FORWARD NEUROSURGERY IN ITALY

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O.C. Mobile Neurosurgical Unit

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This report analyses 700 consecutive neurosurgical cases admitted to a detachment of a mobile neurosurgical unit situated at the Casualty Clearing Station level in the Italian campaign. The work covers the 9 months' period from the beginning of the campaign to midsummer of 1944 as the 8th Army was advancing up the Adriatic coast.

In this sector of the front the lines of communication were long and narrow, and evacuation to the base was by rail only. Air evacuation, so successfully employed on the other side of Italy and now from Western Europe, could not be provided due to the nature of the terrain. For this reason it was not possible to place a unit in such a position that it could both hold cases for a reasonable length of time after operation and at the same time receive them early enough to minimize the ever-present danger of sepsis. Thus, as in the campaign in the Middle East (Eden, 1943), the unit was split into two operating teams, a forward detachment attached to a forward C.C.S. and a rear section at the base hospital level to receive and hold casualties operated on by the forward section. For the most part this arrangement functioned according to plan.

A COMPOSITE SPECIAL TEAM

The idea of specialist teams working together in close collaboration in the forward areas was first conceived by the administrators of the 8th Army in the Middle East, where the neurosurgical and ophthalmic units were usually attached to the same C.C.S. Later on this combination was further augmented by the addition of the maxillo-facial team. Thus at the beginning of the Italian Campaign there existed a composite team made up of a mobile ophthalmic unit and the forward detachments of the neurosurgical and maxillo-facial units. The same arrangement of special units held good at the base, where the rear sections of the neurosurgical and maxillo-facial units and an eye surgeon all worked in the same base hospital. At the base section were received the casualties from the forward detachments, as well as many battle accidents occurring along the lines of communication and patients from the Jugoslav theatre of operations. This "Trinity," although consisting of 3 separate units, was always considered as one large special team which, as the Army advanced, moved from parent unit to parent unit in its effort to receive battle casualties as soon as possible after wounding. This composite team was attached to the C.C.S. which most conveniently drained the whole battle front, i.e., the most forward bottle-neck C.C.S. In most situations, the casualties arrived within 24 hours; in others, depending on the rapidity of the advance and the condition of the roads, the time interval was longer.
The average time interval between wounding and operation in this series was 27.6 hours (maximum 5 days—minimum 6 hours).

The advantage of having the forward special units together are fairly obvious. In the first place, the sorting of casualties by the medical officers farther forward is facilitated: all patients with wounds above the neck are immediately evacuated direct to the special teams. In the second place, many of the wounds are of such a nature that they require treatment by two or more of the special surgeons. The fact that these surgeons are in the same place obviates the necessity of harmful transportation, discontinuity of treatment and multiple anaesthetics in patients who are, not uncommonly, dangerously ill.

THE C.C.S. AS A PARENT UNIT

Casualty clearing stations, to which the units were attached, in every case were accommodated in buildings, usually schools or monasteries. In some instances, due to limitations of space, all the teams were obliged to work in one large operating theatre, but it was found that they functioned more efficiently when separate theatres were provided. There are certain disadvantages under which special units attached to a C.C.S. must necessarily work. These are due to the fact that the C.C.S. is a mobile structure, transports its own equipment, which therefore cannot be elaborate, and must adapt its equipment and the accommodation provided to fulfil its needs. Thus the X-ray and laboratory facilities are limited and cannot attain the standard that exists in a base hospital. The patients, unless dangerously ill, cannot be held for more than 2 or 3 days and must be evacuated to make room for more casualties, and this also applies to head cases. In rush periods, beds are at a premium, and at times it is necessary to nurse dangerously ill patients with head injuries, and even patients with complete spinal cord lesions, on stretchers on the floor.

Nevertheless it was felt that these disadvantages were outweighed by one paramount factor: the patients were given the benefits of complete operation early, with the result that in a large percentage of cases the long drawn-out treatment of intracranial infections with their attendant dire consequences was eliminated.

