

Treatment of Victims of Locked-in-Syndromes :

from Intensive Case for Vascular-Cerebral Accidents
to Return Home

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This study is founded on the observation that, for the period 1997-98 as compared to the period 1995-9, there was an increase in LIS victims and in spinal column lesions (TC) in the neurovascular unit at the Clinic St.Martin in Marseille. It takes into account all the 160 patients admitted in a 4-year period.

We think that this increase, paradoxically, is for the most part the result of progress made in early diagnosis of ischemic vascular accidents and of new surgical attitudes in the face of hemorrhaging vascular-cerebral accidents (VCA). These advances touch, at the same time, neuro-reanimation, neuro-surgery, neurology, and neuro-radiology.

Present progress certainly allows a spectacular improvement in the prognosis for certain patients. On the other hand, if the procedures fail or are used too late, patients who would probably have died survive with severe neurological consequences. Treating these patients, reeducating them and reinserting them socially is difficult and costly.

It seems therefore that the chief problems are too long delay in admission to a hospital on the average, and the unsuitability of our system of treatment. The VCA must be considered as a medical emergency. The public and general practitioners must be informed so that they adopt the same attitude as they do when faced with a myocardial infarction : call an emergency service or immediately direct the patient to the proper medical facility.

Besides the new therapeutics, it is necessary to multiply the creation of special hospital units for the treatment of VCA cases. These units found frequently in Anglo-Saxon countries, are still too rare in France.

Lastly, once past the acute stage, the rest of our system of care must also be adapted to provide these patients with the best chances of recovering and returning home :

- adaptation of rehabilitation centers and increase in the number of neuro-vascular reawakening centers in order to permit early rehabilitation treatment and a better reinsertion of polyhandicapped patients,
- modification of present laws and regulations concerning the care provided by the social security notably by setting up a specific regime for LIS patients.

1 - General Characteristics

- CVAs of the spinal column make up 10% of all VCAs.
- They show the same etiologies and the same ischemic hemorrhagic

mechanisms as VCA hemispherics.

- These correspond to ischemic or hemorrhagic lesions dependent upon the two vertebral arteries, the basillaire trunk, or their branches.

Their initial gravity in the acute stage and their later consequences result from the fact that the vital functions (cardio-respiratory regulation), vigilance control (coma), cranial nerves (speech, swallowing, facial movements), and the sensory and motor tracts tetraplegic are affected.

2 - Classification of LIS and related illnesses

If we wish to consider all patients exhibiting clinical symptoms evoking LIS, we must include all patients who have massive lesions, either primary or secondary, of the cerebral trunk.

It is possible to differentiate three categories :

(1) Real complete LIS : caused by a massive primary injury, vascular or traumatic, to the cerebral trunk. Clinically, there are no movements other than palpebral eyelids during the first months.

(2) Real incomplete LIS : as “real” as the above because also caused by a primary injury to the cerebral trunk, but to a lesser extent. From the first weeks there is partial recovery of the cephalic segment and/or of a part of a limb

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(3) False LIS : caused by an initial injury (hemispheres or cerebellum) at a distance, resulting in an action or direct compression damaging, secondarily, the cerebral trunk. Clinically, these persons show complete LIS symptoms in association with other symptoms.

- In the case of a supra-tentorial lesion : language or memory are affected hemianopsia or optical atrophy are present which can render communication by palpebral code very difficult and may give the erroneous impression that the patient is in a vegetative or pauci-relational state.

- In the case of a massive cerebellar lesion, the resulting cerebellar syndrome, sometimes completed by dystonia or myoclonus caused by the trunk lesion, can make the eventual recuperation of a segment of a limb more difficult or even impossible.

Whether it is a real complete LIS or a false one, the clinical picture is that of the complete LIS for which the prognosis for recovery is precarious : very slow progress over a period of several years, requiring periods of hospitalization of a minimum of one year.

Only the incomplete LIS, often thanks to earlier and better-adapted initial treatment, may expect a more rapid partial recovery of the cephalic

segment of a part of the ENT sphere and/or of one or several segments of limbs already in the first months.

