VALUE OF SYSTEMIC PENICILLIN IN FINGER-PULP INFECTIONS

A CONTROLLED TRIAL OF 169 CASES

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THE serious economic loss to industry from hand sepsis is well recognised. For example, in a large engineering factory in Birmingham 25% of compensation cases had septic hands (J. P. Bull, personal communication, 1948). It follows that any reduction in healing-time, or a quicker return to full function, should be of material advantage both to patients and to industry. The question obviously arises whether penicillin can contribute to these improvements.

Finger-pulp infections appeared to be suitable clinical material for investigating the value of systemic penicillin, because some 90% of them are due to penicillin-sensitive *Staphylococcus aureus*; because the surgical pathology can be defined at operation; and because the lesion, while being one of the commonest forms of sepsis taking more than a fortnight to heal, is mild enough for there to be no moral obligation to give penicillin as a routine, until its value is fully proved.

By a "finger-pulp infection" we mean that the finger shows clinical signs of inflammation in the region of the pulp tissue—i.e., the firm fibrofatty pad between the terminal phalanx and the skin on the volar surface. It is possible to subdivide these cases into many clinical subgroups. We will emphasise only the subdivision into the true pulp infection involving the subcutaneous pulp tissue, and the more superficial abscesses termed by Pilcher "intracutaneous" (Pilcher et al. 1948).

In investigating these finger-pulp infections our primary aim was, by a carefully controlled trial, to demonstrate the effect of systemic penicillin. One series of patients received systemic penicillin while another series received none. Care was taken that these two series were parallel random samples of the same hospital population. Each patient was first examined by one of us, asked if he could come into hospital for 5 days, and only if he agreed was allocated to one or other series by reference to a previously prepared list. The clinical findings on admission (table I) suggest that the two series were virtually random.

Given two comparable series of patients on admission, care had to be taken that the patients in both series received identical treatment in all respects other than systemic penicillin. All details, including criteria for operation, were therefore prescribed in writing and applied to all patients. There were, however, times when the routine surgical treatment was changed in an attempt to improve it. The major alterations are shown in table II, which divides the patients into four treatment groups, the first three inpatient groups following consecutively.

A few cases had to be excluded from the series. For inpatients the only reasons were failure to give the prescribed penicillin—e.g., if the patient had to be discharged before the course was finished—or failure to stay in hospital for 5 days. In the outpatient series no case was excluded, but this series was less satisfactory for demonstrating any effect due to penicillin because of the irregular attendance for injections.

The postoperative data were collected by a personal follow-up of every patient, care being taken to avoid any bias between penicillin and no-penicillin cases either in frequency of attendance (table I) or in clinical examination. The clinical data can be used in various ways. They can be used to learn the value of systemic penicillin. They can be used, if extreme care is taken to avoid the pitfalls, to compare the results of different surgical treatments, particularly those of a minimal incision into the area of greatest tenderness, with those of the large lateral J-shaped incision. Another question is whether, by giving penicillin, incision can be avoided altogether. The evidence on these points will be presented as follows:

(1) The effect of systemic penicillin on the postoperative course.
(2) A comparison of lateral J-shaped and minimal incision.
(3) The results of delaying operation in patients receiving penicillin.
(4) A new technicque for the measurement of swelling of an infected finger.

Effect of Systemic Penicillin on Postoperative Course

The economic effect could have been measured in terms of days off work and end-results. The difficulties were that days off work are affected by many issues other than clinical condition, and end-results cannot be measured quantitatively. Healing-time and complication-rate are measurable and closely associated both with these economic aspects and with other clinical findings. The following description concentrates on the reduced healing-time and reduced complication-rate produced by systemic penicillin. Emphasis is not laid on the other recorded results (often not statistically different in their incidence in the two series) though, for every item tested, the penicillin series fared better than the no-penicillin series—a difference largely contributed by the lower incidence of complicated cases.