PERSONNEL AND OPERATING FACILITIES

The neurosurgical component of the "Trinity" consisted of one surgeon and an operating staff of three. One ward sister, well trained in the difficult art of handling postoperative neurosurgical cases, was found to be almost indispensable. Too much cannot be said for the khaki-clad nursing sisters who cheerfully work in the forward areas, often under very bad conditions. One anaesthetist was shared by the three units. In battle periods this led to situations in which he would often have 3 and occasionally 4 anaesthetics under way at one time. He must needs be an adept and experienced anaesthetist. In order to circumvent this difficulty to some degree, regional block anaesthesia, using 1 per cent novotox, was employed in 56 per cent of pene-
trating brain wounds and nearly all non-dural penetrating wounds. Usually in these cases a basal narcosis was induced, using alpon, gr. 1/3, scopolamine, gr. 1/150 and luminal, gr. 3. Thus, what was considered to be the anaesthetic of choice in suitable head cases became the anaesthetic of necessity in many other cases which would have been more satisfactorily dealt with under general anaesthesia.

The procedure adopted with regard to combined neurosurgical and general surgical cases was as follows. Provided that it was the major wound, the neurosurgeon first dealt with the head wound, using local anaesthesia, after which the patient was returned to the general preoperative ward and was placed on the appropriate priority list for the general surgeons. This, of course, required the cooperation of the general surgeons, which was readily forthcoming at all times. The arrangement, although seeming superfluous to persons who have not been privileged to observe a C.C.S. in action under battle conditions, was considered to be most satisfactory, since it allowed each surgeon to deal with his own cases in their proper priority and at his own convenience.

Since the personnel and equipment on the establishment of a mobile neurosurgical unit does not provide for the splitting of the unit into two sections, considerable adaptation was necessary. This applied more particularly to the personnel, as a considerable amount of captured enemy equipment was acquired and utilized. On several occasions as many as 30 to 40 neurosurgical patients were lying in the preoperative ward at once. One surgeon only was available to sort the wheat from the chaff and dispose of the chaff, do a preoperative neurological examination on the patients who required operation, operate on them, write up the notes on the field medical card, as well as keep unit records, care for them postoperatively, and arrange their evacuation. However in periods of "normal" activity, this burden was lessened considerably and one surgeon was able to cope readily with the situation.

The team was admirably equipped with instruments and in addition possessed a diathermy apparatus and sucker. These special accessories, together with the lighting, were powered by a 4 kilowatt petrol generator. Of all the special facilities required to perform an adequate debridement of a brain track, satisfactory lighting was considered to be the most important. This was provided, in the case of this unit, by a captured German spotlight using a 100 or 200 Watt bulb. It was adjustable and could be "spotted" to light up any required part of even the deepest brain tracks. The next most important item of equipment was the sucker, without which it was impossible to do any deep work. The diathermy was useful but not essential. Bleeding was not severe in the majority of brain tracks, and haemostasis could be secured by means of hot saline sponges. During a long period when the generator broke down, the diathermy was not available and it was necessary to use a foot sucker—an old tire pump with the valve reversed. This answered very well as a substitute.
The sterilizing was done by primus stoves in the operating theatre. Rarely was there sufficient space for a separate sterilizing room.

One table was used for operating while a stretcher placed on two trestles served as a preparation table.

**PRIORITY OF CASES**

The sorting process usually eliminated about 30 per cent of the casualties labelled "neurosurgical." These were either very minor head wounds, with or without other lesions that required the attention of the general surgeons, or deeply comatose patients with severe brain wounds, who were placed in a low operating priority because of their poor prognosis occasioned by gross cerebral destruction. Of the remaining cases, minor injuries with absent or minimal neurological signs were first dealt with. These patients were evacuated immediately following operation and it was not unusual, when the ambulances were running a continuous shuttle service, to have them operated on and evacuated within 2 hours after admission to the C.C.S. Then followed the more severe penetrating wounds in order of their severity. Finally the "bad" lesions were again reviewed and the more hopeful operated on.

**Analysis of Cases**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>British</td>
<td>250</td>
</tr>
<tr>
<td>Canadian</td>
<td>217</td>
</tr>
<tr>
<td>Indian</td>
<td>129</td>
</tr>
<tr>
<td>New Zealand</td>
<td>49</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>(Prisoner-of-War, Italian Army of Liberation, Polish, etc.)</td>
<td>55</td>
</tr>
<tr>
<td>Total</td>
<td>700</td>
</tr>
</tbody>
</table>

The various types of cases are recorded below. The usual classification is used, i.e. those involving scalp only, those involving bone, and those involving brain.