This clinical subdivision into three categories can therefore be reduced to an anatomical classification : Primary LIS ^{(1) and (2)}, and Secondary LIS ⁽³⁾.

One of the principal aims for caring for the VCA rapidly at the acute stage is to avoid the formation of a primary complete LIS. It is essentially a question of delay.

Paradoxically, beginning treatment late results in the absolute increase in the number of primary complete LIS cases who would otherwise have died. This numerical increase in LIS cases represents a failure to begin treatment early enough and thus is the collateral result of the actual progress made.

Once the etiological diagnosis of the VCA is made (ex : thrombosis of the basilar artery), the diagnosis of LIS is easy.

Secondary LIS cases (False LIS) are more difficult to diagnose. Unforeseeable at the beginning of the treatment of what seems to be a hemispheric or a cranial traumatism CVA, the secondary worsening with the effect of mass and of suffering of the cerebral trunk caused by engagement or direct compression usually results in a semblance of coma with a prolonged vegetative state. Evolution from this vegetative state to that of LIS is often unrecognized, particularly since associated problems exist (language, attention span, memory, vision).

Here the diagnosis of LIS is difficult to make. Books such as The Diving Bell and the Butterfly by Jean Dominique BAUBY ¹ and Only his eyes say yes by Philippe VIGAND ², both victims of LIS, have permitted us to recognize a larger number of LIS cases, particularly secondary ones. This has led to a relative increase in the number of LIS cases among the requests for admission to neurovascular reawakening units since a diagnosis of LIS seems to be made more frequently ever since these books were published.

3 - Recent increase in the number of requests by Locked-in-Syndrome sufferers or those with similar problems for treatment in a reawakening center.

In 1995-96 of the 40 patients/year admitted to the reawakening center :

- 1/3 (13/yx) suffered directly from massive cerebral vascular lesions with comas lasting several months. In the majority of cases, the lesions were hemispheric ; only one patient, each year, had severe lesions of the truncus arteriorus.

- 1/3 suffered from initially limited hemorrhagic vascular cerebral lesions with comas that were briefer and they had a fairly good functional recuperation after a period of time. They returned home with at least semi-autonomy.
- 1/3 of the others showed neurological pathologies.

For the two years, 1997-98, the kinds of patients admitted greatly changed :

- 40% had massive lesions of the cerebral trunk (CT),
 - . 10% of these had primary ischemic CT lesions and were considered to be complete or incomplete LIS,
 - . 30% had compressive secondary CT lesions and were considered to be false LIS or secondary LIS, or else to be in chronic vegetative states ;
- 10% had had hemispheric vascular cerebral hemorrhagic accidents,
- The remaining 50% were very polymorphic.

There was an increase in the proportion of patients admitted who exhibited severe lesions of the cerebral trunk (3 in 1997 and 4 in 1998 as opposed to 1 in 1995 and 1 in 1996). On the other hand, there was a marked decrease in the proportion of hemorrhagic lesions (massive or not). This decrease corresponded to the patients treated after the urgent stage had passed or when the urgency was deferred thanks to alternatives to classic surgery with craniotomy (embolization).

If we look at the requests for admission into the unit by LIS (including refusals), we find that from a few sporadic cases in 1995 and 1996 (2 per year), there was an increase to 10 cases in 1997 and 12 in 1998.

Thus there was an increase in requests for treatment in this unit exceeding what could be normally expected. What we need to know is whether this increase corresponded to a real or relative increase in the number of LIS cases.

4 - What may explain this increase ?

It is clear that for several years, there has been undeniable progress in beginning treatment of victims of vascular cerebral accidents early.

We shall consider different areas where this seems to influence the number of LIS cases subsequently admitted to reawakening centers.

(1) Beginning treatment early (or late) is dependent upon informing the public and the general practitioners as well as upon a better system for directing the patients (channel of care). It is accepted that a maximum delay of 6 hours for directing the patient to the proper facility must be respected. This is rarely the case.

(2) Orientation (or non-orientation), right away, to a specialized technical and humane service in a neurovascular or neurosurgical emergency unit.

(3) Medical progresses in neurological intensive care (neuroprotection), in interventional neuro-radiology (embolization, fibrinolyse, angioplasty) and in neuro-surgery (new operational techniques).

