may have extended to twice or three times the original size. A surrounding zone which at first seemed likely to survive becomes necrotic. The base of a blister breaks down and becomes a deep ulcer. Adjacent blood vessels are involved in this necrosis, and severe secondary haemorrhages occur between the third and fourth weeks. Bone involvement results in slowly separating sequestration. Systemic reactions are varied and complex. Death may be instantaneous or may follow a short period of respiratory difficulty, haemorrhage, and cerebral disturbance. A condition of so-called "pseudo-death" is described, with cessation of heart-beat, respiration, and all reflex and nervous activity, without cellular death. Rapid active resuscitation may result in recovery. The onset of the condition may follow a latent period of a few hours.

The scope of first-aid treatment obviously depends upon local conditions. Where the shock is received during military operations it is clearly impossible to give prolonged treatment on the spot. The urgent need is for speedy evacuation. For this purpose a tank with a trap-door in the bottom has been devised. This moves over the casualty so that the man lies between the caterpillars, and can be lifted through on to a bed, where treatment is begun. Immediate treatment usually involves artificial respiration. Stimulant drugs may be given intravenously. Resistance to chilling is low. Cyanosis may require venesection. Severe circulatory collapse may respond to transfusion. Should there be no sign of life the patient must not be given up as dead until visible signs of death appear or stiffness sets in. Movement should be avoided if conceivably possible. A possible addition to routine restorative measures is the electrical stimulation of the phrenic nerve by application of an electrode over the lower part of the sterno-mastoid.

Treatment of external injuries is similar to that for thermal burns. Even the smallest marks, however, require full cleansing and application of coagulants, since these may become macerated and septic as a result of the excessive sweating. Primary amputation is generally inadvisable. It is difficult to define the limits of necrosis. Blood vessels are rigid, bleed violently, and tear across when forceps or ligatures are applied. Stumps become septic and the infection spreads rapidly.

Chest Wounds

[An account of recent British work in this field is omitted for lack of space. The reader is referred to the discussions (1940a, 1940b) held at the Royal Society of Medicine and to the *Bulletin of War Medicine*, 1941, No. 5.]

The available Soviet material in general confirms recent British experience but reveals a number of interesting new aspects. Papers by Linberg (1940) and Matseyev (1940) are based on a series of 972 casualties from the Finnish front treated at a special military hospital for chest wounds between November, 1939, and May, 1940. These included 263 with open pneumothorax and 96 with closed haemothorax. In 97 cases these chest wounds were complicated by severe injuries elsewhere. The total fatalities were 29 (3%). Of these, 12 resulted from severe combined thoracic and other injuries, including 5 cases of gas gangrene. The remaining 17 were from the effects of the chest wounds alone. Comparison with other figures is difficult on account of the very different stages at which these patients reach hospital. Ranson, an American surgeon working at Shanghai, gives mortality figures for chest wounds in hospitals for some of the various wars of the past century:

English Army in the Crimean War	79.2%
American Army in the Civil War	62.6%
German Army in the Franco-Prussian War ..	24.5%
English Army in the Boer War	14.0%
English Army in the 1914-18 War	27.5%
Chinese hospital at Shanghai, 1937	14.8%

The low figure for the Boer War is attributed to the climate and to the high proportion of bullet wounds. The last figure is explained by the fact that the cases with severe wounds did not reach hospital at all. Burdenko carried out a differential analysis of the fatalities from chest wounds on all fronts during the 1914-18 war. He gives a general mortality of 60 to 80%, reduced at primary hospitals to 30 to 40% and at base hospitals to 15 to 35%. In the light of such figures the present series merits careful study. Of these cases 2.5% reached hospital on the first day, 53% between the second and fourth days, 24% between the fifth and seventh days, and 20.5% between the eighth and twentieth days. Wounds of the thoracic wall and uncomplicated bullet wounds of the thoracic cavity gave little trouble and require no special comment.

Bullet and shell wounds with open pneumothorax constituted the most serious group. The 17 deaths from chest wounds alone came under this heading, comprising 6% of 263 cases. Of these, 246 (94%) had been sutured and only 17 extensive wounds left open. In the majority the muscle only had been sutured. Where the skin had been closed, spreading infection and surgical emphysema had developed. No previous operation had been carried out on the lung or pleural cavity. The chief problem in these cases of wide-open pneumothorax is that of keeping the wound closed and avoiding mediastinal flutter. Aspiration of all collections of blood prevents wound disruption from pressure. The lung is drawn out into contact with the chest wall and adhesions can occur. Where this happens residual accumulations can be dealt with as indicated. Where adhesions fail to form the wound is sealed by overlapping watertight strapping. In this group a number of operations were necessary for the removal of foreign bodies. Attempted suture of the lung when infection was established was found to be unsatisfactory.

