CHAPTER

15

Consciousness in the Locked-in Syndrome

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OUTLINE

ABSTRACT

Patients in a locked-in syndrome (LIS) are selectively deefferented, that is, have no means of producing speech, limb, or face movements. Usually the anatomy of the responsible lesion in the brainstem is such that locked-in patients are left with the capacity to use vertical eye movements and blinking to communicate their awareness. The syndrome is subdivided as: (a) *classical* LIS is characterized by total immobility except for vertical eye movements or blinking; (b) *incomplete* LIS permits remnants of voluntary motion; and (c) *total* LIS with complete immobility including all eye movements combined with preserved consciousness. Eye-controlled computer-based communication technology currently allows these patients to control their environment, use a word processor coupled to a speech synthesizer and access the worldwide net.

'Thirty years ago a stroke left me in a coma. When I awoke I found myself completely paralyzed and unable to speak… I didn't know what paralysis was until I could move nothing but my eyes. I didn't know what loneliness was until I had to wait all night in the dark, in pain from head to foot, vainly hoping for someone to come with a teardrop of comfort. I didn't know what silence was until the only sound I could make was that of my own breath issuing from a hole drilled into my throat' [1].

DEFINITION

Plum and Posner first introduced the term 'locked-in syndrome' (LIS) in 1966 referring to the constellation of quadriplegia and anarthria brought about by the disruption of the brainstem's corticospinal and corticobulbar pathways, respectively [2]. In the LIS, unlike coma, the vegetative state or akinetic mutism, consciousness remains intact. The patient is locked inside his body, able to perceive his environment but extremely limited to voluntarily interact with it.

The American Congress of Rehabilitation Medicine most recently defined LIS by (i) the presence of sustained eye opening (bilateral ptosis should be ruled out as a complicating factor); (ii) preserved basic cognitive abilities; (iii) aphonia or severe hypophonia; (iv) quadriplegia or quadriparesis; and (v) a primary mode of communication that uses vertical or lateral eye movement or blinking of the upper eyelid [3].

Bauer *et al*. [4] subdivided the syndrome on the basis of the extent of motor and verbal impairment: (a) *classical* LIS is characterized by total immobility except for vertical eye movements or blinking; (b) *incomplete* LIS permits remnants of voluntary motion; and (c) *total* LIS consists of complete immobility including all eye movements combined with preserved consciousness.

AETIOLOGY

LIS is most frequently caused by a bilateral ventral pontine lesion (e.g., [2, 5]) (Figure 15.1). In rarer instances, it can be the result of a mesencephalic lesion (e.g., [4, 6, 7]). The most common aetiology of LIS is vascular pathology, either a basilar artery occlusion or a pontine haemorrhage [8]. Another relatively frequent cause is traumatic brain injury [9–14]. Following trauma, LIS may be caused either directly by brainstem lesions, secondary to vertebral artery damage and vertebrobasilar arterial occlusion, or to compression of the cerebral peduncles from tentorial herniation [13]. It has also been reported secondary to subarachnoid haemorrhage and vascular spasm of the basilar artery, a brainstem tumour, central pontine myelinolysis, encephalitis, pontine abscess, brainstem drug toxicity, vaccine reaction, and prolonged hypoglycemia [8].

A comparable awake conscious state simulating unresponsiveness may also occur in severe cases of peripheral polyneuropathy as a result of total paralysis of limb, bulbar, and ocular musculature. Transient LIS cases have been reported after Guillain-Barré polyradiculoneuropathy [15–17] and severe post-infectious polyneuropathy [18, 19]. Unlike basilar artery stroke, vertical eye movements are not selectively spared in these extensive peripheral disconnection syndromes. Another important cause of complete LIS can be observed in end-stage amyotrophic lateral sclerosis, that is, motor neuron disease [20–22]. Finally, temporary pharmacologically induced LIS can sporadically be observed in general anaesthesia when patients receive muscle relaxants together with inadequate amounts of anaesthetic drugs (e.g., [23]). Testimonies from victims relate that the worst aspect of the experience was the anxious desire to move or speak while being unable to do so [24–26]. Awake-paralyzed patients undergoing surgery may develop post-traumatic stress disorder (for recent review, see [27]).