Unfortunately, in the beginning, these advances can only serve to increase the absolute number of LIS cases. Effectively, a more aggressive medical attitude will lead to improvement when certain patients are correctly diagnosed, but may inevitably result in partial successes (or failures) in treating them, which results in LIS.

Media coverage of evoking the BAUBY¹ and VIGAND² books has evoked a diagnosis of more readily. Since 1997, this has resulted in a relative increase in the number of LIS cases, particularly secondary ones.

Up until the last few years, most LIS victims were ignored or labeled as "chronic vegetative cases" which was equal to a death sentence for them and resulted, at best, with their placement in a unit for those in that state or in an institution providing long-term care. Due to the geographical distance of these institutions and the loss of motivation of the families, these "abandoned" patients most often died. This caused a large under-estimation of the real

number of LIS cases. A more frequent and/or earlier diagnosis of LIS therefore reduces this underestimation.

In summary, in the short term, the absolute number of patients suffering from LIS can only increase, thanks to medical "progress" in treating vascular accidents, in diagnosing them earlier and more frequently.

On the other hand, if we inform the public and the doctors, adapt our system of care and carry out multicentered studies, we can, in the long term, with constant progress in treatment, diminish the number of primary complete LIS cases.

5 - Campaigns to provide information to the public and to doctors in order to reduce the average delay in hospitalization

This delay can be explained in different ways : underestimation of the gravity of the symptoms, tardiness of initial aid, and poor orientation of the patient.

The public must be informed about possibilities for treatment, advance signs of VCA, and the delay that needs to be respected between the onset of the symptoms and hospitalization : ideally 3 hours and not more than 6.

People need to be taught to act as they would when faced with an acute chest pain : telephone an emergency medical service.

Warning signs are an association of several of the following symptoms : acute headaches, nausea-projective vomiting, severe dizziness, paralysis, numbness of pins and needles in a limb, problems with language, problems to

remain awake (loss of consciousness), vision disorders. The disappearance of these signs within a few hours, if they have been present at the same time, is not disquieting. A fever is not encouraging either.

This information must be circulated either by campaigns aimed at the public-at-large or through doctors who will provide it specifically to high-risk patients. Doctors are in the best position to orient the patient directly to the appropriate facility.

An epidemiological study in the Dijon region (France) showed that 70% of VCA cases were hospitalized, 20% were in clinics, and 10% at home. The choice was based on past record of the patient depending upon the place and the severity of the neurological state : the hospital took on the serious VCA cases and the clinics accepted the VCA cases when the initial symptoms did not appear to be grave. VCA cases (serious or not) stayed at home if the patients were older and had associated problems.

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Along with this study, an information campaign to reach general practitioners and the public was undertaken from 1991-1993. As a result of this campaign, the average delay before hospitalization was reduced from 14 hours in 1985 to 6 hours in 1994 and the rate of infarcts which occurred after warning signs was reduced from 21% to 7%.

We are still too many who believe that during a VCA, when the clinical state of the patient or the lesions shown on the scanner do not seem to justify intensive care or surgical intervention, there is nothing else to do but wait. The same "wait and see" policy is present in cases of (AIT) or partially regressive ischemic VCAs.

Untreated (AITs) and partially regressive VCAs lead to a cerebral infarct in 25% of the cases. These are therefore real emergency cerebral "menace syndromes" and justify immediate transfer to a neuro-vascular unit.

In the same way, certain VCAs can also occur in "two steps", with improvement or stabilization in between. A neuro-surgical and neuro-vascular environment is essential in the case of an intra-parenchymatous hemorrhage in a young person, in the case of a meningeal hemorrhage, or when faced with any ischemia or hemorrhage at the level of the posterior cavity (cerebellum, cerebral trunk).

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6 - What is the purpose of emergency neuro-vascular and/or neuro-surgical units :

The treatment of VCA cases in specialized units (stroke units) has several purposes : to insure a precise, accurate diagnosis, to apply the proper treatment earlier in order to avoid relapses and limit cerebral damage (secondary lesions), and to better fight against the consequences of immobility.