1. Brain wounds 230
2. Bone involved—dura intact 127
3. Scalp wounds 299
4. Spines 24
5. Miscellaneous 11

**Total** 700

It was not possible to evacuate all the patients with non-dural penetrating wounds to the base neurosurgical team and consequently no follow-up on these is available. Of 239 penetrating brain wounds, due to missiles, operated on by the forward section of the unit, follow-ups are available on 217. The great majority of these passed through the rear section of the unit. The average length of follow-up is 42 days. Brain wounds were 34.1 per cent of the total.
The following figures refer only to the series of 217 in which follow-up records were obtained.

*Site of Brain Wound*

1. Cerebral hemispheres 140
2. Orbital and frontal sinus 12
3. Frontal sinus—no orbital involvement 17
4. Mastoid and petrous bone 8
5. Through & through brain wounds 13
6. Ventricular wounds 27

Total 217

The great majority of patients arriving at the forward detachment of the neurosurgical unit had had no previous treatment except possibly a shaving of the scalp around the wound and application of sulphur powder. This non-intervention policy forward of the neurosurgical team was the result of instructions issued by 8th Army Medical authorities and was eminently satisfactory. Reoperating on a patient who has had the scalp wound excised and sutured with silk worm gut increases by ten fold the difficulties of the neurosurgeon who must re-excise the scalp wound and furthermore close it. As previously stated, C.C.S. X-rays, particularly of special regions such as the skull and spine, do not provide the detail that one sees in those taken by static base units. However, reasonably good anteroposterior and lateral views were usually available, showing the position of the metallic foreign bodies and bone chips, but little information as to the number of chips. Occasionally operation had to be performed without preoperative X-rays, and in these cases good debridements were usually obtained. Preoperative X-rays, then, are desirable but not absolutely essential as a preliminary to the adequate debridement of a brain wound.

The principles of treatment of these wounds have already been described. The object aimed at was to debride the brain track thoroughly and remove all bone chips and the metallic foreign body if possible. Rarely was a bone flap necessary for penetrating wounds: the whole operation was performed through the defect caused by the missile. No large area of bone in the vicinity of the wound was ever removed for decompression purposes. Scalp flaps were often necessary to effect closure of the wound in two layers: sharply angled points were avoided if possible in the scalp closure. The wounds were not drained. A firm plaster of Paris head cap was applied in all cases, even scalp wounds, and upon this was written the diagnosis, date of operation and date for removal of the stitches. Temporal wounds tended to develop subcutaneous collections of fluid in the dead space caused by the removal of temporal muscle and the contraction of the remaining muscle fibres contributed to it. Several cases of mild trismus were observed in these patients.

Fascial grafting of the dural defect was resorted to only infrequently in the uncomplicated brain wounds. Recently some ventricular wounds and
wounds involving the paranasal sinuses have been grafted at the primary operation with satisfactory results.

**PENICILLIN**

Penicillin was used in a majority of the cases. It was applied locally to the wound in the form of a calcium powder combined with sulphanilamide or sulphathiazole powder. Usually the proportion was 1000 units penicillin to 1 gram of the powder, but for one period powder containing 5000 units penicillin per gram was used. In periods when penicillin was not available, sulphathiazole powder was used. No routine use was made of parenteral or intrathecal penicillin in the forward area.

**INFECTIONS**

In the whole series of brain wounds, infection occurred in 28 cases. This represents an infection rate of 12.9 per cent of the total. If the deaths due to primary brain destruction are deleted from the total, the figure is 13.9 per cent. Although sulphathiazole powder alone was used in only 32 cases, a comparison of the infection rate between those wounds treated with penicillin combined with a sulph drug and those treated with sulphathiazole alone shows a very striking difference in favour of penicillin. A statistical expert who was consulted stated that the difference in the healing rate of the two groups of cases was “highly significant.”

<table>
<thead>
<tr>
<th>Drug used</th>
<th>No. cases</th>
<th>Infections</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Penicillin &amp; sulpha drug.</td>
<td>184</td>
<td>17</td>
<td>9.2</td>
</tr>
<tr>
<td>2. Sulphathiazole</td>
<td>32</td>
<td>10</td>
<td>31.2</td>
</tr>
<tr>
<td>3. No local application</td>
<td>1</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>Totals</td>
<td>217</td>
<td>28</td>
<td>12.9</td>
</tr>
</tbody>
</table>

This overall figure of 87.1 per cent of primary healing without complicating infection contrasts very favourably with the corresponding figure of 71.6 per cent obtained by this same unit in the Middle East where sulphathiazole only was used locally (Eden). These figures demonstrate the already established fact that penicillin applied locally is a powerful barrier to the development of wound infection. Routine systemic sulphadiazine was a constant factor in both series. The above facts become even more significant when one considers the climatic factors involved. In Italy, as opposed to the desert, pathogenic organisms were more constant inhabitants of the soil and consequently of the wounds. This was demonstrated by the higher frequency with which sepsis occurred in untreated wounds in Italy. As the majority of the above patients were wounded during the Italian winter with its now
famous slush and mud, the sepsis rate would be expected to be on a higher level than in the desert with its clean sands and hot, dry climate.