Healing-time

By "healed" we mean that the skin was seen on inspection to be epithelised, and that no scab was present at subsequent visits. The healing-time after incision or blister-cutting was calculated from our records taken

TABLE I—EVIDENCE OF COMPARABILITY OF "SYSTEMIC PENICILLIN" AND "NO SYSTEMIC PENICILLIN" SERIES

—	Systemic penicillin	No systemic penicillin	Whether difference significant by χ^2 or "t" test
Total no. of patients	83	86	..
Mean age (years)	30·3	28·8	No
Males/females	45/38	56/30	No*
No. with history of accident	48	51	No
Mean interval from accident to first symptom (days)	4·0	3·9	No
Mean interval from symptom to admission (days)	3·7	4·1	No*
No. with thumb affected	29	31	No
No. with pus visible on admission	48	42	No
No. with tenderness on admission extending to middle phalanx	13	12	No
No. incised on day of admission	42	50	No
Mean no. of days to final follow-up	109	110	No
Mean no. of attendances	7·7	7·5	No

* Separate analysis of the surgical treatment groups (groups 1, 2, 3, and 4 in table II) revealed the following differences between the systemic penicillin and no systemic penicillin series:

(1) Among cases treated in hospital (groups 1, 2, and 3) there was a significantly higher proportion of females in the systemic penicillin series (penicillin 12/51, no penicillin 3/53, χ^2 5·36 $P < 0·05$).
(2) Of the outpatients (group 4) the systemic penicillin series had a significantly shorter average history (penicillin 3·2 days, no penicillin 4·3 days).

The results have been reviewed to see whether this distribution could have favoured the patients receiving systemic penicillin. There is no evidence of this. For example, the significant advantages of systemic penicillin over no systemic penicillin persists if either all female inpatients or all outpatients are excluded.

at special weekly clinics. It was the average of "days to healed" and "days to last known to be unhealed." The healing-time of patients receiving no operation (penicillin 6, controls 4) were counted as 0 days.

Table II shows that for each treatment group the patients receiving systemic penicillin had the shorter mean healing-time. Taking the totals, systemic penicillin had an average of 13·8 days, and no systemic penicillin 20·1 days. The difference is 6·3 days—a difference which when submitted to "t" testing is highly significant ($P < 0.02$). The two series are strictly comparable. The difference can therefore be ascribed with confidence to the systemic penicillin. The difference persists if all anomalous cases are excluded, such as intracutaneous as distinct from true pulp infections, or lesions not due to *Staph. aureus*. As table II shows, the difference is still significant if one confines attention to the treatment groups in which the controls received local penicillin as a routine and systemic penicillin for complications.

Postoperative Complications

These complications are shown in table III. Brief reference must be made to anomalous cases in the systemic penicillin series. There were 2 patients, both treated by the lateral J-shaped incision, whose fingers were almost, but not quite, healed at one visit and yet were found 1–2 weeks later to have developed a pocket of pus. Such a finding was never noted in the control lateral-J cases or after any minimal incision. Another anomalous finding was a single penicillin case in which the finger showed local radiographic changes in the absence of any other complication. Of the 2 systemic penicillin cases in the unsatisfactory end-result category one was admitted with a sequestrated terminal phalanx, while in the other the finger was already scarred from an old pulp infection and the current lesion was not due to *Staph. aureus*.

With these exceptions (all included in table III) the complications fell into a well-defined single syndrome, always starting with the appearance of pus and slough. Of the control patients, 41 showed pus and slough, of whom 9 showed other signs of secondary inflammation, such as considerable swelling of the finger or extension of the inflammation. The 15 local radiographic changes were in these fingers and in some fingers showing pus and slough only. The very unsatisfactory end-results were almost all in fingers which had shown secondary inflammation. Each aspect of the complication syndrome had a lower incidince in the penicillin than in the no-penicillin series. The difference is statistically significant where the numbers of cases are large enough for statistical analysis.

TABLE III—POSTOPERATIVE COMPLICATIONS WITH AND WITHOUT SYSTEMIC PENICILLIN

Complication	Systemic penicillin (83 patients)	No systemic penicillin (86 patients)	Significance by χ^2 testing
Pus or slough ..	23	41	$\chi^2 = 6{\cdot}29$ $P = <0{\cdot}02$ S
Local radiographic rarefaction	3	15	$\chi^2 = 7{\cdot}09$ $P = <0{\cdot}01$ S
Early secondary inflammation (1st 14 postoperative days)	1	9	$\chi^2 = 4{\cdot}90$ $P = <0{\cdot}05$ S
Late secondary inflammation (after 1st 14 postoperative days)	2	0	..
End-result: severely tender or scarred finger	2	6	..

S = significant.

The economic importance of these complications lies in their close association with delayed healing and the risk of ending with a scarred or tender finger.

