm.	96 hours	Total excision, except metal F.B. Closure in 2 layers	30,000 local in 5 days	31 g. in 5 days	2 "	7 "	"	"
LA.	1 cm. mid. R. parietal	S. aureus +	1.5 cm. defect. Bony F.B.s to 2 cm.	90 hours	Total excision. Closure in 2 layers	21,500 local in 5 days	36 g. in 5 days	2 "	8 "	"	Haematoma in scalp evac. 5 days after op.
SM.	3 cm. V-shaped L. mid-parietal	P. vulgaris; S. albus; spore-bearers	2 cm. defect. Bony F.B.s to 2 cm.	112 hours	Total excision. Closure in 2 layers	36,000 local 25,000 thecal in 5 days	37 g. in 5 days	5 "	7 "	"	None
AL.	4 × 2 cm. mid-frontal	None	4 cm. depression midline frontal	*1 96 (2) hours	*Cleaned. Edges excised. Bone not touched. Total excision. Closure in 2 layers	30,000 local in 5 days	37 g. in 5 days	2 "	7 "	"	"
JE.	8 cm. tear midline frontal	P. vulgaris; S. albus; spore-bearer	Nil except metal F.B.s in scalp	79 hours	Total excision. Closure in 2 layers	49,000 local in 5 days	39 g. in 5 days	11 "	11 "	"	"
AN.	2 cm. L. temporal	S. albus	2 cm. defect L. temp. Extradural bony F.B.s. V. small metal F.B.s in brain	108 hours	Excision down to dura only. Closure in 2 layers	32,000 local in 5 days	40 g. in 5 days	4 "	7 "	"	"
McG.	Puncture R. occipital	S. albus —	0.5 cm. defect R. occipital. Bony F.B.s to 3 cm. Metal F.B. 1.05 cm.	91 hours	Total excision, except metal F.B.	29,000 local in 5 days	35 g. in 5 days	2 "	7 "	"	"
WI.	1 cm. puncture level 9th rib post-axillary line	"	Bullet lying to side of fractured spine of D 12	56 hours	Total excision. Closure in 3 layers	72,000 local in 5 days	34 g. in 5 days	10 "	10 "	"	"
MA.	L. frontal puncture	"	Metal F.B. lying deep to L. zygoma	5 hours	Total excision. Closure in 1 layer	20,000 local in 5 days	35 g. in 5 days	4 "	8 "	"	"

* Indicates primary operation elsewhere.

unusual precautions are taken to safeguard this channel against bacterial contamination it is easy to imagine the common faecal organisms (which are penicillin-resistant) being carried into the wound at the time of injection.

The occurrence, therefore, of "Gram-negative" purulent discharge from post-operative wounds, side by side with a new portal of entry for hospital infection, is significant, and should lead us towards the conclusion that we are faced with yet

