

EUROPEAN COAL AND STEEL COMMUNITY—HIGH AUTHORITY

# Traumatology and Rehabilitation Burns

Research on industrial medicine, health  
and safety  
as at 1 January 1967

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TRAUMATOLOGY AND REHABILITATION—BURNS



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## FOREWORD

The growing body of knowledge becoming available as activities develop in the research projects makes it increasingly important to keep all concerned fully informed of progress in the different programmes. To ensure the efficient transmission of information it has been decided to issue annual reports, dealing separately with each field of research.

The present document sets out the current position with respect to the industrial injuries programmes listed under A. (b) "Traumatology and rehabilitation" in the Table on page 35. The Table will give readers an idea on the place taken by these matters in the context of the High Authority's overall research promotion work in the field of industrial medicine, health and safety.

The principles which guide the action of the High Authority of the ECSC and the methods used are described in detail in "Policy of the High Authority concerning studies and research on industrial medicine, health and safety." (1)

For readers to whom this publication is not available these principles and methods may be summarized as follows :

a) To promote the health and safety of workers by the acquisition and dissemination of knowledge applicable :

- (i) to the prevention of industrial diseases and accidents ;
- (ii) to the treatment of their manifestations and consequences ;
- (iii) to the rehabilitation of those suffering from them.

To this end, exchanges of views and experience and original research and investigation are sponsored and assisted.

b) To use funds from the Community levy for financing research and other necessary activities under financial plans for programmes spread over several years, each programme being directed towards a specific field of investigation.

c) To effect close co-operation between the High Authority on the one hand and the employers' and workers' organizations and Government departments concerned on the other in drawing up the programmes, in carrying them out, and in making known their results.

DR. M. CONVENEVOLE  
Director

(1) Publications Department of the European Communities, Luxembourg, 1966.



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## Research programme "Traumatology and Rehabilitation"

With a view to extending knowledge of injuries and of their treatment and facilitating the rehabilitation and occupational reorientation of victims of industrial accidents the High Authority decided, on 24 June 1964, to initiate a research programme entitled "Traumatology and Rehabilitation" and to allocate for the purpose a fund of 1.8 million (EMA) units of account.

In implementation of this programme 42 research projects were submitted to the High Authority, which referred them to the appropriate consultative committees for consideration.<sup>(1)</sup> The committees made their recommendations in the course of the year 1965 and the early part of 1966. The High Authority eventually approved 31 of the projects and work on these began in 1966. Their substance is summarized in the following pages, in sections devoted respectively to head, spine, and chest injuries, injuries of the locomotor system, and problems special to amputees.

### Head injuries

In the research undertaken, head injury patients are being studied from three different points of view:

1. Post-traumatic coma: research directed towards diagnosis, using neurophysiological methods ;
2. The "acute" stage as a whole (coma, return of consciousness, the phase immediately following return of consciousness) : metabolic changes in the brain and throughout the body, psychological problems associated with recovery of consciousness ; research directed fundamentally towards treatment ;
3. Global evolution of patient reaction, from the accident to completion of rehabilitation : neurological and neuropsychiatric aspects, gradual development of aptitudes, rehabilitation.

Common to these three lines of research is the clinical application of their objectives.

<sup>(1)</sup> "Traumatology and Rehabilitation" research committee ;  
Producers' and workers' committee on industrial safety and industrial medicine ;  
Committee of Government experts on industrial medicine and rehabilitation.

### *Neurophysiological research on post-traumatic coma*

Professor Perria, at Genoa, is seeking a more accurate approach to diagnosis of the site and severity of cerebral injuries. His method consists in an exploration in two stages :

1. Study of the spontaneous electrical activity of the brain (by standard electroencephalographic (EEG) recording over long periods) and of activity evoked by peripheral stimuli, providing an initial orientation with regard to brain structures damaged ;
2. Study of these same activities by means of deep electrodes implanted within the region thought to be injured.

Dr. Bergamasco, at Turin, is submitting comatose patients to continuous EEG recording. He hopes that the day and night records so obtained will reveal features analogous to the waking and sleeping patterns in the normal subject. The presence or absence of such features may provide a basis for prognosis. At the present time prognosis with regard to patients in coma is not possible.

Dr. Naquet, at Marseilles, is making a long-term study of head injury patients admitted to three of the city's hospitals. Details of this study are given on p. 14, but it is convenient to mention here that the part concerning patients in coma is being conducted in such a way as to permit comparison of the results with those obtained by the teams in Genoa and Turin.

In order to give their work a uniform basis, the three teams have agreed on co-ordination of method : the subjects of each of the three investigations will be patients in coma of traumatic origin ; depth of coma will be assessed in terms of the classification of Fischgold and Mathis (1959) ; in neurophysiological work, an agreed classification of sleep into five stages will be used for reference purposes ; visual evoked potentials will be studied by a standardized derivation technique based upon the grouping of Gastaut and Régis (1964). The broad lines of method will thus be common to all three teams, although each investigation will be directed towards its own specific objective.

It is thought that these research projects will lead to improved diagnosis of the site, extent, and severity of nerve lesions directly due to trauma, and to improved prognosis of the duration and depth of post-traumatic coma.

### *Research on the "acute" stage as a whole*

The guiding concept here is that the clinical course in patients with brain injuries is not simply the expression of localized damage to specific nerve structures. The brain is a soft organ encased in a rigid envelope ;

traumatic oedema in the vicinity of the lesion or localized collections of cerebrospinal fluid generally lead within a very short time to compression of the encephalon as a whole, sparing neither the parts spared by trauma nor the vessels which supply them. The activity of the centres in diencephalon and brain stem which regulate the body's vital functions is thus impeded, and a chain reaction precipitated which worsens both the state of the brain and the clinical condition of the patient. These deteriorate further if the blood volume is reduced by haemorrhage, if shock sets in, or if other lesions interfere with respiration and the general circulation. The consequences of these events are manifest during the "acute" stage (which they prolong and complicate) and continue beyond it. Widespread cicatricial atrophy of cerebral tissue, by no means confined to the structures directly injured, is common and leads to neurological and mental sequelae of the utmost gravity.