Bacteriology

Swabs were taken at operation and at most subsequent dressings. The results (table IV) show that systemic penicillin significantly reduced the incidence of *Staph. aureus* in the first postoperative swab, a result not produced by local penicillin alone. This supports the obvious hypothesis that the systemic penicillin is producing its clinical effect by its action on the pathogenic organisms which probably initiate and spread the disease. Penicillin-resistant *Staph. aureus* (resistant to 0·1 unit per ml.), penicillinase-producing *Staph. aureus*, and any pathogen other than *Staph. aureus* were all so rare that we can offer no useful information on the value of penicillin in lesions produced by these organisms.

Comparison of Lateral J-shaped and Minimal Incisions

Effect on Postoperative Course

We must now consider the improvement in the treatment groups as the investigation proceeded.

Table II shows that in the control series the mean healing-time fell from 35·3 to 12·0 days. It requires detailed knowledge of these groups to give possible reasons for this fall. The reason for the difference between groups 1 and 2 might be the introduction of local penicillin for all patients. The case for local penicillin in addition to systemic penicillin rests on the fact that systemic peni-

TABLE II—MEAN HEALING-TIMES FOR DIFFERENT TREATMENTS WITH AND WITHOUT SYSTEMIC PENICILLIN

Group	Treatment						Results					
	Systemic penicillin (if any)			Other treatment			Systemic pen.		No syst. pen.		Diff.	Standard error of difference
	Units initial	Units daily (for 5 days)	Frequency of injections	Local penicillin	Op.*	Hosp.†	No. of patients	Mean healing-time (days)	No. of patients	Mean healing-time (days)		
1	100,000	100,000–160,000	3-hrly	0	J	In	15	20·00	13	35·31	15·31	10·60
2	500,000	1,000,000	3-hrly	+	J	In	10	17·70	11	27·00	9·30	5·16
3	500,000	1,000,000	3-hrly	+	MI	In	26	13·96	29	19·76	5·80	3·71
4	500,000	1,000,000	b.d.	+	MI	Out	32	9·53	33	12·03	2·50	1·78
Total	..	..	..	..	..	..	83	13·80	86	20·07	6·27‡	2·49
2, 3, 4	500,000	1,000,000	..	+	..	In/Out	68	12·43	73	17·36	4·93§	2·05

* Op. J = lateral J-shaped incision; MI = minimal incision. † Hosp. In = Inpatient; Out = Outpatient.
‡ $t = 2{\cdot}52$; $P = <0{\cdot}02$—significant. § $t = 2{\cdot}40$; $P = <0{\cdot}02$—significant.

cillin does not reduce *Staph. aureus* skin carriage (Moss et al. 1948). The local penicillin is therefore theoretically required to reduce the risk of added infection of the wound from the pus-contaminated skin. The difference between groups 1 and 2 might also be due to the introduction of systemic penicillin for complications in control patients, and the increased dosage of systemic penicillin in the penicillin series. It is impossible to estimate the effect of these changes. They were introduced to compare the value of optimum systemic penicillin therapy with penicillin used only locally or for complications. The reason for the difference between groups 3 and 4 is probably that the outpatients included

TABLE IV—ISOLATION OF *Staph. aureus* FROM FIRST POST-OPERATIVE SWAB * WITH AND WITHOUT SYSTEMIC PENICILLIN †

—	No. of patients				Significance by χ^2 testing
	‡ With swab ++	‡ With swab +	‡ With swab O	Total	
Local penicillin— at operation	24	5	4	33	χ^2 = 13·27
plus systemic penicillin 3-hourly	7	9	11	27	P = <0·01
Local penicillin— at operation	18	5	4	27	χ^2 = 13·75
plus systemic penicillin prescribed twice daily	4	13	8	25	P = <0·01
Total local penicillin— at operation	42	10	8	60	χ^2 = 28·88
plus systemic penicillin	11	22	19	52	P = <0·001

* Swab usually taken 3 days after operation.

† Systemic penicillin—1,000,000 units daily, usually for 3–5 days before postoperative swab.

‡ ++, *Staph. aureus* colonies extending beyond area of direct spread on penicillinase blood-agar plate.
+, *Staph. aureus* colonies either confined to area of direct spread or only present on subculture of broth culture.
O, no *Staph. aureus* isolated even by anaerobic broth subculture method.