Stimulated by this experience, Verhovich and Ignatovskaya (1940) carried out an extensive series of animal experiments. Their conclusions may be summarized as follows: (1) Either the thoracoscope or the cystoscope may be used with advantage in the exploration of open wounds of the thoracic cavity. (2) Increasing haemorrhage should be dealt with by lung suture and pneumopexy. (3) Where this is impracticable valvular suction drainage should be substituted. (4) Suture of the wound around a drainage tube with a 5-mm. orifice did not prevent the onset of severe symptoms. (5) Substitution of a tube with a 2-mm. orifice brought about improvement and allowed further exploration within twenty-four hours. (6) Mattress sutures produce necrosis of the lung tissue and should be avoided. On the basis of this work and of the general experience of the hospital, instructions were issued to those working in the advanced posts to attempt more radical primary intervention wherever possible in open pneumothorax.

The other important group, discussed particularly by Matseyev (1940), consists of the cases of closed haemothorax. Until recently these had been treated conservatively, but existing evidence suggests that early aspiration is the treatment of choice. Complete evacuation of the blood by repeated aspirations under radiological control is begun on the third or fourth day. This is combined with irrigation with mild antiseptic solutions—chloramine 1/500 or rivanol, 50 to 100 c.cm. This technique is substituted for air replacement on the basis of clinical and experimental evidence. Of the 96 cases only 2 became infected, and there were no deaths. Much of the general success obtained in this series is attributed to the fact that 65% of the cases were transported from the front by air. The condition of these, including many of the most severely wounded, was far and away better than that of those brought back by road. Other factors besides that of efficiency of organization suggested as explanations of the excellent results were: (1) the magnificent state of health of the soldiers; (2) the predominance of bullet wounds; (3) correct treatment.

Another contribution to the surgery of chest wounds consists of a report to a conference of evacuation hospitals by Achutin (1940). It covers all chest wounds in the war zone during the Finnish campaign. No adequate justice can be done to this contribution in the space available, and only a few of the more important conclusions will be mentioned. With reference to the recommendations of Prof. Linberg, referred to above, Achutin admits that up to the present the problem of major surgical intervention in the war zone for open wounds of the chest has not been solved. Satisfactory results have been obtained only when cases have been seen within one to two hours and when the lung could be seized through the wound, sutured, and fixed to the parietes. Personal observations have led him tentatively to advocate the trial of vago-sympathetic novocain block as additional treatment for shock. The report reiterates the importance of air transport and of the different attitude which can be adopted towards these cases where such transport is available. This was especially important during the campaign in the far north, where the intense cold produced a high incidence of pneumonia, which developed about the fourth or fifth day. Evacuation after recovery from the initial shock and before the time of onset of these chest complications would appear to have been almost ideal.

Congratulating Prof. Linberg and the special unit on their magnificent work, Achutin points out that the total mortality is still high. As many as 40% of chest-wound cases do not leave the battlefield, while 20% of these patients die before the base hospital is reached. The solution of this problem requires the full application of all the available organizational, experimental, and clinical experience.

Conclusion

The march of history has done much to sweep away the veil of distrust which has separated the people of Britain from the people of the Soviet Union. I hope that this meeting will serve three purposes: first, to begin the removal of that prejudice and ignorance which has interfered with our understanding of the development of Soviet medicine and surgery; secondly, to help to get an understanding of some of the things which the Soviet people are fighting to defend; thirdly, to obtain some ideas for the improvement and reorganization of our work here.

Whatever success we may have to-day can only be a beginning. British medicine has much to contribute to the exigencies of this common struggle. We have a great deal to give, but we have plenty to learn.

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* These and other Soviet publications are available in the library of the Society for Cultural Relations with the Soviet Union, 98, Gower Street, W.C.1.

THE REDUCTION OF HOSPITAL INFECTION OF WOUNDS

A CONTROLLED EXPERIMENT

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The demonstration by Miles *et al.* (1940) of a high incidence of hospital infection of wounds, and the recommendations formulated by them to reduce this incidence, were based in part upon investigations made on patients treated in this unit. It was thereupon decided to attempt the development of a dressing technique which would eliminate hospital infection as completely as possible.

Conditions of Experiment

The value of modifications in dressing technique was judged by the reduction of hospital infection observed in a four-months period from February 1 to May 31, 1941, as compared with a previous four-months period from September 1 to December 31, 1940. The intervening period of January, 1941, was excluded, since during this month the new dressing technique was being evolved and perfected.