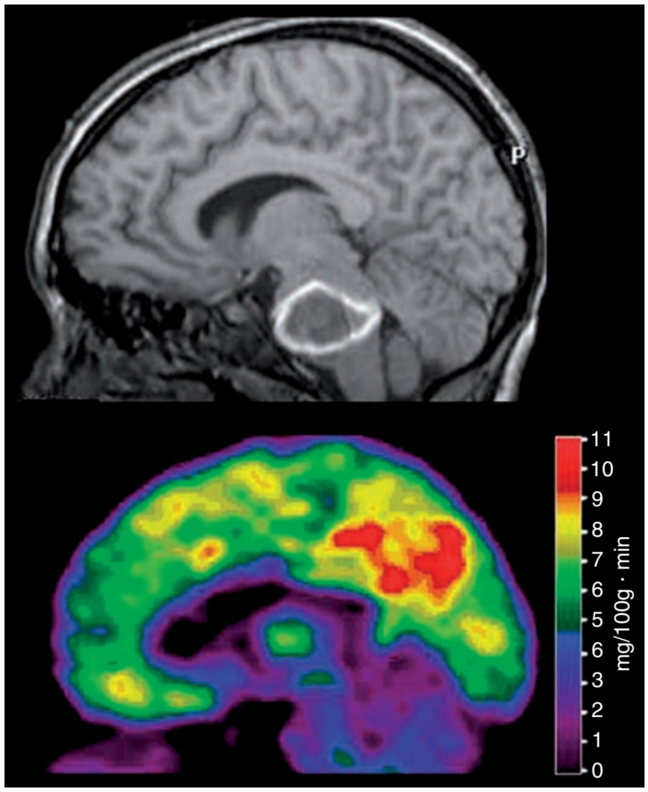

FIGURE 15.1 Upper panel: Magnetic resonance image (sagittal section) showing a massive hemorrhage in the brainstem (circular hyperintensity) causing LIS in a 13-year old girl. Lower panel: ^{18}F-fluorodeoxyglucose-Positron Emission Tomography illustrating intact cerebral metabolism in the acute phase of the LIS when eye-coded communication was difficult due to fluctuating vigilance. The colour scale shows the amount of glucose metabolized per 100 g of brain tissue per minute. Statistical analysis revealed that metabolism in the supra-tentorial gray matter was not significantly lower as compared to healthy controls (taken from Laureys *et al*., [8]).

MISDIAGNOSIS

Unless the physician is familiar with the signs and symptoms of the LIS, the diagnosis may be missed

BOX 15.1

FAMOUS LOCKED-IN PATIENTS

The LIS first described in Alexandre Dumas's novel the Count of Monte Cristo (1844–1845) [28]. Herein, Monsieur Noirtier de Villefort, was depicted as 'a corpse with living eyes'. Mr. Noirtier had been in this state for more than 6 years, and he could only communicate by blinking his eyes. His helper pointed at words in a dictionary and the monsignor indicated with his eyes the words he wanted. Some years later, Emile Zola wrote in his novel Thérèse Raquin [29] (1868) about a paralyzed woman who 'was buried alive in a dead body' and 'had language only in her eyes'. Dumas and Zola highlighted the locked-in condition before the medical community did.

For a long time, LIS has mainly been a retrospective diagnosis based on post-mortem findings [5, 30]. Medical technology now can achieve long survival in such cases – the longest history of this condition being 29 years (French ALIS). Computerized devices now allow the LIS patient and other patients with severe motor impairment to 'speak'. The preeminent physicist Stephen Hawking, author of the best-sellers *A Brief History of Time* and *The Universe in a Nutshell*, is able to communicate solely through the use of a computerized voice synthesizer. With one finger, he selects words presented serially on a computer screen; the words are then stored and later presented as a synthesized and coherent message (http://www.hawking.org.uk). The continuing brilliant productivity of Hawking despite his failure to move or speak illustrates that locked-in patients can be productive members of the society.

In December 1995, Jean-Dominique Bauby, aged 43 and editor-in-chief of the fashion magazine 'Elle', had a brainstem stroke. He emerged from a coma several weeks later to find himself in a LIS only able to move his left eyelid and with very little hope of recovery. Bauby wanted to show the world that this pathology, which impedes movement and speech, does not prevent patients from living. He has proven it in an extraordinary book in which he composed each passage mentally and then dictated it, letter by letter, to an amanuensis who painstakingly recited a frequency-ordered alphabet until Bauby chose a letter by blinking his left eyelid once to signify 'yes'. His book [31] *The diving bell and the butterfly* became a best-seller only weeks after his death due to septic shock on March 9, 1997. Bauby created an ALIS aimed to help patients with this condition and their families (http://www.alis-asso.fr).