χ^2 testing of comparable groups shows that significantly fewer *Staph. aureus* colonies were isolated from patients receiving systemic penicillin.

a higher proportion of intracutaneous as against true pulp infections.

The difference between groups 2 and 3 lies in the operation done. Though it is impossible to be certain that these groups are comparable in all other respects, the significant improvement in postoperative results can probably be ascribed to the adoption of the minimal incision technique.

The mean healing-time is lower in the minimal incision group (table II) but this is not statistically significant because of the small numbers of cases. There are, however, significantly fewer cases (table V) which take 28 days or more to heal in the lateral J-shaped incision group—a point of some practical importance.

The cases which received no systemic penicillin showed a lower complication-rate with minimal incision (table VI). The statistically significant difference was in the incidence of pus and slough. Among patients receiving systemic

TABLE V—COMPARISON OF HEALING-TIMES WITH LATERAL J-SHAPED AND MINIMAL INCISIONS

—	Lateral J-shaped incision (group 2)*	Minimal incision (group 3)*
Fingers healed in less than 28 days ..	12 (57%)	46 (84%)
Fingers healed in 28 days or more ..	9	9
Total	21	55

* See table II for further details of these groups.
χ^2 = 4·54. P = <0·05.—significant.

TABLE VI—NUMBER OF PATIENTS WHOSE FINGERS SHOWED POSTOPERATIVE COMPLICATIONS WITH LATERAL J-SHAPED AND MINIMAL INCISIONS

—	Systemic penicillin		No systemic penicillin	
	Lateral J-shaped incision (10 patients)	Minimal incision (26 patients)	Lateral J-shaped incision (11 patients)	Minimal incision (29 patients)
Pus or slough ..	3 (30%)	9 (35%)	10 (91%)	14 S (48%)
Local radiographic rarefaction	1 (10%)	1 (4%)	4 (36%)	5 (17%)
Acute inflammation	2 (20%)	0	3 (27%)	3 (10%)

S = significant for no systemic penicillin. χ^2 = 4·38.
P = <0·05.

penicillin these differences are not so evident, but the incidence of acute inflammation and radiographic rarefaction was again slightly lower with minimal incision than with lateral J-shaped incision.

The minimal incision scar was almost always subjectively much more satisfactory than the lateral J-shaped scar. In most of the fingers which had the minimal incision there was no palpable abnormality of any kind, and all that could be seen on close inspection was a fine linear loss of skin markings about 1/4 in. or less in length.

In the present state of knowledge we consider it unjustifiable to continue the use of the lateral J-shaped incision. Our best results were obtained with systemic penicillin plus minimal incision. The technical details of the minimal incision are therefore worth recording in some detail.

Minimal Incision and Atraumatic Technique

Whatever support the minimal incision may or may not receive from statistical information, it seems to us to be

TABLE VII—FINAL TREATMENT OF FINGERS NOT INCISED ON DAY OF ADMISSION, SHOWING THAT A FINGER SWOLLEN MORE THAN 10% USUALLY REQUIRED INCISION

Surgical treatment	Systemic penicillin		No systemic penicillin	Total (S)
	Deliberate delay	Early operation	Early operation	
Finger volume 10% or less on admission:				
Incision	1	5	4	10
No operation, or blister cut only ..	4	3	2	9
Finger volume more than 10% on admission:				
Incision	6	7	10	23
No operation, or blister cut only ..	1	3*	0	4
Total:				
Incision	7	12	14	33
No operation, or blister cut only ..	5	6	2	13

* All of these 3 patients had fingers swollen only very slightly more than 10%—i.e., 11%, 12%, and 12%.
S = significant. χ^2 = 4·33. P = <0·05.

of first importance clinically. It was evolved by one of us (S. H. H.) from a close study of pulp infections at operation.

The lateral J-shaped incision divides all the fibrous septæ of the finger but does not necessarily prevent the pus from discharging through the pulp. All too often a sinus to the pulp is formed before the patient comes to operation, and the lateral J-shaped incision will not reverse the flow. The extensive incision must contaminate with bacteria previously uninfected sites.

TABLE VIII—SHOWING THAT PUS IS USUALLY PRESENT IN FINGER SWOLLEN MORE THAN 10%

Finger-volume on day of operation	Operation finding	
	Pus in pulp	No pus or intracuticular pus only
Less than 10%	2	7
More than 10%	45	7

$\chi^2 = 14{\cdot}44$. P = <0·001 significant.