Table of Results: Second Series

Name	Wound	Pre-operative Wound Swab	X-ray	Time of Operation after Wounding	Operation	Penicillin Units	Sulphur Drug	Wound Healing	Stab Wound Healing	Hospital or Cross-infection (Potential)	Complications
HA.	1 cm. R. parietal	<i>S. aureus</i>	Circular depressed fracture	48 hours	Total excision	30,000 local in 5 days	30 g. in 5 days	3 days	7 days	—	—
AL.	0.5 cm. R. temporal	<i>S. albus</i>	2 cm. circular depressed fracture	48 hours	" "	30,000 local in 5 days	30 g. in 5 days	5 "	7 "	—	—
DA.	2 cm. in eye and canthus	<i>S. aureus</i>	Comminuted roof orbit. Metal and bony F.B.s in R. frontal lobe	72 hours	Total excision except metal F.B.	44,000 local in 5 days 135,000 thecal in 5 days	30 g. in 5 days	2 "	10 "	<i>Ps. Pyocyanea</i>	—
MA.	3 punctures, each $\frac{1}{2}$ cm. temporal-occipital	"	Small depressed temporal. Many bony F.B.s in brain. Metal F.B.s deeper	48 hours	" "	46,000 local in 5 days 80,000 thecal in 5 days	30 g. in 5 days	2 "	5 "	—	Died. Basal haemorrhage
GO.	8 cm. R. parietal	Sterile	2 x 3 cm. depressed fracture R. parietal	48 hours	Total excision	30,000 local in 5 days	30 g. in 5 days	3 "	6 "	—	—
LA.	1.5 cm. R. frontal	"	1.5 cm. defect R. frontal. Many bony F.B.s down to 6 cm.	144 hours	" "	41,000 local in 5 days 459,000 I.M. in 5 days	30 g. in 5 days	3 "	7 "	—	—
HI.	3 cm. L. frontal	<i>S. albus</i>	1 cm. depressed L. frontal	36 hours	" "	26,000 local in 5 days	30 g. in 5 days	3 "	7 "	—	—
LA.	5 cm. transverse at hair line; 1 cm. lateral to R. orbit	Sterile	2 cm. x 0.5 cm. depressed fracture, frontal	96 hours	" "	10,000 local in 5 days	30 g. in 5 days	2 "	7 "	—	—
MO.	U-shaped 1 cm. R. eyebrow	<i>S. albus</i>	Fracture frontal sinus and ethmoids	48 hours	" "	38,000 local in 5 days	30 g. in 5 days	2 "	6 "	<i>Ps. pyocyanea</i>	Haematoma in wound (sterile)
SI.	3-4 mm. L. parietal	"	1 cm. defect L. parietal. Bony F.B.s in brain; Metal F.B. in R. side	72 hours	Total excision except metal F.B.		30 g. in 5 days	2 "	6 "	"	None
ER.	2 cm. L. parietal	Sterile	1.5 cm. defect. Bony F.B.s in brain	48 hours	Total excision	19,000 local in 5 days	30 g. in 5 days	2 "	8 "	"	"
BE.	1 cm. R. parietal	<i>S. aureus</i>	1 cm. defect R. parietal. Bony F.B.s in brain; metal F.B. in L. side of skull	72 hours	Total excision except metal F.B.	50,000 local in 5 days	30 g. in 5 days	Not healed at 12 days	5 "	<i>S. albus</i>	"
*HE.	7 cm. R. parietal and multiple punctures	Sterile	1.5 cm. defect R. fronto-parietal. Bony and metal F.B.s in brain	48 hours	" "		30 g. in 5 days	14 days	14 "	<i>Ps. pyocyanea</i>	" (Hospital infection)
HO.	8 cm. L. occipito-parietal	<i>Ps. pyocyanea</i>	3 x 1 cm. depressed fracture L. parietal	96 hours	Total excision	10,000 local in 5 days	30 g. in 5 days	3 "	7 "	None	None
MA.	3 cm. R. post-parietal	<i>P. vulgaris</i>	3 cm. defect R. post-parietal. Bony F.B.s in brain; metal F.B. in L. side	72 hours	Total excision, except metal F.B.	50,000 local in 5 days 90,000 thecal in 5 days	30 g. in 5 days	2 "	7 "	"	"
WO.	5 cm. x 2 cm. R. parietal	Haemolytic staph.	Depressed fracture R. parietal	48 hours	Total excision	32,000 local in 5 days	30 g. in 5 days	2 "	6 "	—	"
WR.	2 cm. R. frontal	<i>P. vulgaris</i> ; non-haem. strep.	2 cm. R. frontal defect. Bony F.B.s in brain; metal F.B. much deeper	48 hours	Total excision, except metal F.B.	22,000 local in 5 days 90,000 thecal in 5 days	30 g. in 5 days	2 "	6 "	None	Died. Large metal F.B. in area of softening in corpus callosum
JO.	7 cm. R. post-parietal	<i>S. albus</i>	2 cm. defect R. post-parietal. Bony and metal F.B.s in brain	48 hours	" "	30,000 local in 5 days	30 g. in 5 days	4 "	7 "	"	None
McR.	4 cm. L. post-parietal	<i>Ps. pyocyanea</i>	4 cm. defect L. parietal. Many bony F.B.s in brain	144 hours	Total excision	31,000 local in 5 days 90,000 thecal in 5 days	30 g. in 5 days	7 "	7 "	<i>Ps. pyocyanea</i>	Wound break-down
TA.	1 cm. mid-line occipital	Sterile	2 cm. defect R. post-parietal. Bony F.B.s in brain; Large metal F.B. deep	72 hours	Total excision, except metal F.B.	30,000 local in 5 days 90,000 thecal in 5 days	30 g. in 5 days	2 "	7 "	<i>B. proteus</i> ; haemolytic staph.	None

* Case of hospital infection.

another illustration of hospital infection of wounds, to add to the many already in existence.

It may be true that, in the vast majority of cases, added infection of the nature which we have been discussing leads to no more untoward result than a short-lived discharge, delaying healing only by a few days, but, in dealing with large numbers of patients, those few additional days in hospital amount to a very appreciable number over the course of a year. The inevitable result must be an unnecessary use of hospital beds, drugs and dressings, and the time of hospital personnel. Apart from such minor complications and delays, more serious sequelae will certainly occur in the neurosurgical field, even if in small numbers, for *Bact. coli*, *Proteus vulgaris*,

and *Ps. pyocyanea* are all capable of producing meningitis or localized abscess.