The first problem to be tackled in this complex field is the maintenance of the oxygen supply to the brain. Professor Toennis at Cologne has shown that, after a cranial injury :

- a) normal oxygen saturation of the cerebral arterial blood not infrequently coexists with reduced oxygen supply to the brain cells, the latter phenomenon deriving from circulatory conditions—such as raised intracranial pressure, fall in arterial pressure, and anaemia due to haemorrhage—within the brain substance ;
- b) the nerve centres which regulate the respiration suffer with the rest of the brain and their excitability (that is, their response to high carbon dioxide content) is generally :
  - (i) increased in states of agitation or of increased muscle tone,
  - (ii) diminished in the presence of generalized muscular hypotonia.

However, the reaction of the respiratory centre to oxygen lack in post-traumatic coma is not fully understood. If it were, better use could be made of resuscitation techniques and of methods for assisted respiration. Professor Toennis' team are at present carrying out continuous measurement of the blood gases by means of microelectrodes introduced into the bulb of the jugular vein, a study which obviously has great possibilities, although many difficulties have still to be overcome before it can acquire an absolute value.

At Paris Professor David, adopting a thoroughly practical approach from the start, plans intensive treatment of ventilatory disturbance, followed by accurate observation of resultant improvement in the course of post-traumatic coma.

Professor David is also to study the endocrine mechanisms of cerebral oedema, a field closely related to that of Professor Laine's team who, in studies of free water clearance and using labelled ions, will attempt to identify the hormonal

or renal causes of the water retention which gives rise to cerebral oedema. The same group will investigate the causes of recurrent hydroma and, through transaminase determinations, will explore means of measuring cell destruction.

Professor Laine's group will carry out a parallel study of, on the one hand, disorders of consciousness in the initial phase and neuropsychiatric disorders in the later phases and, on the other hand, autonomic, endocrine, and metabolic disturbance.

In this they will build upon the results they have already obtained in analysis of the autonomic mechanisms of coma, of the return of consciousness, and of factors complicating the latter, and will take full advantage of the fact that a psychiatrist will be working with them.

This part of Professor Laine's work effects a transition to the work of the last group, which we are now to describe.

#### *Long-term research directed towards rehabilitation*

Convalescence from head injuries is often marked by the onset of psychological symptoms accompanying disorders of the regulatory mechanisms controlled by the autonomic nervous system. These symptoms may persist for two or three years and then disappear, or it may then become evident that they are to be permanent.

This post-traumatic psychopathological syndrome is characterized by defects of memory, disorders of affect, and personality changes. It lasts so long that it is rarely possible to provide treatment under ideal conditions throughout. Such ideal conditions would include re-adaptation and rehabilitation suited to each patient's individual needs and graduated training for return to work.

Research workers in this field are thus faced by three sets of problems :

- a) Is there a relation between the acute stage—its symptoms and the treatment given—and the late sequelae ? Can measures be taken to prevent the psychopathological picture described above from developing ?
- b) How best to ensure that the tasks allotted to the patient during rehabilitation are gradually adjusted to his aptitudes and capacities at any given moment ?
- c) How should therapeutic effort be co-ordinated and apportioned in order to make rational use of hospital services, rehabilitation centres, and employers' contributions ?

It is in this perspective that Dr. Naquet at Marseilles, Professor Gomirato at Pisa, Professors Scheid and Jochheim at Cologne, and Drs. Venema and Greebe at Enschede are pursuing their researches. As far as is compatible with the equipment and specialized functions of the research institutes, the



studies are carried out jointly and in parallel. The investigators take the patients under their care from the acute stage inclusive, and keep them under clinical observation for as long as possible. Criteria for patient selection and the methods and programmes of observation were chosen in common. The first aim will be to make an accurate assessment of each patient's post-accident personality, and the next to train him for resettlement in suitable employment. During rehabilitation, consideration will be given to the anatomical injury and its clinical consequences, to the depth of coma that prevailed during the acute stage, to the EEG changes, to disturbance of the regulatory mechanisms controlled by the autonomic nervous system, and to neurological sequelae, motor or other. The patient will remain under constant supervision by the same research team, and the tasks required of him will be continuously adapted to his condition. Thus, an endeavour will be made, in particular at Cologne, to allow a much longer "rehabilitation interval" than has been customary in traditional rehabilitation centres.

### **Spinal injuries**

The research now in progress in this field is concerned with two types of lesion :

- a) purely bony injuries of the vertebral column (uncomplicated injuries) ;
- b) injuries affecting both vertebral column and spinal cord.

#### *Uncomplicated spinal injuries*

All the research projects sponsored are based upon the following data :

1. Range of movement differs at different levels of the vertebral column and it is the most mobile segment—the cervical segment (especially C<sub>5</sub>-C<sub>6</sub>) and the thoraco-lumbar hinge—that are the most vulnerable ;
2. The mechanisms of trauma include hyperflexion, hyperextension, violence applied to the vertex, excessive or prolonged rotation, and repeated or rhythmic stress of variable force and frequency ; several of these may be operative at the same time and interpretation is always difficult ;
3. The clinical sequelae are not necessarily proportional to the apparent severity of the trauma : some lesions remain silent for long periods ; others, small in extent, find late expression and account for clinical features that had been regarded as purely subjective ;
4. The symptomatology is often as complex as the anatomy of the cervical region ; symptoms due to trauma may coexist with symptoms due to other common conditions such as intervertebral disk arthrosis ;
5. There is no general agreement on the respective advantages and disadvantages of different methods of treatment : immobilization, re-education, bone-grafting, drugs.