In the minimal incision emphasis is laid on the removal of keratinised skin overlying the sinus and area of greatest tenderness. By this procedure the pathology is sharply defined and the full extent of the sinus exposed. Pocketing between the keratin layer and the true skin is avoided, and penicillin applied locally is allowed full access to that part of the skin which might permit the overflow of organisms into the wound. If the sinus is large enough, no incision is required. In about half the cases a stab incision is necessary. This is made through the minute sinus, or through the point of purplish discoloration which precedes the formation of a sinus, or, in the absence of any visual sign, through the predetermined area of greatest tenderness. In no case have we failed to locate an abscess on the first incision. The incision lies parallel to Langer's lines and is never more than a stab with the point of a fine Bard Parker no. 10 blade. The abscess is opened and its extent explored. Fine forceps and scissors are used to excise the slough and unhealthy subcutaneous tissue.

The area of skin surrounding the sinus has an impoverished blood-supply, and the success of the operation depends on a rigid adherence to atraumatic technique. It should never be necessary to grasp the skin edges, use retractors, or pack the wound.

Great care and some experience are required to make sure that the resulting cavity is clean and free from at least visible dead tissue. General anæsthesia, a pneumatic tourniquet, and a liberal stock of patience are all essential. Finally, the surgeon himself should apply the bandage firmly and with care. Even pressure along the digit and a bandage that does not slip are by no means unimportant parts of the operation.

It has become our practice to do dressings on the third day after operation and subsequently at 7-day intervals. This may have clinical advantages, for the infrequency of the dressings will not only lower the risk of added infection but also will benefit the economic position of both the patient and the hospital dressing-clinics. The principles of elevation and immobilisation have been maintained in so far as the finger has been efficiently bandaged and the patient kept in bed for 5 days.

TABLE IX—CLINICAL PROGRESS OF FINGERS NOT INCISED ON THE DAY OF ADMISSION, WITH AND WITHOUT SYSTEMIC PENICILLIN

A. CHANGE IN PHYSICAL SIGNS DURING FIRST 24 HR. IN HOSPITAL

Physical sign	Systemic penicillin (No. of patients)			No systemic penicillin (No. of patients)		
	Less or same	More	Totals	Less or same	More	Totals
Area of subcuticular pus ..	14	13	27	13	10	23
Degree of apparent swelling	12	10	22	9	13	22
Area of tenderness ..	22	4	26	10	13	23S

B. OPERATION FINDINGS IN FINGERS INCISED ON 2ND DAY IN HOSPITAL

Operation finding	Systemic penicillin (No. of patients)			No systemic penicillin (No. of patients)		
	+	O	Totals	+	O	Totals
Pulp extensively involved ..	5	14	19	2	12	14
Pus in contact with periosteum	7	11	18	3	11	14
Pus in contact with tendon sheath	2	16	18	2	12	14
Staph. aureus isolated	18	1	19	12	1	13

S = significant. $\chi^2 = 7{\cdot}38$. P = <0·01.

A shows that with systemic penicillin the area of tenderness often did not extend. B shows no effect of systemic penicillin.

TABLE X—COMPARISON OF FINGER-VOLUME ON ADMISSION WITH MEASUREMENT 24 HOURS LATER, SHOWING THAT THE AFFECTED FINGER CONTINUES TO SWELL DURING THE FIRST DAY OF TREATMENT WITH SYSTEMIC PENICILLIN

Patients receiving systemic penicillin	Change in volume of affected finger (c.cm.)	Change in volume of corresponding unaffected finger (c.cm.)
1	+0·03	−0·19
2	+0·09	−0·05
3	+0·26	−0·20
4	+0·04	+0·14
5	+0·09	−0·17
6	+0·10	+0·05
7	+0·13	−0·02
8	+0·13	..
9	+0·38	−0·16
10	+0·12	−0·15
11	−0·02	−0·01
Mean	+0·123	−0·076
Standard error of mean	0·1661	0·0058
Probability that true mean is zero	0·01	0·1
Change in volume..	Significant	Not significant

Results of Delaying Operation

Day-to-day records are available on the clinical progress of 77 patients whose fingers were not incised on admission, and on a further 16 in whom operation was deliberately delayed. These results indicate :

(1) Which clinical cases may not require incision at all.