Since its creation in 1997, ALIS has registered 438 locked-in patients in France (situation in May 2007).

and the patient may erroneously be considered as being in a coma, vegetative state, or akinetic mutism [32]. In a recent survey in 44 LIS patients belonging to the French Association for Locked-in Syndrome (ALIS, see Box 15.1) the first person to realize the patient was conscious and could communicate via eye movements most often was a family member (55% of cases) and not the treating physician (23% of cases) [33]. Most distressingly, the time elapsed between brain insult and LIS diagnosis was on an average of 2.5 months (78 days). Several patients were not diagnosed for more than 4 years. Leon-Carrion *et al*. [33] believed that this delay in the diagnosis of LIS mainly reflected initial misdiagnosis. Clinical experience indeed shows how difficult it is to recognize unambiguous signs of conscious perception of the environment and of the self in severely brain-injured patients. Voluntary eye movements and/or blinking can erroneously be interpreted as reflexive in anarthric and nearly completely paralyzed patients who classically show decerebration posturing (i.e., stereotyped extension reflexes). However, part of the delay could be explained by an initial lower level neurological state (e.g., decreased or fluctuating arousal levels) or even psychiatric symptoms which would mask residual cognitive functions at the outset of LIS.

SURVIVAL AND MORTALITY

It has been stated that long-term survival in LIS is rare [34]. Mortality is indeed high in acute LIS (76% for vascular cases and 41% for non-vascular cases) with 87% of the deaths occurring in the first 4 months [5]. In 1987, Haig *et al*. first [35] reported on the life expectancy of persons with LIS, showing that individuals can actually survive for significant periods of time. Encompassing 29 patients from a major US rehabilitation hospital who had been in a LIS for more than 1 year they reported formal survival curves at 5-year [36] and 10-year follow-up [37]. These authors have shown that once a patient has medically stabilized in LIS for more than a year, 10-year survival is 83% and 20-year survival is 40% [37].

Data from the ALIS database ($n = 320$) show that survivors are younger at onset than those who die (Figure 15.2). The mean time spent in locked-in is 6 ± 4 years (range 14 days to 29 years, the latter patient still being alive). Reported causes of death for the 42 deceased subjects are predominantly infectious (40%, most frequently pneumonia), primary brainstem stroke (25%), recurrent brainstem stroke (10%), patient's refusal of artificial nutrition and hydration (10%), and other causes (i.e., cardiac arrest, gastrostomy surgery, heart failure, and hepatitis). It should be noted that the ALIS database does not contain the many LIS patients who die in the acute setting without being reported to the association. Recruitment of the ALIS database is based on case reporting by family and health care workers prompted by the exceptional media publicity of ALIS in France and tracked by continuing yearly surveys. This recruitment bias should, however, be taken into account when interpreting the presented data.

PROGNOSIS AND OUTCOME

Classically, the motor recovery of LIS of vascular origin is very limited [5, 37] even if rare cases of good recovery have been reported [38, 39]. Chang and Morariu [40] reported the first transient LIS caused by a traumatic damage of the brainstem. In their milestone paper, Patterson and Grabois [5], reviewed 139 patients – 6 cases from the author's rehabilitation centre in Texas, USA and 133 taken from 71 published studies from 1959 to 1983 and reported earlier and more complete recovery in non-vascular LIS compared to vascular LIS. Return of horizontal pursuit eye movements within 4 weeks post-onset are thought to be predictive of good recovery [6]. Richard *et al*. [41] followed 11 LIS patients for 7 months to 10 years and observed that despite the persisting serious motor deficit, all patients did recover some distal control of fingers and toe movements, often allowing a functional use of a digital switch. The motor improvement occurred with a distal to proximal progression and included a striking axial hypotonia.

LIS is uncommon enough that many clinicians do not know how to approach rehabilitation and there are no existing guidelines as how to organize the revalidation process. Casanova *et al*. [42] recently followed 14 LIS patients in three Italian rehabilitation centres for a period of 5 months to 6 years. They reported that intensive and early rehabilitative care improved functional outcome and reduced mortality rate when compared to the older studies by Patterson and Grabois [5] and Haig *et al*. [35].