The research now being considered deals with large numbers of patients and relies on well documented investigative methods, chiefly radiography and clinical examination.

Radiological study of the cervical spine requires in the first place good films taken in at least four positions : frontal, lateral, and right and left oblique. Other oblique views may be needed, especially to determine the state of the intervertebral foramina. Tomography is of paramount importance. Thus, posteromedian osteophytosis affecting the median cartilaginous joints of the vertebral bodies—indistinguishable on standard films from postero-lateral osteophytosis affecting the small synovial joints which, in the cervical region, joint the vertebral bodies laterally—shows clearly in lateral tomograms. Radiocinematography demonstrates the range of segmental movements in relation to the cervical spine ; it may reveal local rigidity, especially during attempted hyperflexion and hyperextension.

In clinical examination, passive mobility of the cervical spine about its three axes is tested and compared with spontaneous, active mobility. A note is made of subjective symptoms, such as pain in the neck, arms, upper thoracic region, or face ; headache ; giddiness ; visual, aural, pharyngeal, or laryngeal phenomena ; anxiety ; asthenia ; and feelings that the legs are "giving way." The investigator is on the look-out for provoked pain, for neurological signs in the limbs, for abnormal pupillary reaction, and for the presence or absence of nystagmus. Consultation with specialists in ophthalmology, otorhinolaryngology, or neuropsychiatry may be desirable. Electroencephalography, performed if necessary during rotatory movements of the head and neck, is useful after an initial loss of consciousness or in the presence of special incidents such as syncope or momentary black-out. Vertebral arteriography, although valuable, cannot be adopted as a routine procedure.

Radiographic and clinical examination are supplemented by certain special investigations, according to the objectives of the various projects.

Professor Junghanns is devoting his attention to combined injuries of cervical spine and skull. In particular he hopes to identify the mechanism, type, and site of the lesions responsible for the painful sequelae often seen in sufferers from such combined injuries. The cervical spines (bones, nerve tissue, blood vessels, ligaments, etc.) of deceased head injury patients will be subjected to detailed pathological examination.

Professor Decoux is focusing his research on the physiopathology of unstable fractures of the cervical spine. Unstable fractures are more frequent and more dangerous at this than at other levels of the vertebral column. His aim is to define their mechanisms, the secondary risks which they involve, and the indications, technique, and results of anterior vertebral body grafts. Radiocinematography, which enables the spine to be studied in its functional aspects, will be used routinely.

Dr. Cremona's sphere of interest is the effects of heavy physical work on the vertebral column. He compares the spine in labourers and in controls at the time of engagement and a year later, carries out regular examinations of workmen on the job, and is conducting a radiological study of the behaviour of the vertebral column on a vibrating table. He also plans a management job survey and an inquiry into the criteria of medical supervision.

Dr. Desenfans is investigating the techniques of fracture treatment and of post-fracture rehabilitation, and his programme includes a study of the commonest injuries of the vertebral column. He believes that, whether spinal fractures are uncomplicated or accompanied by reversible neurological lesions, the re-educational methods which have replaced the immobilization in plaster of former times should now be defined and systematized. Other activities in this group are an analysis of the mechanics of spinal movements and an assessment of occupational movements during physical retraining.

### *Spinal injuries with cord involvement*

An examination of the physiopathological and clinical problems of paraplegia in its initial and secondary stages respectively determined the orientation of research in this field. One group are conducting two projects on the respiratory and circulatory problems of paraplegia—how these evolve as the initial stage passes into the secondary stage and how they affect rehabilitation. Another group is investigating the peripheral circulation, its regulation, and its influence on tissue metabolism.

### *Respiration and general circulation*

Interference with respiration is governed by the level of the lesion. Implication of the motor nuclei of the phrenic nerve will lead to loss of movement of the diaphragm, while lesions at a lower level may paralyse the intercostal muscles. In the early stage respiratory movements may be impeded by pain from fractured ribs or vertebrae, by hæmopneumothorax, or by paralytic ileus. There may be in addition bronchopulmonary complications such as pulmonary oedema or simple bronchial hypersecretion, the consequences of which will be worsened if the cough muscles are paralysed. In spite of progress in therapy these complications are often fatal. In the secondary stage of paraplegia there is practically no longer any fear of pulmonary oedema. Respiratory insufficiency remains in evidence in cervical lesions only, in which it often limits effort and activity ; more severe in the elderly and in the presence of chest retraction, it may then revive certain of the complications of the early stage and call for assisted respiration. Assisted respiration is both necessary and effective, the more so as breathing in quadriplegic patients seems to use up more than the normal amount of oxygen.

The risk of pulmonary embolism, which dominates the whole of the early stage, become less as time goes on, but vasomotor paralysis in the entire body below the lesion persists. When the patient stands up blood rapidly accumulates in the abdomen and in the lower limbs with consequent reduction in return to the central veins. The result is insufficient cardiac output and sometimes syncope.

In quadriplegic patients, the customary hypotension may be replaced by paroxysmal hypertensive crises, precipitated by a stimulus in the sacral region and producing more or less completely the syndrome of autonomic hyperreflexia with bradycardia, headache, sweating over all or part of the body above the lesion, nasal congestion, etc. How these fluctuations in arterial tension affect the heart in the long run is not fully known.