(2) How penicillin may alter the preoperative course and affect the need for incision.

(3) How deliberate delay of operation may affect the postoperative findings.

The daily observations included the results of a special fluid-displacement technique for measuring the finger-volume as described below. Volumetric measurements were made on the affected finger and another finger, usually the corresponding one of the opposite hand. The expected normal of the affected finger could be calculated by reference to a table compiled from measurements made on many normal people. The swelling was then expressed as a percentage increase over the expected normal. Clinically, a swelling of less than 10% is barely perceptible ; as a rule a swelling of more than 10% is associated with obscured skin markings on the dorsum of the finger, visible swelling and some tenseness of the pulp, and enough stiffness to limit movement of the terminal interphalangeal joint.

Table VII shows that many fingers swollen less than 10% above the expected normal never required incision. It follows that there is a case for delaying incision, at least if no pus is visible (table VIII). In contrast, the finger swollen more than 12% almost invariably contained pus and almost invariably required operation. In the definitely swollen finger it is therefore unlikely that incision will be avoided, however long the delay.

Our knowledge of how penicillin alters the prognosis of the unswollen finger is limited by the small number of cases. As can be seen from table VII, in the fingers swollen less than 10% on admission incision was less often necessary in the penicillin than in the control series, but the difference is not statistically significant. For fingers swollen more than 10% we have shown that penicillin usually does not avoid the necessity of incision. Does it in any way alter the clinical syndrome? Table IX shows that during the first 24 hours after admission systemic penicillin did not alter the findings for apparent swelling, area of subcuticular pus, operation findings of extent of pulp involved, whether or not bone was exposed, or presence of *Staph. aureus* in pus. Finger-volume measurements showed (table X) that there was a significant increase in finger volume during the first 24 hours of penicillin. In contrast to these negative findings, systemic penicillin did seem to limit the extension of the area of tenderness.

The data on the 16 patients in whom operation was deliberately delayed helped to show, as described above, that in the presence of significant swelling penicillin only rarely will avoid the necessity of operation. They also provide evidence that delay in incision of the swollen finger may do harm. The postoperative findings in these 16 cases can be compared with the postoperative findings in the parallel penicillin and no-penicillin patients receiving early operation—these three series being random samples of the same hospital population. The "penicillin plus delay" series had a longer mean healing-time and a higher complication-rate than the "penicillin, early operation" series (table XI). Since the unsatisfactory results were all in fingers swollen more than 20% on admission, it was considered clinically unjustifiable to delay incision beyond this point, and this investigation was therefore discontinued.

TABLE XI—RESULTS OF DELIBERATELY DELAYING OPERATION. COMPARISON OF THREE GROUPS OF PATIENTS WHICH WERE PARALLEL RANDOM SAMPLES OF THE SAME HOSPITAL POPULATION

Result	Systemic penicillin		No systemic penicillin
	Early operation (15 patients)	Delayed operation (16 patients)	Early operation (15 patients)
Tendon-sheath infection	0	1	0
No operation	0	4	1
Mean healing-time (all fingers)	14·8	19·9	26·9*
Standard error of mean	1·84	4·58	6·16
Mean healing-time (incised fingers)	14·8	26·5	28·7
Postoperative pus and slough	5	6	10
Local radiographic rarefaction	0	4	5
Acute inflammation ..	0	0	3
End-result (severe scar or tenderness)	1†	1	2

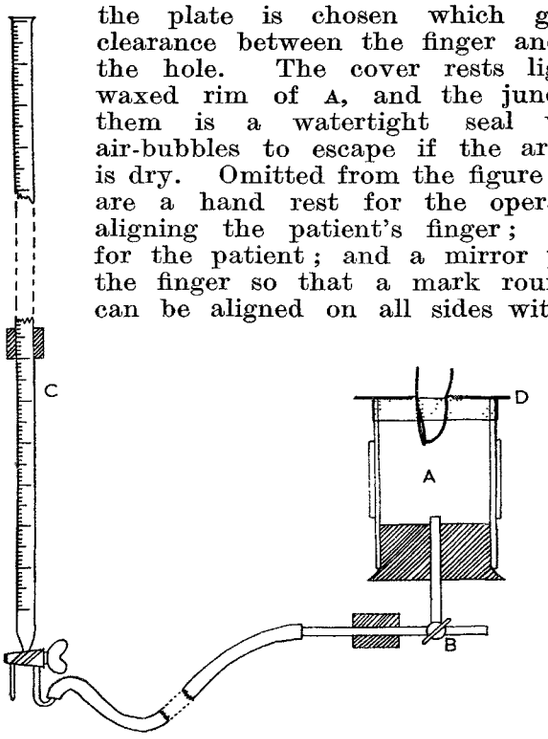
* High mean due to one patient whose finger took 96 days to heal.
† See text for reasons for not considering this a penicillin failure.