Often unknown to physicians caring for LIS in the acute setting and despite the limited motor recovery of LIS patients, many patients can return living at home. The ALIS database shows that out of 245 patients, 108

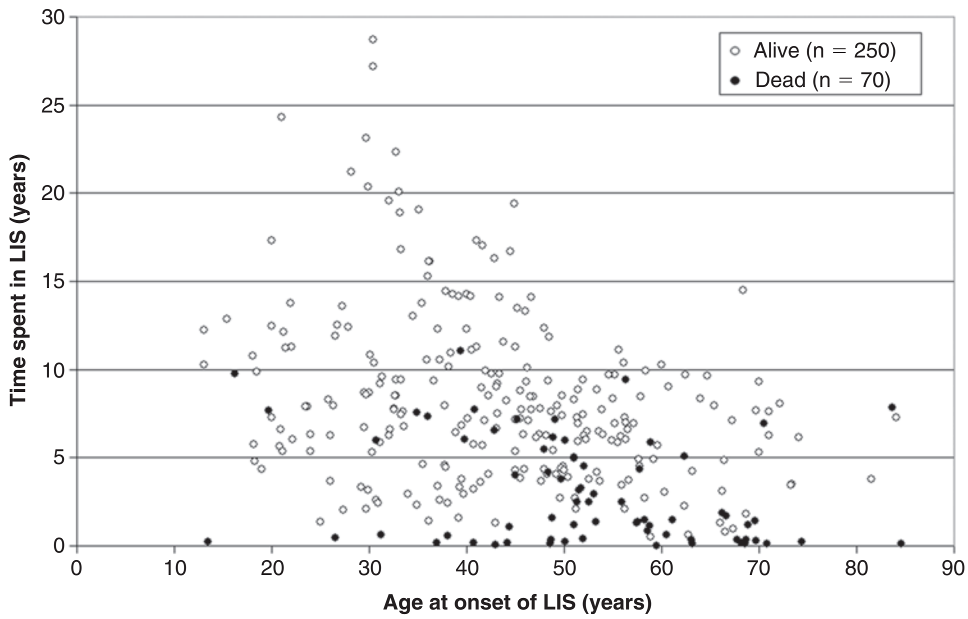

FIGURE 15.2 Age at insult vs. survival time of 320 locked-in patients registered in the ALIS database, 70 of whom died (filled circles).

(44%) are known to live at home (21% are staying in a hospital setting and 17% in a revalidation centre). Patients return home after a mean period of 2±16 years (range 2 months to 6 years, data obtained on $n = 55$). Results obtained in 95 patients show a moderate to significant recovery of head movement in 92% of patients, 65% showed small movement in one of the upper limbs (finger, hand, or arm) and 74% show a small movement in lower limbs (foot or leg). Half of the patients has recovered some speech production (limited to single comprehensible words) and 95% can vocalize unintelligible sounds (data obtained on $n = 50$). Some kind of electrical communication device is used by 81% of the LIS patients (data obtained on $n = 95$) [8].

COMMUNICATION

In order to functionally communicate, it is necessary for the LIS patient to be motivated and to be able to receive (verbally or visually; i.e., written commands) and emit information. The first contact to be made with these patients is through a code using eyelid blinks or vertical eye movements. In cases of bilateral ptosis the eyelids need to be manually opened in order to verify voluntary eye movements on command. To establish a yes/no eye code, the following instruction can suffice: 'yes' is indicated by one blink and 'no' by two or look indicates 'yes' and look down 'no'. In practice, the patient's best eye movement should be chosen and the same eye code should be used by all interlocutors. Such a code will only permit to communicate via closed questions (i.e., yes/no answers on presented questions). The principal aim of reeducation is to reestablish a genuine exchange with the LIS patient by putting into place various codes to permit them to reach a higher level of communication and thus to achieve an active participation. With sufficient practice, it is possible for LIS patients to communicate complex ideas in coded eye movements. Feldman [43] has first described a LIS patient who used jaw and eyelid movements to communicate in Morse Code.

Most frequently used are alphabetical communication systems. The simplest way is to list the alphabet and ask the LIS patient to make a pre-arranged eye movement to indicate a letter. Some patients prefer a listing of the letters sorted in function of appearance rate in usual language (i.e., in the English language: E-T-A-O-I-N-S-R-H-L-D-C-U-M-F-P-G-W-Y-B-V-K-X-J-Q-Z). The interlocutor pronounces the letters beginning with the most frequently used, E, and continues until the patient blinks after hearing the desired letter which the interlocutor then notes. It is necessary to begin over again for each letter to form words and phrases. The rapidity of this system depends upon practice and the ability of patient and interlocutor to work together. The interlocutor may be able to guess at a word or a phrase before all the letters have been pronounced. It is sufficient for him to pronounce the word or the rest of the sentence. The patient than confirms the word by making his eye code for 'yes' or disproves by making his eye code for 'no'. Other systems have been discussed elsewhere [8].