A Short-term Experiment

It was with such thoughts in mind that a short-term experiment was undertaken to see whether these organisms need necessarily appear in penicillin-treated wounds or whether they could be excluded by methods designed to close the supposed new portal of entry (the penicillin tube) and by the other precautions against hospital infection of wounds already in use in the department (M.R.C. War Memoranda, 1941, 1944). No details of the ward and dressing technique in use need be given, for the basic principles have already been widely disseminated (Miles *et al.*, 1940), although far from extensively adopted.

To protect the penicillin tube from possible contamination the open end was closed with the metal valve and cap of a bicycle inner tube, the valve being cut short at the level of the side opening. This appliance could be sterilized and inserted into the tube before the introduction of the latter into the wound. Injections could subsequently be made through the metal valve using a syringe and needle, removing and replacing the screw cap each time, thus preventing soiling of the open end. Later a more satisfactory instrument was designed, the end of which accurately fitted a Record syringe, thus simplifying the giving of the twice-daily injections (McKissock, 1944).

The first 20 battle casualties from the Normandy campaign to be admitted to the department and treated with penicillin solution as a local injection were bacteriologically investigated. Swabs were taken before operation, at each subsequent dressing, and from the surface of the healed wound and surrounding scalp on the fifth day, when the penicillin tube was withdrawn. This last swab was taken to see what organisms were present on the scalp and healed linear wound surface, and were thus available to cross-infect the small 3-4 mm. stab wound from which the penicillin tube was later withdrawn.

It should be noted that these 20 cases were treated in a well-established neurosurgical unit with a numerically adequate, experienced, and well-trained nursing staff. Special attention had been paid to the education of the nursing personnel in all matters relating to ward and dressing technique and to the potentialities of hospital infection of wounds.

Shortly after the completion of the experiment, with the results which are given above (Table, First Series), the medical personnel of the unit, with a staff of theatre nurses only, were transferred to a hospital in the country to continue the treatment of battle casualties. The nursing staff of this hospital had had no previous experience of neurosurgical work or specialized ward and dressing technique, nor had they been extensively educated in matters relating to hospital infection. In these new surroundings it was felt that the risks of cross-infection would inevitably be greater, more especially as cases were admitted in much larger numbers and at shorter intervals. Under such circumstances many of the finer details in the avoidance of hospital infection (all, nevertheless, of considerable importance) could not be observed. It was decided, therefore, to investigate another similar series of 20 cases (Table, Second Series).

Roughly two-thirds of the 40 cases were operated upon by one surgeon (W. McK.) and one-third by the other (V. L.), the surgical technique in all essential details being the same throughout. Each patient received a five-day course of treatment with one of the sulphonamides, as follows: (1) All wounds were powdered with sulphanilamide before closure. (2) The first series received intravenous sulphathiazole for the first 24 hours, followed by sulphamezathine by mouth for a further four days. (3) The second series were given sulphathiazole by mouth for five days—sulphamezathine not being available—and because of the shortage of trained personnel no patient received intravenous medication.

Penicillin was administered as a sodium salt solution in a strength of 1,000 units per c.cm., given twice daily for 5 days. The average dose in the first series of 20 cases was just over 39,000 units and in the second about 31,000 units. The average lapse of time between wounding and operation was 94 hours in the first series and 67 hours in the second: healing of the wound was complete in an average of 5.25 and 3.5 days respectively in the two sets of cases. The stab wound through which the penicillin tube was invariably inserted healed in 7.75 days in the first series and 7.3 days in the second: as this tube remained *in situ* for five days healing was reasonably prompt in all cases.

Results

An analysis of the accompanying tables reveals that in three cases in the first series organisms which could not be cultured from swabs taken from the wound at the time of the pre-operative dressing were grown from the healed linear wound surface and surrounding scalp when the dressings were removed for the withdrawal of the penicillin tube, although in no case

was there any evidence of infection of the wound or stab opening. In two of these cases the organism was *Bact. coli* and in one *Staph. aureus*. Healing of these three stab wounds was complete on the seventh, eighth, and seventh day respectively from the date of operation—i.e., two, three, and two days after removal of the penicillin tube on the fifth post-operative day. These three cases can be classed as potential hospital infections, although clinically they happened to be of no significance, as the wounds were already healed. These figures give a percentage rate of potential cross-infection of 15, the clinical cross-infection rate being 0.0%.