The development of these units is accompanied by a reduction in premature mortality (from 25% to 20%), an increase in the level of autonomy, an 8% decrease in average time in the hospital, and an increase from 53% to 60% in home returns.

These structures favor quality but also reduce costs of care by often avoiding out-of-date treatment - at best unnecessary, at worst dangerous and inappropriate examinations. Finally, by grouping the cases, they permit the collection of statistics (which serve to inform those in positions of authority about the needs of the population) and the validation of new treatments (neuroprotectors, thrombolysis).

Such structures can set the following units to work rapidly :

- a medical unit : anesthesiologist, neuro-surgeon or neurologist, neuro-radiologist, cardiologist, and trans-cranial echodopplerist,
- a technical cardiovascular and a full neuro-radiological unit : arteriography, scanner and/or (*IRM*), cardiac echography, cervical and trans-cranial doppler,
- as well as an intensive case unit, neurological if possible.

In view of the small number of these specialized structures and the large number of VCA cases, it is necessary, at present, to reserve these units for patients in generally good physical condition (without restrictions on operating or using anticoagulants), under the age of 65, and who have been experiencing acute central neurological symptoms for no more than a few hours. It is necessary to promote the creation of such structures in all establishments which possess adequate technical facilities.

7 - Progress in treatment

7.1 General measures :

The progress of medical science decreasing the number and intensity of general complications has improved the vital and also the functional prognosis by indirectly reducing indirectly cerebral suffering. Maintenance of a sufficient cerebral blood supply depends upon good cardiovascular condition and the quality of oxygenation of this blood depends upon efficient respiratory functioning. Progress to protect against infection, to prevent phlebitis and digestive hemorrhages, to stabilize alimentary supplies in water and electrolytes, also influences the level of cerebral pain.

7.2 Measures of cerebral protection : Maintenance of the pressure of cerebral perfusion.

In the last fifteen years there has been a very rapid development in cerebral intensive care concepts and practices. This progress aims at decreasing the risk of secondary lesions due to poor perfusion of the cerebral regions still unimpaired but which suffer from increased intracranial pressure, known as PIC in France. This latter is a secondary result of the effect of the mass due to the oedema or the haematoma.

Measures tending to restrict the cerebral oedema have been replaced by the notion of preserving the cerebral perfusion (PPC). The pressure of the cerebral perfusion (PPC) is the difference between the arterial pressure and the PIC. **The primary objective is the maintenance of the PPC.** At the time of the acute compression of the brain by a haematoma, the PIC increases and approaches the level of the average arterial pressure. When the PPC falls below the critical value of 50-60 mm Hg, the supply of oxygen to the brain diminishes. This results in an underperfusion of the peri-injured zones (ischemic penumbria) which aggravates suffering and induces secondary lesions. The PPC can be increased initially by increasing the arterial pressure and then by acting directly on the compressive intracranial cause (neurosurgery : draining of the haematoma, lobectomy, derivation).

7.3 Recent progress : new neuroprotectors.

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New molecules may be able to diminish ischemic pain at the cellular level. Multicentric studies of some have already been carried out but none have proved really effective. Their association with a thrombolytic treatment or their early administration, even before arrival at the hospital, represents a promising future track.

8 - **Progress of interventional neuro-radiology**

Progress of endovascular treatments has profoundly modified surgical attitudes about cerebrovascular malformations (embolizations) and, more recently, about early treatment of ischemic vascular accidents, thanks to revascularization interventions (fibrinolysis and angioplasty). The object of these interventions is to restore the blood supply in the ischemic area before definite lesions occur.

8.1 Embolization

This consists of blocking the source of an aneurysm or an angioma by using selective arteriography. In order to shut them out of the arterial flow. During the 1980s technological progress with endovascular material allowed

ever easier access to cerebral vascular structures. During the 1990s new technological breakthroughs in radiology permitted the control of these interventions in a closed skull.

At present this alternative technique can be extended to open skull surgery and can even substitute for that type of surgery in a large proportion of cases. In effect, it presents undeniable medical advantages (absence of craniotomy thus absence of additional trauma, less risk with anesthesia) during the acute phase of a cerebral hemorrhage.