**Types of Infection**

<table>
<thead>
<tr>
<th>Type of infection</th>
<th>Total</th>
<th>Early</th>
<th>Late</th>
<th>Deaths</th>
<th>Treated by</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Penicillin</td>
</tr>
<tr>
<td>1. Abscess</td>
<td>11</td>
<td>7</td>
<td>4</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>2. Meningitis</td>
<td>8</td>
<td>7</td>
<td>1</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>3. Encephalitis</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>4. Anaerobic</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>5. Fungus (uncomplicated)</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>6. Superficial only</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>28</strong></td>
<td><strong>19</strong></td>
<td><strong>9</strong></td>
<td><strong>13</strong></td>
<td><strong>17</strong></td>
</tr>
</tbody>
</table>

An infection classified as “late” in the above table is one which became manifest more than 10 days after operation. Fungi were also present in many cases otherwise classified.

Three of the abscesses occurred around metallic foreign bodies remote from the entrance wound. This phenomenon was not observed in the Middle East series, where no effort was made to remove the foreign body unless easily accessible. However, more recently, since these infections have occurred, more attention has been paid to the removal of the metal.

Two of the patients with abscess indicate the need for long-term follow-up in the evaluation of sepsis rate. One had been perfectly well with a healed retracted wound for 5 weeks. After his routine lumbar encephalogram he failed to recover as expected and the X-rays showed a space-occupying lesion of the brain under his skin wound. A large amount of sterile pus was evacuated by aspiration through the wound and thorotrast inserted for radiological visualization of the abscess cavity. This was repeated until the abscess had shrunk to about one-third its original size as shown by radiographs. He is now perfectly well and awaits removal of the fibrous capsule. The other patient, also with a healed skin wound, developed Jacksonian seizures 2 months after operation, and a large loculated abscess was evacuated. His wound later healed by granulation.

The high mortality in cases complicated by meningitis can partly be explained by the fact that these patients had all been on full doses of sulphadiazine since operation, but despite this had developed meningitis. The armamentarium of treatment was exhausted, since it was before the days of intrathecal and intraventricular penicillin therapy.

**MORTALITY**

The mortality rate has very little significance since it depends on the time interval between wounding and arrival at the C.C.S. The farther forward the
unit was stationed, the higher the mortality rate became, because more of the severely wounded reached the unit alive but moribund. Many patients in this category who arrived in rush periods were not operated on. Had these patients arrived in a slack period, they would probably have been operated on with the same fatal results due to gross brain destruction.

In this series 32 deaths occurred, i.e., 14.7 per cent of the patients operated on. Fourteen of these died of infections of various types, i.e., 6.4 per cent of the total. Most of the others died of primary brain damage. One man died 10 weeks after injury of bronchopneumonia with no sign of intracranial infection at post mortem, although he had had a severe wound with a large fungus which had become completely epithelialized.

SUMMARY

1. A series of 700 neurosurgical patients operated on by the forward detachment of a mobile neurosurgical unit in Italy has been analysed. Comments are made on the accommodation and facilities provided for the unit and some of the difficulties encountered.

2. A forward composite specialist team which operated at the Casualty Clearing Station level is described. This team consisted of a mobile ophthalmic unit, and the forward detachments of a mobile neurosurgical and a maxillo-facial unit.

3. Principles of treatment of penetrating brain wounds are briefly outlined.

4. Primary healing of penetrating brain wounds due to missiles in this series was 87.1 per cent.

5. The sepsis rate in brain wounds was significantly lower when penicillin powder was applied locally at operation than when sulphathiazole powder was used.

I wish to tender my sincere thanks to all the members of both forward and rear sections of the unit for their efficient co-operation at all times and to Brigadier Hugh Cairns, Consultant Neurosurgeon to the Army, for his encouragement and criticism in the preparation of this paper.