The research work undertaken by Professor Rehn at Bochum and Dr. Houssa at Brussels is devoted to these problems. In one project attention is focused mainly on how the autonomic nervous system, released by the cord injury from the control normally exercised by higher centres, adapts itself to functional autonomy and on how the adaptation may be facilitated. At the same time investigations are being conducted on blood clotting, which often raises complex difficulties in treating victims of recent spinal cord injury, liable as they are to embolism on the one hand and to gastrointestinal bleeding on the other. Another project is aimed at assessing the degree of physical effort that can be expected from paraplegic and quadriplegic patients during the re-educational period and subsequently. Although these patients' effort capacity is no doubt influenced by the nature of the treatment they received in the early stage, by any complications that may have occurred, and by their own pre-accident "constitution" it is clear that the principal determining factors are disturbance of blood pressure regulation and its possible cardiac repercussions, and respiratory insufficiency and abnormal oxygen consumption.

*Metabolic consequences of circulatory disturbance in paralysed areas*

Paralysis of the autonomic nervous system below the level of the lesion does not only affect the general circulation. It also causes physico-chemical changes in the blood. The opening of sympathetic-innervated arteriovenous shunts leads often, if not always, to premature venous return visible in angiographs of the paralysed parts, in which the venous and arterial blood become approximately identical in composition (total  $\text{CO}_2$ , pH, alkaline reserve, and  $\text{pCO}_2$ ). The question has been raised as to whether there may be a relation between this arterialisatation of venous blood and the formation of the osteomata which are encountered in paraplegics and which occur near the proximal joints only—hip and knee in the lower limb, shoulder and elbow in the upper. That there is serious derangement of phosphorus-protein-calcium metabolism in paraplegia is beyond doubt. It is manifested by diffuse and constant oste-

oporosis affecting chiefly the metaphyses, and by the extra-articular ossification of metaplastic type frequently revealed by routine radiography. In many cases this ossification limits joint movement, thereby increasing disability. The only available treatment is surgery and its results are disappointing. Ectopic ossification is seen in many conditions which have in common severe disturbance of metabolism and disfunction of the autonomic nervous system. Such conditions include lesions of the spinal cord, cranial injuries (chiefly frontal), intracranial operations, hemiplegia due to medical conditions, cerebral dysfunction due to anoxia or hypercapnia, burns, and tetanus.

Professor Decoulx at Lille and Dr. Maury at Fontainebleau have initiated two research projects on disorders of osteogenesis and their relation to the state of the circulation in paralysed parts, in particular their relation to the frequent opening of arteriovenous shunts. One team will concentrate mainly on (i) radiography of patients who have undergone angiography, (ii) measurements of blood velocity and cardiac output, (iii) study in biopsy specimens of disorders of local metabolism, and (iv) histological examination of osteomata removed surgically. A second team plans (i) to compare the results of clinical examination and of routine radiography in patients grouped according to level of lesion, (ii) to compare peripheral blood flow and the results of neurodermometry recorded simultaneously in the body above and below the level of the lesion, and (iii) to study gaseous exchange in the tissues.

The research projects just described have a number of features in common : (a) they concern the vertebral column and the spinal cord ; (b) many of the patients they deal with are the victims of industrial accidents ; (c) the conditions they deal with are the cause, or an aggravating cause, of much disability.

### **Chest injuries**

The study of chest injuries is complicated by the fact that the thorax contains the organs necessary for the circulation of the blood and for the respiration.

The clinical course in patients with chest injuries generally comprises an acute stage, marked by respiratory distress calling for assisted respiration and often for surgical intervention, and a later stage in which functional re-education may be beneficial. Such re-education is directed to the movements of thorax and diaphragm and its aim is the restoration of normal circulation and respiration despite persisting organic deficit. It has to be remembered that patients with chest injuries often also have injuries elsewhere (skull, limbs, etc.).

Only one research project in chest injuries was started in 1966. It is under Dr. Lagèze of Lyons and its aims are :

- a) analysis of respiratory function at the beginning of a course of re-education in patients who have suffered severe chest injuries ;
- b) study of changes in respiratory function during the course of re-education ;
- c) evaluation *a posteriori*—in the light of data obtained from (a) and (b) and taking into account disability still present on completion of the course—of the re-educational methods used.

## **Injuries of the locomotor system**

### *Morphological and physiopathological aspects*

In the preceding sections lesions possessing a certain specificity conferred on them by their proximity to, or their direct involvement of, important nerve centres were considered and the special features of lesions of the thoracic cage were discussed. The present section, coming before that dealing with physical loss of limbs and with attempts at functional substitution, is concerned primarily with changes in the tissues (nerves, bone, cartilage, and muscle) which constitute the organs of movement ; these changes will be studied more or less independently of the anatomical site of the lesions.

#### *Nerves*

Professor Scaglietti is reviewing the results of treatment in 1200 patients with peripheral nerve injuries. Treatment methods will be evaluated in the light of the patients' symptoms, of the microscopic and macroscopic appearances of the nerves at the time of operation, and of the operative techniques used. The conclusions reached will be verified later in animal experiments and by confrontation with the experience of other research centres.

#### *Bone and cartilage*

Research into the problem of why repair of fractures sometimes miscarries, with resultant pseudarthrosis, has already been initiated under the preceding programme by Dr. Maurer of Professor Merle d'Aubigné's department at Paris and by Professor Lacroix and his colleagues at Louvain. Using a special technique for labelling newly formed bone "two substances having an affinity for bone that is in process of formation and having fluorescence of different colours," (1) Professor Lacroix has studied the time sequence of the basic processes of fracture repair, with special attention to processes depending on the periosteum and having to do with callus formation.

(1) Tetracyclines and porphyrins, giving yellow and red fluorescence respectively to ultraviolet light.