In the two periods the underlying conditions were essentially the same. The clinical material handled was similar, consisting (1) of cases of head injury, mainly air-raid casualties whose wounds were infected at the time of admission; and (2) of neurosurgically clean cases, mainly intracranial tumours. The employment of chemotherapy was on the same basis during the two periods, and, finally, the personnel concerned with the dressing of wounds remained relatively unchanged throughout the entire eight months of the experiment.

The Improved Dressing Technique

The dressing technique here described was designed on the assumption that the main cause of hospital infection demonstrated in the first four-months period was the carriage of infected discharge from one patient's wounds to another's by members of the medical or nursing staff, settlement from the air and droplet infection being less important. Our aim was to combat the spread of infection in as simple a manner as possible—contact infection by the dressing technique itself, dust-borne infection by Rules 1, 2, and 6 in the instructions below, and droplet infection by Rules 3, 4, 5, and 9.

It was found impossible to reduce the dressing team to fewer than four persons unless dirty-dressing bins with foot-action lids could be procured. With this addition to the equipment the team could be reduced to a minimum of three. The first member of the team is the dresser, who begins his work when the bandage and outer dressings have been removed from the wound, finishing by applying the new bandage assisted by the "dirty nurse," after which he washes his hands and forearms and dries them on an ordinary towel. The "clean nurse" looks after the trolley and its contents only, touching nothing throughout the entire dressing round, and washing her hands and forearms only at the beginning and end of the series of dressings. The "dirty nurse"—an indispensable member of the team—removes the outer dressings and bandage and then stands by until the end of the dressing, when she assists in the application of the final bandage, afterwards washing her

hands and forearms. The bin porter carries two bins (one for washable soiled dressings and the other for dressings which must be destroyed) from one bed to the next, removing the lids and replacing them as required. He washes his hands and forearms at the beginning and end only of the round of dressings.

The dresser and "dirty nurse" therefore wash between each case, while the "clean nurse" and bin porter wash at the beginning and end of the dressing round, remaining "clean" and "dirty" respectively throughout. None of the team "scrubs up" in the surgical sense. The nurses wear ordinary uniform; the dresser works in shirt-sleeves.

Instructions Issued to Ward Personnel

GENERAL RULES FOR DRESSING

1. All bed-making, sweeping, and other activities likely to raise dust to finish half an hour before the start of dressings.
2. All windows allowing draughts, and the entrance doors to the wards, to be closed at the start of the dressing and kept closed.
3. All persons attending the dressing or having occasion to be near the dressing trolley or sterilizer *must wear masks*, consisting of two layers of gauze interleaved with impervious material (e.g., paper, cellulose acetate).
4. All persons such as ward maids, porters, and patients' visitors to leave the ward.
5. Any person entering the ward unavoidably must take a mask from the supply ready at the door of the ward and adjust it correctly.
6. No more than *one dressing to be uncovered at the same time.*
7. For patients with more than one dressing the full procedure must be observed for each separate dressing.
8. The door of the service room containing the washing sinks must be fixed open so that there is never the need to touch the door-handles.
9. No person having an infected lesion of the hand or with a sneezing cold to participate in the dressings.

TECHNIQUE OF DRESSING

1. Four persons only to take part in any one dressing: (*a*) the dresser; (*b*) the "clean nurse"; (*c*) the "dirty nurse"; (*d*) the bin porter.
2. The "dirty nurse" removes the safety pins and places them in a dish for sterilizing.
3. The "dirty nurse" removes all the outer dressings unaided and places them in covered enamelled bins, one for soiled dressings and the other for apparently clean dressings. The lids of these bins will be removed and replaced by the bin porter.
4. The "dirty nurse" then raises the patient's head.
5. The dresser places a towel beneath the head.
6. The "clean nurse" passes all dressings to the dresser with two pairs of sterile forceps.
7. The dresser carries out the dressing, using another two pairs of sterile forceps.
8. No contact between the two sets of forceps is permitted.
9. The dresser then places the dirty forceps in the sterile kidney bowl offered by the "clean nurse."
10. The dresser applies the final bandage, assisted by the "dirty nurse."
11. The "dirty nurse" takes the dresser's forceps in the kidney bowl, washes them with a wire brush in lysol, and places both instruments and bowl in the sterilizer, the lid of which is held open by the "clean nurse."
12. The "dirty nurse" washes her hands and forearms.
13. The dresser washes his hands and forearms.
14. The instruments are removed from the sterilizer by the "clean nurse," who places them on the trolley for the next case.
15. The bins for the dirty dressings are carried from one bed to the next by the bin porter.
16. At the end of the round of dressings the bin porter washes his hands for the only time.