Measurement of Swelling of an Infected Finger

(J. E. LENNARD-JONES)

Measurement of Finger-volume

The essentials of the water-displacement apparatus used are shown in the figure. The particular feature of the apparatus is the detachable 'Perspex' cover-plate, D. A series of these plates is available, each of which has a different size of central hole, and for each measurement the plate is chosen which gives a small clearance between the finger and the side of the hole. The cover rests lightly on the waxed rim of A, and the junction between them is a watertight seal which allows air-bubbles to escape if the area of contact is dry. Omitted from the figure for simplicity are a hand rest for the operator, used in aligning the patient's finger; an arm rest for the patient; and a mark round the finger can be aligned on all sides with the surface of the plate.



Apparatus for measuring finger volume: A, glass vessel with upper part waxed; B, 3-way tap; C, 50 c.cm. burette graduated in 0·05 c.cm.; D, detachable perspex cover-plate.

A line is carefully marked round the finger, with the volar and lateral creases of the distal interphalangeal joint as points of reference. The finger is inserted through the hole in the plate, gripped lightly between the index finger and thumb of the operator, and aligned so that the mark is everywhere at the level of the surface of the plate. By turning tap B, water is run into A until the surface is level with the top of the plate in the narrow space between the finger and the side of the hole. The finger is withdrawn, the hole in the plate is covered with a lightly waxed microscope slide, and water is run into A until it is in contact with the waxed slide over the hole. The volume of water required corresponds to the volume of the phalanx.

All observations are recorded as the mean of three successive measurements. The standard deviation of the difference between two such means lies between 0·18 c.cm. (2·4%) for the thumb and 0·12 c.cm. (3·6%) for the little finger (values derived from observations made on all the digits of 13 people). When one mark is used two means may be compared with about the same accuracy whether they are obtained on the same or different days. Normal circulatory changes in the finger produce small changes in finger volume and may be ignored.

Estimation of Amount of Swelling

The results obtained from measuring all the digits of 13 normal people are summarised below. It will be seen that the size of one finger can be estimated with an accuracy of 12% ($P = 0·05$) from the size of another finger. The magnitude of this error is due to biological variation and to the difficulty of obtaining an anatomically constant mark rather than to instrumental errors. The results also show that in right-handed people the digits of the right hand are larger than those on the left, at least for the most used digits.

The size of a normal finger can be estimated from the size of other normal fingers in two ways:

(1) From the corresponding finger on the opposite hand. The figures given below show the correction which must be applied in a right-handed person owing to the lack of symmetry between the two hands.

(2) From the middle finger on the same hand. The sizes of the three fingers, but not the thumb, each bear a fairly constant ratio to the size of middle finger.

The figures obtained were as follows:

Method	Digit to be estimated I	II	III	IV	V
(1) The size of the right digit expressed as a percentage of the size of the left in right-handed people	106 (± 4)	108 (±5)	106 (±4)	104 (±5)	103 (±6)
(2) The size of each digit expressed as a percentage of the size of the middle finger in the same hand	162* (±18)	92 (±6)	100	88 (±4)	68 (±5)

The standard deviation of each value is given in parentheses. Apart from the one value for the thumb marked * the standard deviation does not exceed 6%, and therefore any difference between the observed volume and the estimated volume of a finger exceeding 12% may be considered significantly different from normal ($P = 0.05$).