After experimental fracture of a long bone in an animal the first event is the formation, round the two ends and at some distance from the fracture line, of an encircling revetment composed of primary newly formed bone, trabecular in structure. This is followed by the appearance, nearer the fracture line, of two cartilaginous rings which grow towards it, meet, and unite to form a single cartilaginous cuff. The two rings, and later the entire cuff, undergo endochondral ossification. This ossification is directed in an orderly manner from the original rings towards the fracture line, whereas if a piece of the same cartilage is grafted outside the immediate environment of the skeleton the ossification proceeds haphazardly.

The above sequence and orientation of events have been confirmed by Dr. Maurer. He has also studied the formation of new blood vessels. These first appear at some distance from the fracture line, at right angles to the main axis of the bone, but later converge towards the fracture site, concurrently with ossification of the callus.

The next problem is to find out how, in the vicinity of the fracture and during normal healing, the potential properties of each of the different tissues present are organized and directed. It is known that delay or interference with the processes just described allows time for the fracture line, invaded first by fracture-haematoma and then by young connective-tissue cells from the marrow and from the periphery of the lesion, to become the seat of fibrous proliferation which separates the bone ends from each other.

It is with these facts in mind that Dr. Maurer plans to investigate :

- a) local factors capable of precipitating and guiding the formation of new blood vessels (the possible existence of an "inducer substance" being studied) ;
- b) the parts played by the different types of tissue represented at the fracture site (consideration being given to the possible intervention of immunological factors) ;
- c) the importance of certain general factors, such as the degree of oxygenation of the blood.

In the same context and in close collaboration with Dr. Maurer, Professor Lacroix is to use two-colour fluorescence microscopy to study the healing of fractures. The sequence of events described above may be regarded as typical ; the only difference between one species and another or between one bone and another is the time taken by the various stages ; this differs in different bone segments in man and varies with age and physical condition. (1)

The same fluorescence technique will be used for morphological studies on non-fractured bone.

(1) For research on osteogenesis in paraplegics, see previous section.

Normal bony tissue undergoes a continuous physiological turnover or remodeling in which a fine balance is maintained between resorption of old tissue and formation of new. In 1961 Dr. Dhem showed that osteoporosis is due to excessive resorption for which osteogenesis, although very active, cannot compensate. In the compact tissue of the long bones the remodeling process takes place through the Haversian canals, tunnels hollowed out by multinuclear cells called osteoclasts and later filled in with concentric layers of new tissue. Dr. Dhem recently illustrated the appearance of the Haversian canals in longitudinal section. This demonstrated the rapidity with which local destruction and reconstruction follow upon each other, and the contrast between the rapid advance of the tunnel head and the slow and gradual laying down of new tissue. Since the Haversian canals seem to increase in number in osteoporosis, it is important to find out what induces their formation in the first place and what is the relation between the bone-destruction-bone-formation cycle and the distribution of the blood vessels to bone. This is the second facet of the research work which is to be carried out under the direction of Professor Lacroix.

Post-traumatic changes in articular cartilage will be the subject of a third research project. Applying a technique of experimental dislocation in animals which produces changes superimposable upon those of post-traumatic arthrosis of the hip joint in man, Professor Monteleone hopes to elucidate the pathogenesis of arthrosis. He will use morphological methods, in particular histochemistry and microradiography, and biochemical analyses of carbohydrates and amino acids. Parallel studies will be conducted on human material in so far as this can be obtained from surgical sources. Finally, an attempt will be made to determine the therapeutic application of the knowledge gained.

In fact, all the basic problems discussed above on p. 20 are being studied with a clinical and therapeutic application in view. An understanding of the biology of repair phenomena is of real practical importance. In treating fractures the surgeon of to-day can use artificial devices which by providing direct mechanical support keep bony fragments firmly in the desired position (osteosynthesis). The use of osteosynthetic techniques is becoming more general and the techniques themselves more diversified. They have many advantages. They facilitate treatment of comminuted fractures and of fractures in situations in which immobilization by other methods is difficult; obviating the use of plaster, they permit re-educational measures in adjacent limb segments to be begun earlier than was formerly possible. A curious fact is that the use of these methods may ultimately modify the biological repair processes. It has been shown that when bone fragments are firmly held together in perfect apposition, end-to-end union is achieved through the Haversian canals. Bridging the gap and subsequently becoming solidified, these constitute a scaffolding upon which bony continuity is progressively restored (Schenk). This type of repair produces a highly finished end result but, since the healing process calls upon a "slow" phenomenon, it is complete later than in normal circumstances in which the periosteal reaction sets "rapid" phenomena in train. This obser-



vation is at present no more than a biological curiosity. It must not cause us to lose sight of the need for (a) experimental confirmation of the practical advantages which the many osteosynthetic techniques appear to offer than (b) exploration of how these techniques can be made to render the best functional results. To meet these requirements two research projects have been planned.

Dr. Hernandez-Richter and Dr. Struck will conduct studies on experimental fractures of limb bones in dogs. Some of the animals will be treated by immobilization in plaster, others by various osteosynthetic procedures. Throughout the entire healing process the mechanical resistance of the callus will be tested with an apparatus measuring the degree of buckling of the bone segment under the influence of progressively increasing lateral loads. The radiological appearance of the lesion will be checked periodically and tissue specimens will be removed for histological and histochemical examination of collagen. By comparing the data obtained and noting the chronological sequence of the phenomena observed, these workers hope to reach conclusions about the advantages of, and indications for, the different osteosynthetic techniques tried.