Note.—None of the team "scrubs up" in the surgical sense of the term; each member starts work with hands and forearms washed with soap and hot water and dried on a clean towel. The "dirty nurse" washes her hands and forearms after each dressing, as does the dresser. The "clean nurse" after the initial wash does not wash throughout the periods of the dressings.

NURSING RULES

1. Washing of Patients.—A personal bath blanket to be kept in each patient's locker. Baths to be disinfected with lysol, and washing-bowls to be steeped for ten minutes in 5% lysol each time they have been used.
2. Bed-making.—All bed-clothes, pillows, and mackintosh sheets to be placed on chair at foot of bed and *never* transferred from one bed to another.
3. Soiled Linen, etc.—Bed-linen to be laundered in the usual manner. Face-flannels to be boiled. Blankets and pillows to be "stoved." Mackintosh sheets, combs, and brushes to be disinfected with 5% carbolic, and bedsteads and lockers with 5% lysol. Used linen for laundering to be placed immediately in a bin kept for that purpose. Linen soiled by discharges, pus, etc., to be soaked in 5% lysol before laundering.
4. Infected Patients.—Nurses must so far as is possible prevent infected patients from passing articles (books, newspapers, etc.) to other patients.

Sources of Infection

The hospital infection rate was determined with regard to *Streptococcus pyogenes*. The similarity of the sources of infection in the two periods is evident from the following surveys of the likely reservoirs of *Strep. pyogenes* in the unit—namely, air, throats, and wounds. All cultures from swabs and air exposures were made in blood-agar plates, and each colonial form of any haemolytic streptococci that appeared was sampled for grouping by Lancefield's method. Only those falling into Lancefield's Group A were regarded as potentially pathogenic *Strep. pyogenes*.

Air-borne Infection.—No systematic observations of air-borne streptococci were made in the first period; a few plates exposed during dressing-time yielded an occasional *Strep. pyogenes* colony. In the second period the deposition of *Strep. pyogenes* particles was measured twenty-two times, from 7 a.m. to 10 a.m., by exposing plates in both male and female wards. The bacterial counts were similar to those previously described (Brown and Allison, 1937; Miles *et al.*, 1940), reaching peaks during bed-making and sweeping. During these busy periods in the female ward an average of 7, and in the male ward an average of 9.6, *Strep. pyogenes* particles were deposited per hour on an area of one square foot. A few series of counts made throughout the day showed that during the quiet period (Rule 1) there was a reduction of 90% from an average number of about 8,000 bacterial particles deposited per hour on a square foot in the peak period, and it may be assumed that at dressing-time air-borne *Strep. pyogenes*, though correspondingly reduced, was nevertheless a source of potential infection.

Throats.—Throat swabs of patients, doctors, nurses, ward maids, and all other frequenters of the department were taken at intervals of not more than a fortnight throughout the two periods of investigation. The number of persons carrying *Strep. pyogenes* in the throat in each of the three groups—staff, female patients, and male patients—at any one period varied between 0 and 3, though periods when no throat carriers were found were infrequent. At no time was the community as a whole free from throat carriers. In the two wards the incidence was similar; reckoned on the basis of fortnightly sampling, 12% of all persons in the unit during the first period were carriers at one time or another, and 10.1% in the second period.

Wounds.—Wound swabs were taken from all air-raid casualties at the first dressing after admission, and subsequently as opportunity arose, usually twice weekly. First swabs were cultivated both aerobically and anaerobically; subsequent swabs, if the first swab had yielded no obligate anaerobe, were tested aerobically only. From "clean" cases swabs were taken if sepsis developed.

The reservoir of *Strep. pyogenes* contributed by infected wounds existed throughout almost the entire eight-months period. For two spells of twenty days and fifteen days in the second period there was in the male ward no patient with a wound discharging these organisms; during these spells, nevertheless, *Strep. pyogenes* was present in the air and in the throats of several of the community as a potential source of hospital infection. In the female ward there was a constant reservoir in one or more wounds. The wounds discharging *Strep. pyogenes* comprised those which became infected in the ward (see table) and those which were already infected with this organism on admission. Of the latter there were in all in the first period 3 (2 in the male ward and 1 in the female ward), and in the second period 11 (5 in the male ward, 6 in the female ward); therefore, including the patients infected on admission, there were altogether 15 streptococcal wounds in the first period and 15 in the second period.