The above discussed communication systems all require assistance from others. Recent developments in informatics are drastically changing the lives of patients with LIS. Instead of passively responding to the requests of others, new communication facilitation devices couplet to computers now allow the patient to initiate conversations [8]. Experts in rehabilitation engineering and speech-language pathology are continuingly improving various brain–computer interfaces (BCI). BCIs (also named thought translation devices) are a mean of communication in which messages or commands that an individual sends to the external world do not pass through the brain's normal output pathways of peripheral nerves and muscles [44]. These patient–computer interfaces such as infrared eye movement sensors which can be coupled to on-screen virtual keyboards allowing the LIS survivor to control his environment, use a word processor (which can be coupled to a text-to-speech synthesizer), operate a telephone of fax, or access the Internet and use e-mail (Figure 15.3; Box 15.2).

Wilhelm *et al*. [45] have shown that mental manipulation of salivary *p*H may be an alternative way to document consciousness in acute LIS (see Figure 15.4). Birbaumer *et al*. [46] reported that chronic near-complete LIS and end-stage amyotrophic lateral sclerosis, patients were able to communicate without any verbal or motor report but solely by modulating their electroencephalographic (EEG). In the future, more widely available access to enhanced communication computer prosthetics should additionally enhance the quality of life of LIS survivors (also see Chapter 17).

RESIDUAL BRAIN FUNCTION

Neuropsychological Testing

Surprisingly, there are no systematic neuropsychological studies of the cognitive functions in patients living with a LIS. Most case reports, however, failed to show any significant cognitive impairment when LIS patients were tested 1 year or more after the brainstem

BOX 15.2

TESTIMONIES WRITTEN BY LIS SURVIVORS

Some memoirs written by LIS patients well illustrate the clinical challenge of recognizing a LIS. A striking example is *Look Up for Yes* written by Julia Tavalaro [1]. In 1966, 32-year old Tavalaro fell into a coma following a subarachnoid hemorrhage. She remained in a coma for 7 months and gradually woke up to find herself in a New York State chronic care facility. There, she was known as 'the vegetable' and it was not until 1973 (i.e., after 6 years) that her family identified a voluntary 'attempt to smile' when Julia was told a dirty joke. This made speech therapist Arlene Kraat brake through Julia's isolation. With the speech therapist pointing to each letter on a letter board, Julia began to use her eyes to spell out her thoughts and relate the turmoil of her terrible years in captivity. She later used a communication device, started to write poetry and could cheek-control her wheelchair around the hospital. Julia Tavalaro died in 2003 at age 68 from aspiration pneumonia.

Another poignant testimony comes from Philippe Vigand, author of *Only the Eyes Say Yes* (original publication in 1997) and formerly publishing executive with the French conglomerate Hachette. The book is written in two parts, the first by Philippe, the second by his wife Stéphane detailing *her* experiences. In 1990, Philippe Vigand, 32-years old, presented a vertebral artery dissection and remained in a coma for 2 months. Philippe and his wife write that at first, doctors believed he was a 'vegetable and was treated as such'. His wife eventually realized that he was blinking his eyes in response to her comments and questions to him but had difficulties convincing the treating physicians. It was speech therapist Philippe Van Eeckhout who formally made the diagnosis of LIS: when testing Vigand's gag reflex, Van Eeckhout was bit in his finger and yelled 'chameau' (French for 'camel'), whereupon the patient started to grin. On the subsequent question 'how much is 2 plus 2' Vigand blinked four times confirming his cognitive capacities. He later communicated his first phrase by means of a letter board: 'my feet hurt'. After many months of hospital care, Vigand was brought home, where an infrared camera attached to a computer enabled him to 'speak'. The couple conceived a child after Philippe became paralyzed and he has written his second book (dealing with the menaced French ecosystem) on the beach of the Martinique isles [47] illustrating that LIS patients can resume a significant role in family and society.