Modern surgical methods often enable functional rehabilitation to be started on the very day following operation. Since an injured limb could not be discharged a full work load at this early stage, special apparatus will be used to place the joint concerned in optimal conditions for executing desired movements, without interfering with necessary physiotherapy. The devising of such apparatus will call for a detailed understanding of joint structure and function, of the changes produced by trauma, of the new conditions created by surgical intervention, and of the objectives of well planned functional re-education at every stage of healing. A field so vast must obviously be treated monographically, on the basis of the repair operations most frequently performed in industrial traumatology. Dr. Desenfans has already carried out a study of this type, as part of the preceding programme, on the tibio-tarsal joint. He is at present turning his attention to the knee and hip joints, after which he intends to tackle the joints of the upper limb.

#### *Muscles*

None of the research projects now in progress is devoted specifically to muscle changes following trauma. However, the aim of these projects is restoration of function—of movement—and it would not be possible to study the vehicle of function without studying its propelling machinery. This is not forgotten by those doing basic research on bone and it is the predominant concept in research on functional re-education.

## *Rehabilitation of amputees*

### *Upper limb amputees*

The rehabilitation of upper limb amputees raises many problems. These are connected on the one hand with the amputee's personal circumstances and with the degree of functional incapacity, and on the other hand with technical measures for reducing the incapacity, that is, with the provision of prostheses.

The disability suffered by upper limb amputees depends primarily on the level of the amputation and on whether it is unilateral or bilateral. It also depends, however, on the amputee's individual circumstances, on how much he needs to use his hands and arms, on his occupation before the amputation, and on the occupation he intends to follow after being equipped with an appliance. Finally, it is influenced by the time elapsing between the accident and provision of the artificial limb, by apprenticeship in its use, by vocational training, and by the social assistance available.

The utility of an upper limb prosthesis depends on its type, on the technical quality of its fabrication, and on its suitability to the user's needs. His personal situation (as defined above) will guide the choice between a simple non-functional artificial arm, an artificial arm with a limited number of active functions, a working arm with a mobile artificial hand or specially adapted gripping device designed without regard for cosmetic considerations, or a heavy working limb, with or without active motor functions, for operations requiring sheer force. Whether the prosthesis is to be activated by the user's own power or by external power such as electricity or compressed gas will be decided in part by the degree of motor function remaining after the amputation.

Once the type of prosthesis best suited to the patient's needs has been selected, the practical usefulness of the appliance will be governed by the efficiency with which it is fitted and attached to the stump, for on this will hinge its comfort and convenience. Other significant factors are the acquisition of skill in its use, subsequent verification of its functional value, and elimination of disadvantages which do not become evident until it has been in use for some time.

From among this complexity of factors, some related to the amputee himself and some to the technical aspects of equipping him with a prosthesis, a group of problems has been selected for study under the new research programme.

Dr. E. Marquardt, *Privatdozent*, of the Orthopaedic Centre of the University of Heidelberg, Heidelberg-Schlierbach, will concentrate on the use of upper limb prostheses by patients who have lost both arms. They get more positive benefit from their appliance than do those who have lost one arm only; indeed, many of them are totally unable to manage without it. At a later stage Dr. Marquardt will make a comparative study of the use of prostheses in individuals who have lost one and both upper limbs respectively.

Professor Gerundini, of the Rehabilitation Institute at the Legnano Hospital, is to go into the question of the choice of occupation for upper limb amputees. He will study the requirements of different occupations in relation to the functional value of the healthy limb and of the prosthesis, the vocational training required by amputees wishing to follow certain occupations, and the performance that can be expected of amputees in comparison with intact individuals.

Dr. J. E. Lescœur, of the Functional Rehabilitation Centre at Saint-Cloud, intends to evaluate the usefulness of different types of upper limb prosthesis in work and daily life. He would like to be able to appraise the practical utility of arm prostheses by tests determining how much they facilitate re-employment in certain occupations. In an attempt to assess the value of occupational training for individuals with artificial limbs, he will conduct a statistical study, bearing on a 10-year period, in amputees who have, and have not, received such training.

The research projects so far described deal mainly with the functional value of upper limb prostheses in relation to the patient's work. Other projects are concerned more with the appliance itself and are aimed at improving its performance.

Dr. J. M. Paquin of the Rehabilitation Institute at Gondreville plans to continue work begun under Professor Pierquin for improving prostheses for heavy workers.

Dr. Paquin's plans will be helped by the research work of Dr. G. G. Kuhn, of the division of technical orthopaedics and rehabilitation of the University Orthopaedic Clinic at Münster, who is to try to develop a highly efficient working hand.

These two projects stem from the fact that even to-day no artificial hands or gripping devices fulfilling in all respects the exigencies of heavy work are available.

The practical usefulness of an upper limb prosthesis is not solely a matter of the comfort and convenience conferred by efficient fitting and attachment. The user must have an idea of the functional position of the appliance at any given time without having to look and see, and he must be able to adjust its position without conscious effort. These requirements call on the one hand for an appropriate "afferent" signalling system which keeps the user constantly informed of the position of his prosthesis in space, and on the other for fine control by the user over the movements of the artificial hand.

Improved myoelectric control of movements in electrically or pneumatically powered prostheses for upper limb amputees is the aim of research to be undertaken by Mr. H. Schmidl and Professor F. Zarotti of the INAIL orthopaedic workshop at Vigorso di Budrio. They are seeking to develop the results obtained in a preliminary research project completed on 31 December 1965.

### *Lower limb amputees*

Rehabilitation problems in lower limb amputees are less complex than in upper limb amputees. The majority of the former find that walking with an artificial limb has obvious advantages both in work and in everyday life.

As in the upper limb, a distinction has to be made between problems connected with the amputee himself and with the length of the stump, and problems related to the type and design of the prosthesis.