Table showing Incidence of Hospital Infection of Head Wounds with Strep. pyogenes in Two Four-month Periods, before and after Introduction of Improved Dressing Technique

	1st Period	2nd Period
Air-raid casualty wounds:		
Number uninfected on admission	32	46
Number of hospital infections	10	1
Percentage incidence of hospital infection	31·3	2·2
"Clean" operation wounds:		
Number operated upon	46	49
Number of hospital infections	2	0
Percentage incidence of hospital infection	4·4	0·0

Results and Discussion

The table records the incidence of hospital infection by *Strep. pyogenes* in the two periods. Hospital infection by haemolytic streptococci other than Lancefield A occurred during the first period, but has not been included in the analysis. It appears that a total infection rate of 15.4% has been reduced to 1.1% by the enforcement of the improved dressing technique and ward organization described above. A number of air-raid casualties admitted in the second period had in addition to their head injuries wounds of the trunk and limbs. Thirteen of these wounds were dressed by the improved technique, and in this group there was no streptococcal hospital infection. Six limb wounds, however, because of their minor character, were dressed without these improved precautions—a relaxation of procedure which proved to be indefensible, since three of them became infected with *Strep. pyogenes*. The result indicates clearly that a large risk of hospital infection was present in the unit during the second period.

The improved technique was devised for neurosurgical work mainly on head wounds. In surgical wards where wounds are larger in area or are exposed for longer periods, and where dressing involves more disturbance of bed-clothes (Thomas and van den Ende, 1941), air-borne bacteria may constitute a greater risk; and in wards where, for example, bathing and irrigation form part of the wound treatment here may be additional channels of infection important enough to warrant revision of the existing therapeutic methods. Nevertheless, it is possible that a greater relative reduction in incidence of hospital infection than that which we have recorded might be achieved in other surgical wards by the adoption of the improved dressing technique only. The technique originally used in the unit was considered to be bacteriologically safer than methods normally employed in general surgical wards, an opinion supported by the fact that the incidence of hospital infection in the preliminary observation period was lower than that obtained under war conditions elsewhere in the same hospital and in other hospitals.

It proved possible to maintain the improved dressing technique under the difficult conditions following the admission of a large number of air-raid casualties in a short period of time. At all times, and especially in times of stress, the intelligent co-operation of the nursing staff is essential if satisfactory results are to be obtained. We cannot praise too highly the work of Miss Mackinder, the sister in charge of the unit, and her nursing staff, without whose help the improved technique could not have been put into effective use.

We have presented no data upon the ill effects of hospital infection, since they will form the subject of another paper; it may be said here, however, that the hospital infection produced serious complications in a small number of patients and a marked and significant lengthening of the average time of stay in hospital in the group of patients so infected.

Summary

During a preliminary observation period of four months the incidence of hospital infection with *Strep. pyogenes* among head wounds in a neurosurgical unit was 10, or 31.3% of 32 air-raid casualties, and 2, or 4.4% of 46 "clean" operation cases.

An improved dressing technique and a partially revised general ward procedure were designed to lower this rate of hospital infection.

During a test period of four months following the introduction of this technique as the routine method of dressing head wounds, the incidence of hospital infection with *Strep. pyogenes* was 1, or 2.2% of 46 air-raid casualties, and 0 of 49 "clean" operation cases.

Among the patients with head injuries treated in the test period were 19 with limb or trunk wounds. Thirteen were dressed by the improved technique, and there was no instance of hospital infection with *Strep. pyogenes* in this group. The remaining 6 were dressed without the improved precautions, and 3 of these, or 50%, became infected with this organism.

The conditions in the wards were essentially similar in the two four-months periods of investigation, and we attribute the striking reduction of hospital wound infection from 15.4% to 1.1% to the introduction of the improved dressing and nursing technique.

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Medical Memoranda

Tenosynovitis of the Tendo Achillis

This condition has become extremely prevalent in infantry units. Forty cases have been investigated and the following observations made.

CLINICAL SIGNS AND SYMPTOMS

The patient complains of pain in the heel along the Achilles tendon. This is relieved by wearing light shoes, but reappears on wearing boots, particularly after marching. On examination slight swelling of the lower inch of the tendon sheath is apparent. There is usually one point extremely tender to pressure about an inch from the insertion of the tendon into the os calcis. On movement of the foot, flexion, and dorsiflexion, tendon crepitus is easily palpable in most cases. The crepitus is often felt along the whole course of the tendon from its origin in the muscle belly of soleus and gastrocnemius to its insertion. Clinically the condition is identical with simple tenosynovitis as seen in the extensor sheaths of the forearm.

This condition occurring in the Achilles tendon has been described as a bursitis. Tendo Achillis bursitis is a completely different clinical entity which generally follows some violent exertion—e.g., a cross-country run: the painful spot is usually nearer the point of insertion of the tendon, and there is complete absence of tendon crepitus.