The early mortality rate which remains still much the same thus seems, therefore to be due to the hemorrhage itself. On the other hand, when there are no immediate complications, it seems that the sequels are clearly reduced from the neurological and, particularly, the neuro-psychological viewpoint. Social readaptation can only be better.

8.2 Fibrinolyse

This consists of early eradication of the thrombus which caused the vascular ischemic accident by injection "in situ" of fibrinolytic substances using selective arteriography. This revascularization can only be accomplished within the first 3 to 6 hours.

Certain (8) authorities state that the maximum delay is 3 hours because, when that limit has been exceeded (3 to 6 hours), there is an increase in the early and in the total death rate. The only gain is a decrease in the global "mortality + dependence" figure whereas in less than 3 hours, there is a reduction in both mortality and dependence rates.

8.3 Angioplasty

This is an intravascular dilatation achieved with the aid of a small inflatable balloon. This has become one of the preferred treatments for the arterial spasm after a meningeal hemorrhage, along with an intra-arterial injection of papaverine.

These techniques for early revascularization of cerebral arteries (fibrinolysis and angioplasty) are recent and are the objects of multi-centered studies. It appears that they will enjoy an important development and it seems logical to envisage this development identical to that for the early treatment of cardiac coronary pathology.

9 - Neuro-surgical progress : new operative strategies

Cerebral trunk hematomas although very imperatively require supervision in a neurological intensive care unit because of the risk of death.

Ischemias and cerebral hematomas because of their proximity to the cerebral trunk and to the fourth ventricle with risk of acute hydrocephalus can experience a rapid lack of compensation. They then may require an immediate surgical intervention (dérivation or decompressive lobectomy).

The same is true for superficial cerebral hematomas which, in a young patient, require classic surgery.

Meningeal hemorrhages require supervision in neurosurgical intensive care ; later discovery of a malformation on the arteriography then leads to a surgical or endovascular intervention.

Other hemispheric VCAs rarely require surgery nor surveillance in neurological intensive care or in neurosurgery unless there is an effect of mass.

It is not so much surgical techniques themselves which have progressed in recent years but rather "alternative" procedures - such as interventional neuro-radiology - which have really changed surgical tactics.

It is the high-risk at risk or badly-tolerated hematomas, easy to reach, which requires immediate surgery, not the malformation.

10 - Progress in neuro-réhabilitation :

the neuro-vascular reawakening center, a new structure between intensive care and rehabilitation

This unit opened at the Clinique Saint-Martin in 1995 on the model of the reawakening center for patients with cranial trauma already in existence there since 1989. Its purpose is to admit patients who have experienced severe VCAs after their acute phase in intensive care is past. They may still be in a coma, in the process of awakening, or totally awake like LIS patients.

They no longer need respiratory or cardio-vascular assistance but retain a tracheotomy and are fed through a nasal-gastric tube or a gastrostomy.

Since there are so few facilities of this type, we do find ourselves admitting Locked-in-Syndrome patients even without comas or patients with similar clinical symptoms resulting from extensive injuries to the cerebral trunk and presenting for "false LIS" or "secondary LIS" clinical pictures.

Actually, few classic rehabilitation departments are able to manage several of these patients, judged too medically difficult to handle and whose prognosis for recovery in the long-term is considered to be bad. If the patient can breathe spontaneously, thanks to a tracheotomy cannula, and poses no more acute medical problems, a return home is the only alternative solution for families ready to try, by all means, to come to the patient's aid. Certain rehabilitation departments sometimes accept these patients on an on off basis but the limited punctually but the restricted number of these departments in France

again raise the problem of geographical distance and, after a few months, lead once again to envisaging the patient's return home. This was the case of J.D. BAUBY, a resident of the Paris area who agreed to go to the Berck rehabilitation center, at a distance of 250 kilometers from his family and friends.

For our service, with 12 beds available, we cannot accept more than 4 LIS patients and realize that a "quota" of 2-3 is preferable since other patients requiring lots of care (vegetative conditions, (*anoxique*) comas) are also present. Accepting more LIS patients would be detrimental to the care and security of all the patients.

Other factors such as geographical distance, family environment, and age of the patient determine whether or not the patient will be admitted.