Increasing interest has been shown in recent years in the possibility of fitting artificial limbs immediately after amputation, and Dr. Weiss at Warsaw is carrying out an extensive programme of research in this subject. Both American (for example Burgess) and British workers agree that the method may be expected to yield satisfactory results. Research within the context of the new ECSC programme has been begun by Dr. E. Marquardt, *Privatdozent*, of the Orthopaedic Centre of the University Clinic at Heidelberg-Schlierbach. His observations will be compared with those made in parallel studies pursued in other centres taking part in the programme (the University Orthopaedic Clinic at Münster, the Surgical Clinic of the Cochin Hospital at Paris, etc.).

Other research activities are concerned with technical problems in the design of temporary prostheses.

Starting from preparatory work already done on monotubular apparatus, Dr. J. M. Paquin of the Rehabilitation Institute at Gondreville is attempting to design standard apparatus with tubular framework which would facilitate the production of both provisional and permanent lower limb prostheses from prefabricated parts of constant dimensions.

The future will show whether this method will lead to normalization and reorganization in the use of material for lower limb prostheses.

Stable locking and braking of knee flexion during walking in persons who have had above-knee amputation or coxofemoral disarticulation has hitherto been achieved by friction brakes, check devices, and pneumatic and hydraulic dampening mechanisms. New possibilities will perhaps be opened up as the result of the research activities of *Privatdozent* Dr. G. G. Kuhn, of the division of technical orthopaedics and rehabilitation of the University orthopaedic Clinic at Münster, whose work may lead to the use of magnetic coupling elements for the control systems of prostheses.

## Research programme "Burns"

The programme entitled "Treatment and rehabilitation of burned persons" was adopted by the High Authority on 18 May 1966.

In its decision the High Authority defined certain fields of research bearing on problems of major importance. These problems, the solution of which would open up many therapeutic possibilities, may be summarized as follows :

- a) A burned person is a sick person suffering from severe disturbance of general body functions ; the therapeutic implications of this concept : renal function and displacement of organic fluids ; disorders of other organs and of metabolism ; nutrition and diet ; infection in burns and means of combating it ;
- b) Changes in the tissue surrounding and underlying the burn : direct effects of the burn ; preparation of terrain suitable for grafts ; part played by grafts of different source and preparation in the reconstruction of a skin surface, in the quality of the skin surface, and in later developments in the scar ; role of tissue infection ;
- c) Use of skin from voluntary donors : choice and classification of donors ; natural and artificial tolerance in the recipient ; methods of preservation and preparation ;
- d) Prevention of late complications liable to interfere with rehabilitation : renal complications ; tegumentary complications, in particular in hands and face (scars).

*Two comments are pertinent :*

1. Only by the closest co-operation between the specialized treatment centres participating in the programme will it be possible to derive concrete results from the clinical research activities envisaged, especially in the fields outlined under a).
2. The fields summarized above do not cover all the aspects of the subject which deserve attention, but only those in which new knowledge is needed ; in other problems, such as first aid, or rehabilitation of victims of burns, co-operation with the relevant industrial concerns and members of the

medical profession in comparing experience and viewpoints, in organizing studies, and in educating the public is more important : such activities are by no means excluded from the research programme, and in the case of some of them it will be a question of carrying through to a successful conclusion projects begun long ago by groups working under the High Authority's auspices.

The High Authority thus wishes to impart a special impetus to co-operation, to bring together in this research a series of studies centred on practical problems, and at the same time to promote the necessary dissemination of information.

For this purpose the High Authority has allocated to the new "Treatment and rehabilitation of burned persons" programme a total sum of 1.5 million EMA units of account.

The programme is expected to take four years to complete, counted from the date of initiation of the research. The programme will be inaugurated in 1967.

## ANNEXES





## Research programme "Traumatology and Rehabilitation"

Research projects in progress at 1 January 1967

### Head injuries

#### *Germany*

- 6241/21/05 Professor K. A. Jochheim, Cologne  
"Rehabilitation after head injury"
- 6241/23/04 Professor W. Toennis, Cologne  
"Effects of hypoxia on rehabilitation after severe head injury"

#### *France*

- 6241/23/08 Professor M. David, Paris  
"The effect on the post-concussional syndrome of attempts at early treatment"
- 6241/21/02 Professor E. Laine, Lille  
"Study of biological and metabolic disturbances, and associated neuropsychiatric disorders, following head injury. Therapeutic applications. Prevention and early treatment of neuropsychiatric disorders following head injury"
- 6241/21/03 Dr. R. Naquet, Marseilles  
"Clinical and electroencephalographic course after head injury. Recovery or a post-traumatic neuropsychiatric syndrome ?"

#### *Italy*

- 6241/32/22 Dr. B. Bergamasco, Turin  
"Prognosis in post-traumatic coma"
- 6241/21/01 Professor G. Gomirato, Pisa  
"Research in the clinical and post-clinical course of the post-traumatic neuropsychiatric syndrome, with fundamental research in biological and metabolic changes in head injury patients"
- 6241/32/01 Professor L. Perria, Genoa  
"Changes in the functional conditions of the encephalon in head injury patients"

#### *Luxemburg*

- 6241/32/12 Dr. G. Müller, Esch/Alzette  
"Correlation between the late effects (clinical, electroencephalographic, and psychological) of head injuries and the severity of the initial trauma"

*Netherlands*

- 6241/21/06 Dr. F. B. Venema, Dr. H. M. Greebe, Enschede  
"Rehabilitation of head injury patients"

**Spinal injuries**

*Germany*

- 6241/37/13 Professor H. Junghanns, Frankfurt/Main  
"Combined injuries of vertebral column and skull (and whiplash injuries)"
- 6241/22/10 Professor J. Rehn, Bochum  
"Injuries of vertebral column and spinal cord"