In the second series, under the changed domiciliary and nursing conditions, with the concomitant changes and lapses in ward and dressing techniques, new organisms were recovered from the healed wound surface and adjacent scalp in 7 cases of the 20 when the penicillin tube was withdrawn, giving a potential cross-infection rate of 35%. In only one of these seven cases did clinical evidence of actual cross-infection appear, giving a clinical cross-infection rate of 5% for this series of 20 cases. In five of the seven cases *Ps. pyocyanea* was grown, one produced the *Staph. albus*, and one grew *Proteus vulgaris* and a haemolytic staphylococcus.

The total average figures for the 40 cases are thus a 25% rate of potential cross-infection and a 2.5% rate of clinical cross-infection.

In the whole series of 40 cases there were thus 10 in which new organisms were grown, of which one case became clinically cross-infected, producing a profuse growth of *Ps. pyocyanea* and indicating very well the importance of the potential rate of hospital infection (25%); for, if the wounds had not healed so early, actual clinical infection might have taken place in every one of the ten cases. In the remaining nine cases, in which new organisms were found, the operation wounds were already healed, and the only portal of entry for the organisms to the deeper tissues would have been through the stab wound from which the penicillin tube had been removed. In the case actually and clinically infected there were upwards of a dozen superficial wounds (none reaching the galea) surrounding the wound overlying the fracture, none of which could be surgically excised. The exudate from these wounds formed a perfect pabulum in which the cross-infecting *Ps. pyocyanea* could flourish. The wounds were fortunately very superficial in character and healed in 14 days from the date of operation.

Commentary

It would seem, therefore, that in a department where adequate numbers of experienced and specially trained nursing personnel and reasonable structural facilities exist, actual hospital infection of battle wounds of the head may be almost entirely eliminated, although a constant potential threat of such complications will always remain. When there was a shortage of neurosurgically experienced nurses, and cases were admitted in greater numbers and at shorter intervals, the incidence of potential cross-infection rose from 15 to 35%, and one case (2.5%), the wound conditions of which were particularly suitable, became clinically cross-infected.

From these facts alone the desirability of obtaining proper skin-healing in the first two to four days is evident: a scalp wound closed with sparsely placed through-and-through sutures, especially when exposing portions of the subcutaneous tissue, provides ideal conditions for the entry and growth of organisms which may have found their way to the wound surface. Delay in healing, even if no worse calamity befalls, means an unnecessary waste of hospital time, a delayed convalescence for the patient with its risks of post-traumatic complications (either physical or mental), and an augmentation of the already overflowing reservoir of pathogenic bacteria in the hospital. It would appear that penicillin tubes need not give rise to cross-infection if closed with an aseptic screw cap of the design mentioned above, as no such trouble ensued in this series of forty cases.

The single case in which the wound broke down some days after healing was apparently complete and produced a profuse growth of *Ps. pyocyanea* showed a pure culture of the same organism from a swab taken pre-operatively. The first definitive

surgery in this patient was performed six days after wounding, and at operation the wound was foul-smelling and semi-purulent, and contained a piece of wood two inches long firmly plugging the skull defect and penetrating deeply into the brain. Many bone fragments lay deep in the brain substance; two of them were still visible in post-operative radiographs, indicating that wound excision had been imperfect.

The non-occurrence of a cross-infective discharge from these 40 wounds (except in one case of superficial infection) clearly suggests that when such discharge occurs it is more probably due to hospital than to initial infection.

It has been shown by Cowan (1938) that organisms occurring in the air and normally regarded as saprophytes may be the cause of serious intracranial infection, and this was later emphasized by Cairns (1939) in reporting a series of 23 deaths from infection following intracranial operations. In Cairns's cases the various organisms isolated had previously been considered non-pathogenic to man and were thought to have gained access to the cerebrospinal fluid spaces from the air during the prolonged exposure of the brain necessitated by some neurosurgical procedures. The effect of introducing *Ps. pyocyanea*, or any other pathogen, into the brain or cerebrospinal fluid spaces can well be imagined, and would be a matter for serious concern. If, therefore, penicillin is to be given by the method of local instillation the precaution of using an aseptic cap for the tube should certainly be taken.

No reflection upon the nursing staff concerned in the treatment of the second series of cases is intended: they have shown a capacity for hard work and co-operation which is admirable, and they could not have been expected to adopt and maintain a specialized system of ward asepsis and anti-sepsis which has been gradually developed over a period of four years. Nor could so small a number of nurses, even if trained and experienced in neurosurgical work, hope to attain a high standard (i.e., a low potential rate of hospital infection) when confronted with large numbers of patients with serious head injuries, whose sole ambition appeared to be the immediate removal of their headress.