Intensive and varied types of rehabilitation (physiotherapy, ergotherapy, and speech therapy including swallowing problems) can be begun early without waiting for the tracheotomy to be closed. This closure is often the condition for the patient to be transferred from the normal intensive care unit to the rehabilitation one). By beginning therapy before the transfer, weeks or even months can be gained since this is the time when the plasticity and the (*neuronal*) reorganization, take place.

From the first days of reawakening from the initial comatose phase, a simple eyelid code, yes by closing the eyes, no by keeping the eyes open, and eventually an alphabetical code can be set up to allow these LIS patients, literally "locked inside their bodies" to "minimally" communicate with hospital staff and, above all, with their families. Then it is necessary to be on the look out for the recovery of other auxiliary movements which can render communication easier and more rapid and,

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most important, provide a glimpse of hope a "good" prognosis for recovery of written (keyboard, mouse, telecommand) or oral expression. On the other hand, if, after 6-12 months, auxiliary recovery is not present, it is then necessary to envisage equipping the patient with an electronic or computerized system to aid with communication.

Partial progress is sometimes possible : more a finger or the head, recover the ability to swallow close the tracheotomy, articulate a few words. These are objectives to be set for LIS patients to enable them to reduce their handicap, to break out of their isolation (systems to control the environment, electric wheelchair). Unfortunately all this sometimes requires several years which is humanly unacceptable for the patient and those around him.

Our other aim is, therefore, to prepare for a return home by making the patient as little medicalized as possible : weaning him from oxygen, from the tracheotomy, from the bladder (*sonde*), sometimes from the gastronomy. This can be done in the first months with rare cases of primary incomplete LIS.

For complete LIS, at the end of 6 to 12 months we sometimes succeed in taking away the (*canule*) of the tracheotomy of a patient who continues to have problems swallowing by the proper channels (more or less tolerated) and who continues to be nourished with a gastronomy.

In general, for recovery in other areas (speech, movements of finger, head, part of limbs), progress follows the same evolutive rhythm. For incomplete LIS, progress appears early and continues for 6-12 months or more, leading in the best of cases to an incomplete tetraplegia more or less spastic and/or (*dystonique*) with (*dysarthrie*) and residual swallowing problems. In the case of complete LIS patients, it is difficult to achieve any functional motor progress even after/or 2 years of hospitalization. For these cases, the length of time of hospitalization depends upon the time required for "weaning" and that necessary for the patient and his family to accept the fact that no improvement is possible. This is often very long, making the preparation for a return home difficult, often requiring lots of arrangements, architectural, professional, and within the family.

11 - Progress in Home Treatment

Once the LIS patient returns home, he and his family feel abandoned by the medical profession and not recognized by society.

The required formalities most often do not result in the rapid complete and prolonged treatment case and/or equipment necessary for the patient's rehabilitation. This is the case for the adaptation of the home, the electronic material to permit the patient to acquire a minimum of autonomy (electric wheelchairs with special operating devices, (*téléthèses*), systems of environmental control). Above all, the compensatory allowance for the hours required for the help of an additional person at home is insufficient.

In these areas, families can seek aid from private associations (Association for the Locked-in-Syndrome, for those who are paralyzed, etc...). At the medical level, the lack of training of personnel to cope with the problems of LIS may make their first months of treating LIS patients a "training period", not always appreciated by the patients and their families. However, if these latter show that they are unhappy, the physiotherapist, the nurse, the doctor, or all three, may just drop out.

It seems to me to be indispensable at the end of the hospitalization period to include these persons in the patients preparations for returning home (something had not done correctly previously), and to insure minimum follow-up afterwards.

Even doing that certain problems cannot not be resolved during a simple visit to the doctors because they require special medical competence or

examinations. It is therefore necessary to establish a real network : ORL, speech therapist qualified in reeducating swallowing
neuropsychologist (*phoniatre*) doctor qualified in (*urodynamiques*),
ergotherapist specialized in (*domotique*), hepato-gastro-enterologist qualified in
gastronomy problems.

Setting up such a network in each region will considerably lighten
the burden of medical follow-up at home.