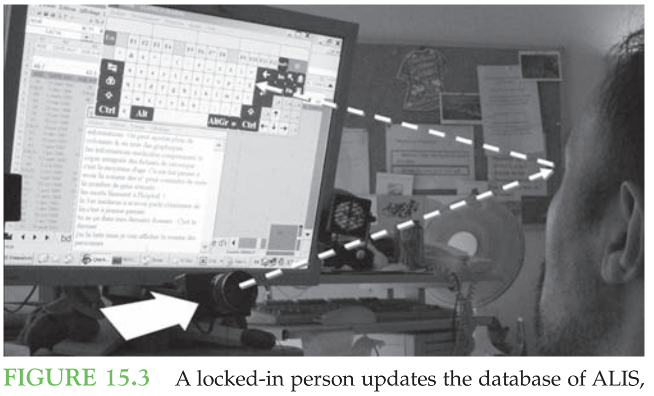

FIGURE 15.3 A locked-in person updates the database of ALIS, moving the cursor on screen by eye movements. An infrared camera (white arrow) mounted below the monitor observes one of the user's eyes, an image processing software continually analyzes the video image of the eye and determines where the user is looking on the screen. The user looks at a virtual keyboard that is displayed on the monitor and uses his eye as a computer-mouse. To 'click' he looks at the key for a specified period of time (typically a fraction of a second) or blinks. An array of menu keys allow the user to control his environment, use a speech synthesizer, browse the worldwide web or send e-mail independently (picture used with kind permission from DT).With a similar device Philippe Vigand, locked-in since 1990, has written a testimony of his LIS experience in an astonishing book 'Putain de silence' translated as 'Only the eyes say yes' [48].

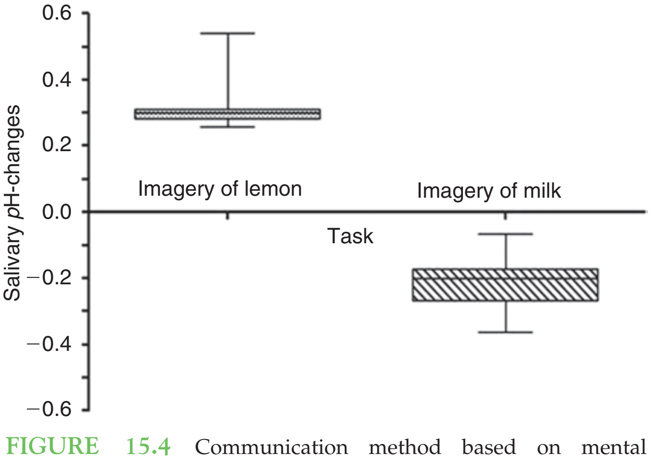

FIGURE 15.4 Communication method based on mental imagery and measurement of salivary *p*H changes. Imagery of lemon increases salivary *p*H and is used to communicate 'yes' while imagery of milk decreases *p*H and communicates 'no'. Result obtained in one healthy volunteer box and whiskers represent mean, SD and minimum/maximum measurements. *Source*: Adapted from Vanhaudenhuyse *et al*. [49].

insult. Allain *et al*. [50] performed extensive neuropsychological testing in two LIS patients studied 2 and 3 years after their basilar artery thrombosis. Patients communicated via a communication PrintWriter system and showed no impairment of language, memory, and intellectual functioning. Cappa *et al*. [51, 52] studied one patient who was LIS for over 12 years and observed intact performances on language, calculation, spatial orientation, right–left discrimination, and personality testing. Recently, New and Thomas [53] assessed cognitive functioning in a LIS patient 6 months after basilar artery occlusion and noted significant reduction in speed of processing, moderate impairment of perceptual organization and executive skills, mild difficulties with attention, concentration, and new learning of verbal information. Interestingly, they subsequently observed progressive improvement in most areas of cognitive functioning until over 2 years after his brainstem stroke.

In a survey conducted by ALIS and Léon-Carrion *et al*. [33] in 44 chronic LIS patients, 86% reported a good attentional level, all but two patients could watch and follow a film on TV and all but one were well-oriented in time (mean duration of LIS was 5 years). More recently, ALIS and Schnakers *et al*. [54] adapted a standard battery of neuropsychological testing (i.e., sustained and selective attention, working and episodic memory, executive functioning, phonological and lexico-semantic processing and vocabulary knowledge) to an eye-response mode for specific use in LIS patients. Overall, performances in the LIS patients studied 3 to 6 years after their brainstem insult were not significantly different from matched healthy controls who, like the LIS patients, had to respond solely via eye movements (Figure 15.5). These data re-emphasize the fact that LIS due to purely pontine lesions is characterized by the restoration of a globally intact cognitive potential.