Conclusion

We feel that attention to three main points is responsible for the very low rate of hospital or cross-infection of wounds in the above series. These points are: (1) The care taken in closing scalp wounds to obtain very early healing. (2) The insistence upon very careful ward and dressing technique as advocated in an earlier paper and the M.R.C. Memoranda on hospital infection. (3) The aseptic cap used to close the penicillin tube.

Summary

Two series of cases are reported, each of 20 battle casualties, in which local penicillin therapy was employed.

The incidence of potential cross-infection was three cases in 20 in the unit's original surroundings, and no clinical cross-infection occurred. In the second series, under less perfect conditions, the potential rate rose to seven cases in 20 (35%), and one superficial case of clinical hospital infection resulted (5%).

Cross-infection of wounds by way of the penicillin tube is an obvious possibility and, as it has not appeared in the present series (the one case described being only a superficial cutaneous infection), it is suggested that the aseptic screw cap in use is the responsible factor in prevention.

The need for proper closure of the scalp wound and very early skin-healing is emphasized in view of the total average potential hospital- (or cross-) infection rate (25%).

Our thanks are due to Dr. Lever and Dr. Cross, who carried out the necessary bacteriological investigation of the large number of wound swabs taken during the period under review, and whose admirable co-operation could not have been bettered.

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SOME MISTAKEN DIAGNOSES IN THE COMMON INFECTIOUS FEVERS

BY

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Recently I had occasion to go through the records of this hospital, and it occurred to me that it might be of general interest to sift carefully all those cases of "everyday" infectious disease in which my own diagnosis differed from that of the certifying practitioner. I have deleted all the doubtful cases, where almost anybody might be right: those to which I allude have been proved, so far as was possible, by bacteriological and pathological aids, for which I am indebted to Dr. Wordley of Plymouth, who is ever helpful in the elucidation of obscure medical problems.

Most senior practitioners will be well acquainted with the contents of this paper, but perhaps those who have had little opportunity for the study of infectious disease may derive some benefit. Many of us after qualification find the diagnosis of the infectious fevers difficult, and I am not sure that it becomes any easier the more cases one sees, with the consequent larger number of possibilities that arise with each fresh problem.

This brief review covers the last five years' admissions to the City Isolation Hospital, Plymouth, and includes 3,516 cases of diphtheria, 2,102 cases of scarlet fever, and a miscellany of 700 other diseases. I have tried to stress the clinical aspect throughout in view of the fact that pathological aid may well be wanting when needed most; but, naturally, in many of these cases the only ultimate proof lay with the laboratory, so it was essential to send these patients to a hospital where pathological facilities existed for full investigation. Nor do I wish to convey the impression that I am in any way critical of the differences mentioned, for I well know the heavy responsibility that rests with a practitioner who, perhaps living at a distance, is called to see some of these cases and is expected to give an infallible diagnosis in impossible surroundings within a few minutes. Quite rightly, he removes the case to where observation and treatment can be carried out under more favourable conditions. Still, there is always some satisfaction in making a correct mental diagnosis, irrespective of the administrative aspects of the disease.

Diphtheria

Diphtheria is the commonest infectious disease sent to the fever hospital in this district. I propose to divide the cases, 3,516 in all, into two groups—the faucial, nasopharyngeal, and nasal varieties, accounting for some 3,363 cases, and laryngeal, making up the remainder, a total of 153.

As can well be imagined, the commonest, safest, and most justifiable error in the first group is a diagnosis of tonsillitis. This occurs in 347 cases, or 72% of the total 483 mistaken diagnoses. Next comes scarlet fever, accounting for 14% (67 cases); and third on the list are various forms of Vincent's angina and stomatitis. The remainder is made up of the following diseases: Anginous form of glandular fever (4 cases), streptococcal cervical adenitis (4), post-tonsillectomy sloughs (2), chicken-pox (1), purpura (1), secondary syphilis (1), alveolar abscess (1), mumps (1), thrush (1), acute lymphatic leukaemia (1), and, quite inexplicably, a toxic erythema, a tuberculous meningitis, a case of meningococcal meningitis, and an attempted suicide; but to this last case I shall allude later.

The clinical differentiation of acute tonsillitis from an early diphtheria may be extremely puzzling at the outset, and I have noticed during the last few years that it is increasingly common for diphtheria to start just like an early follicular tonsillitis, and at this stage it is almost impossible without bacteriological aid to make a sure diagnosis. The following points may be borne in mind when faced with such a case:

1. In diphtheria of this type the onset is insidious. I have had nurses with a vague uneasiness in their throats report to me with considerable follicular exudate on one or both tonsils who only thought that something might be wrong when they looked at their own throats. The constitutional disturbance, pain on swallowing,