*Belgium*

- 6241/22/12 Dr. P. Houssa, Brussels  
"Cardiorespiratory disturbance in paraplegia"

*France*

- 6241/37/15 Professor P. Decoux, Lille  
"The stability of the cervical spine, its mobility its equilibrium, and its instability after trauma"
- 6241/23/07 Professor P. Decoux, Lille  
"Disorders of osteogenesis in paraplegia"
- 6241/23/09 Dr. M. Maury, Fontainebleau  
"The effects of loss of autonomic nervous regulation on the state of the circulation below the lesion in patients with vertebral column and spinal cord injuries, and the possible role of such loss in the development of the para-osteoarthropathies"
- 6241/33/20 Dr. E. Cremona, Algrange  
"The vertebral column in heavy workers in mines in ironworks"

**Chest injuries**

*France*

- 6241/31/17 Dr. P. Lagèze, Lyons  
"The value of respiratory re-educational exercises in the sequelæ of severe chest injuries"

**Injuries of the locomoter system**

*Morphological and physiopathological aspects*

*Germany*

- 6241/36/14 Professor J. Hernandez-Richter, Dr. H. Struck, Cologne  
"Formation of bony callus and resistance to load in upper and lower para-articular fractures of the femur, after osteosynthesis and conservative treatment"

### *Belgium*

- 6241/36/06 Dr. G. Desenfans, Montigny-sur-Sambre  
"Treatment and re-education in joint lesions"
- 6241/13/10 Professor P. Lacroix, Louvain  
"Physiopathology of the sequelae of limb injuries"

### *France*

- 6241/13/05 Professor R. Merle d'Aubigné, Professor P. Maurer, Paris  
"Consolidation of bone"

### *Italy*

- 6241/36/21 Dr. M. Monteleone, Rome  
"An experimental study of the aetiology, pathogenesis, and treatment of post-traumatic coxarthrosis"
- 6241/13/03 Professor O. Scaglietti, Florence  
"Repair of peripheral nerve injuries"

## *Rehabilitation of amputees*

### *Germany*

- 6241/11/07 Professor G. Jentschura, Heidelberg-Schlierbach  
"The use of upper limb prostheses, with special attention to patients who have had both arms amputated. Early fitting with prostheses in lower limb amputees"
- 6241/11/12 Dr. G. G. Kuhn, Münster  
"Design of an artificial working hand, and electronic substitute for deep sensibility, a magnetic knee-control device, and individually adapted seats for the severely handicapped"

### *France*

- 6241/12/04 Professor R. Merle d'Aubigné, Paris  
"Fitting prostheses in lower limb amputees"
- 6241/11/08 Dr. J. M. Paquin, Nancy  
"The utilization of upper limb prostheses. Amputation levels, re-educational therapy, and early fitting of prostheses in lower limb amputees"
- 6241/11/11 Dr. J. E. Lescœur, Saint-Cloud  
"The utilization of prostheses. Fitting techniques and re-educational methods ; utility tests ; occupational capacities of amputees equipped with prostheses"

### *Italy*

- 6241/11/09 Professor G. Gerundini, Legnano  
"An experimental study on the occupational resettlement of upper limb amputees, after provision of prostheses and after occupational rehabilitation. Clinical, ergonomic, and psychological aspects"
- 6241/11/01 H. Schmid and Professor F. Zarotti, Vigorso di Budrio  
"Design of a myoelectric prosthesis and of a myoelectric control mechanism for pneumatic prostheses"



**Research programmes on industrial medicine, health and safety, as at 1 January 1967**

Field and title of programme	Approved on	Financial assistance (in units of account, rounded figures)	
		Total allocated	Committed
<i>A — Industrial medicine and health</i>			
a) Physiopathological and clinical aspects			
1st programme (industrial medicine)	5-10-1955	1 200 000	1 200 000
2nd programme (industrial medicine)	7-4-1960	2 800 000	2 700 000
3rd programme (physiopathological and clinical aspects)	28-4-1964	3 000 000	2 275 000
b) Traumatology and rehabilitation			
1st programme (rehabilitation) <sup>(1)</sup>	5-12-1957	500 000	500 000
2nd programme (traumatology and rehabilitation)	19-6-1964	1 800 000	990 000
3rd programme (burns)	18-5-1966	1 500 000	281
<i>B — Industrial physiology and psychology</i>			
a) Human factors and safety			
1st programme (human factors and safety) <sup>(1)</sup>	5-12-1957	1 000 000	1 000 000
2nd programme (human factors and safety) <sup>(2)</sup>	4-11-1964	1 200 000	321 348
b) Ergonomics			
1st programme (industrial physiology and psychology and job adaptation) <sup>(2)</sup>	4-11-1964	2 000 000	859 552
<i>C — Industrial hygiene</i>			
a) Dust suppression in mines			
1st programme <sup>(1)</sup>	5-12-1957	900 000	900 000
2nd programme	21-12-1964	6 000 000	3 613 300
b) Dust suppression in the iron and steel industry			
1st programme <sup>(1)</sup>	5-12-1957	600 000	428 000
2nd programme			
c) Individual research projects			
Brown converter smoke	18-7-1961	1 000 000	800 000
Brown converter smoke	19-6-1964	1 825 000	1 050 000
Climatic factors in mines	16-3-1966	116 000	116 000
<b>Total</b>		<b>25 441 000</b>	<b>16 753 481</b>

<sup>(1)</sup> Comes under a combined financing arrangement covering four programmes, which are grouped under the general head "Safety."

<sup>(2)</sup> Comes under a combined financing arrangement covering two programmes, which are grouped under the general head "Human Factors and Ergonomics."





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