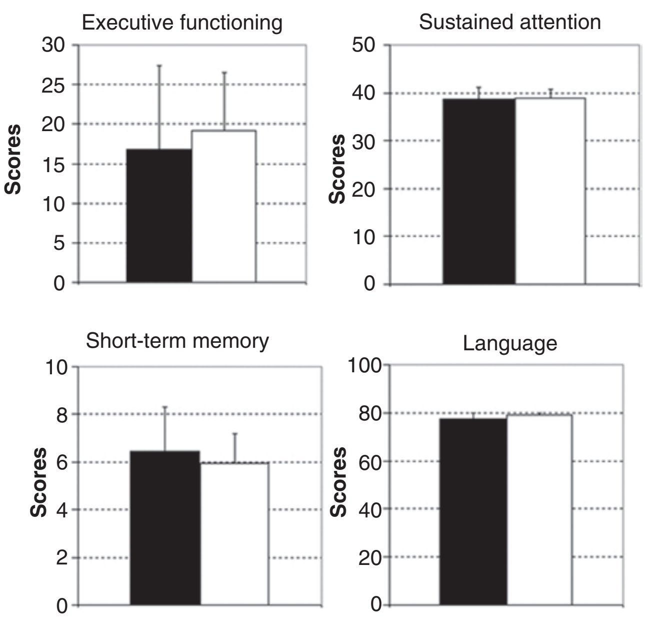

FIGURE 15.5 Neuropsychological testing data from six LIS patients (three males; mean age 42 ± 16 years) and 40 healthy adults (matched according to age and level of education). Note that LIS patients show cognitive functioning not significantly different from controls. *Source*: Data adapted from Schnakers *et al*. [54].

Electrophysiologic Measurements

Markland [55] reviewed EEG recordings in eight patients with LIS and reported it was normal or minimally slow in seven and showed reactivity to external stimuli in all patients. These results were confirmed by Bassetti *et al*. [56] who observed a predominance of reactive alpha activity in six LIS patients. In their seminal paper, Patterson and Grabois [5] reported normal EEG findings in 39 (45%) and abnormal (mostly slowing over the temporal or frontal leads or more diffuse slowing) in 48 (55%) patients out of 87 reviewed patients. Jacome and Morilla-Pastor [57], however, reported three patients with acute brainstem strokes and LIS whose repeated EEG recordings exhibited an 'alpha coma' pattern including an unreactive alpha rhythm to multimodal stimuli. Unreactive EEG in LIS was also reported by Gutling *et al*. [58] confirming that lack of alpha reactivity is not a reliable indicator of unconsciousness and cannot be used to distinguish the 'locked-in' patients from those comatose due to a brainstem lesion. Nevertheless, the presence of a relatively normal reactive EEG rhythm in a patient that appears to be unconscious should alert one to the possibility of a LIS.

Somatosensory evoked potentials are known to be unreliable predictors of prognosis [56, 59] but motor evoked potentials have been proposed to evaluate the potential motor recovery (e.g., [56]).

Cognitive event-related potentials (ERPs) in patients with LIS may have a role in differential diagnosis of brainstem lesions [60] and have also shown their utility to document consciousness in total LIS due to end-stage amyotrophic lateral sclerosis [22] and fulminant Guillain-Barré syndrome [16]. Figure 15.6 shows ERPs in locked-in patients showing a positive 'P3' component only evoked by the patient's own name (thick line) and not by other names (thin line). It should, however, be noted that such responses can also be evoked in minimally conscious patients [61]