Discussion

The results of previous attempts to demonstrate the value of systemic penicillin in finger-pulp infections have shown that the effect is not dramatic and can easily be obscured by other factors. d'Abreu's successful 7 pulp infections and paronychia were compared with 135 earlier cases not receiving penicillin (d'Abreu et al. 1947). Loudon et al. (1948) had no controls but compared their results with other published series in which local penicillin had been evaluated (Florey and Williams 1944, Curr 1945). Webster (1947) has, however, clearly demonstrated the uselessness of comparing the results of treatment carried out at different times, by showing that his patients treated without penicillin fared very much better than earlier cases similarly treated. Like us, he found an improvement in results as the investigation continued; but, since his penicillin-treated cases preceded the no-penicillin cases, the implication was that penicillin was not of much value. Bolton et al. (1947) treated 69 simple felons, alternate cases having penicillin 100,000 units daily. They found "no significant difference in morbidity time or development of complications in the two classes." The detailed figures are not published.

The present investigation was designed to assess by a controlled trial the value of systemic penicillin to patients receiving the optimal associated treatment. Comparing "systemic penicillin" with "no systemic penicillin" we have found that the patients receiving systemic penicillin showed a significantly reduced healing-time and a significantly reduced complication-rate—not dramatic in extent but, we suggest, very well worth the time, cost, and trauma of the injections. The use of local penicillin as a routine and systemic penicillin for complications was not in itself adequate. We therefore consider that there is a case for the routine administration of systemic penicillin in all genuine cases of subcutaneous finger-pulp infections.

We have not enough cases to say whether systemic penicillin was valuable in the intracutaneous infections. Since it is impossible always to differentiate the two before operation, there is something to be said for a single preoperative injection of penicillin followed by a further course if the pulp tissue is found to be involved.

The investigation was not designed to do more than prove whether or not systemic penicillin was valuable, but the experience gained from the present trial inevitably led to other hypotheses. Review of the literature, especially the correspondence in these columns after the provocative article of Pilcher et al. (1948), shows that conflicting views are held on surgical treatment.

We have defined the atraumatic technique of minimal incision through the area of greatest tenderness. This should be applicable to the surgery of hand sepsis in general. For the finger-pulp infection, we compared our results by this method with those for the lateral J-shaped incision. Though we have not shown by a controlled trial that the minimal incision is superior, all the evidence points this way. We consider it clinically unjustifiable to continue the use of the lateral J-shaped incision, except possibly in a controlled trial designed to assess effectively its value.

Pilcher discusses theoretically when to incise a finger (Pilcher et al. 1948). Our finding that a finger swollen less than 10% often never required incision adds support to his practice of delaying operation in the extremely early cases. Our very unsatisfactory results of delaying incision once the finger was swollen more than 20% suggests that the hospital case that will benefit from delay is not common.

We have no evidence on the optimal dosage or frequency of administration of systemic penicillin; those we used are shown in table II, and the bacteriological results in table IV.

Further trials are necessary in many hospitals and communities, particularly on the best method of out-patient administration of penicillin, on the value of penicillin as an aid to avoiding incision of the very early pulp infection, and on the best time for incision. Carefully controlled trials of different parallel treatments, using necessity of incision, healing-time, and complication-rate as criteria, should produce many useful answers.

Summary

In a controlled trial of 169 finger-pulp infections systemic penicillin reduced the mean healing-time by 6 days and reduced the complication-rate. Such an improvement should be of importance to industry and to the patient. It is not obtained with local penicillin.

The associated treatment was altered as the investigation continued. It is suggested that the improvements in results were in part due to the adoption of a minimal incision over the area of greatest tenderness. This atraumatic technique is described.

Daily observations were made on fingers not incised. By a special method of estimating the finger-volume patients were divided on admission into those whose fingers were swollen more and less than 10%. The finger swollen less than 10% often never required operation. The finger swollen more than 10% generally required operation in spite of penicillin. Evidence is presented that, even when systemic penicillin is being given, delay in operation after the finger is swollen 20% is harmful to the patient.

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"... One crucial feature of the difficulty in England, I believe, is that the responsibility for being healthy and economically self-sufficient has been shifted from the patient to his physician. ... There are three groups of cases in which the physician is at a peculiar disadvantage when the patient sheds the responsibility for getting well. In the first of these the person with a purely psychogenic or simulated disorder is thought to have organic disease. ... The converse situation, in which an organic disorder is diagnosed as psychoneurosis by the physician, is also seen with disconcerting frequency. ... But the most difficult group of all is the much larger one of the patients with unequivocal evidence of structural malady in whom the question arises whether the complaints are excessive for the degree of anatomic damage present."—Prof. WILLIAM H. SWEET, *New Engl. J. Med.* 1949, **240**, 168.