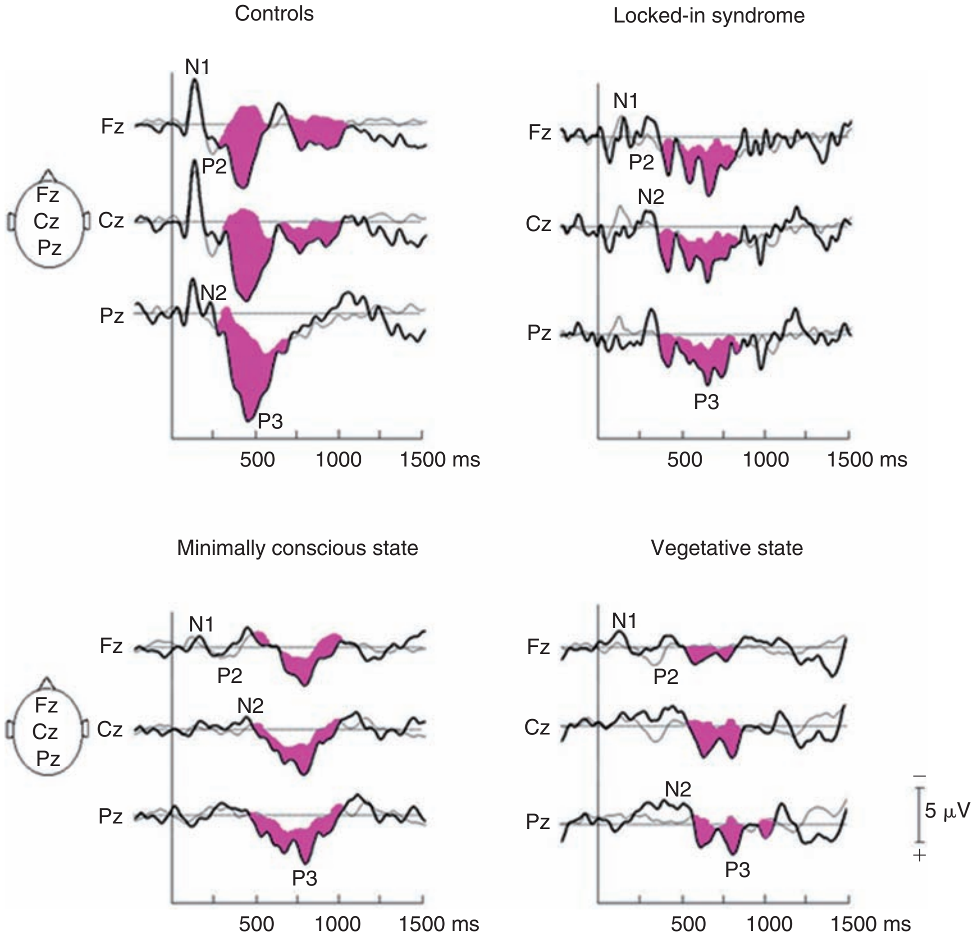

FIGURE 15.6 ERPs to the subject's own name (thick traces) and to other first names (thin traces) in controls ($n = 5$), LIS ($n = 4$), minimally conscious state ($n = 6$) and vegetative state ($n = 5$) patients. Note that a P3 response (pink) is no reliable marker of consciousness as it could be obtained in well-documented vegetative patients who never recovered. *Source*: Adapted from Perrin *et al*. [69].

and that they even persist in the vegetative state [62] and sleeping normal subjects [63].

Functional Neuroimaging

Classically, structural brain imaging (MRI) may show isolated lesions (bilateral infarction, haemorrhage, or tumour) of the ventral portion of the basis pontis or midbrain (e.g., [64]). PET scanning has shown significantly higher metabolic levels in the brains of patients in a LIS compared to patients in the vegetative state [65]. Preliminary results PET studies [66, 67] indicate that no supra-tentorial cortical area show significantly lower metabolism in acute and chronic LIS patients when compared to age-matched healthy controls (Figure 15.2). Conversely, a significantly hyperactivity was observed in bilateral amygdala of acute, but not chronic, LIS patients [8]. The absence of metabolic signs of reduced function in any area of the gray matter re-emphasizes the fact that LIS patients suffer from a pure motor deefferentation and recover an entirely intact intellectual capacity. Previous PET studies in normal volunteers have demonstrated amygdala activation in relation to negative emotions such as fear and anxiety (e.g., [69]). It is difficult to make judgments about patient's thoughts and feelings when they awake from their coma in a motionless shell. However, in the absence of decreased neural activity in any cortical region, we assume that the increased activity in the amygdala in acute non-communicative LIS patients, relates to the terrifying situation of an intact awareness in a sensitive being, experiencing frustration, stress and anguish, locked in an immobile body. These preliminary findings emphasize the need to quickly make the diagnosis and also recognize the terrifying situation of a pseudocoma (i.e., LIS) at the intensive care or coma unit. Health care workers should adapt their bedside-behaviour and consider pharmacological anxiolytic therapy of locked-in patients, taking into account the intense emotional state they go through.

DAILY ACTIVITIES

For those not dealing with these patients on a daily basis it is surprising to see how chronic LIS patients, with the help of family and friends, still have essential social interaction and lead meaningful lives. Doble *et al*. [37] reported that most of their chronic LIS patients continued to remain active through eye and facial movements. Listed activities included: TV, radio, music, books on tape, visiting with family, visit vacation home, e-mail, telephone, teaching, movies, shows, the beach, bars, school, and vocational training. They also reported an attorney who uses Morse code eye blinks to provide legal opinions and keeps up with colleagues through fax and e-mail. Another patient teached math and spelling to third graders using a mouth stick to trigger an electronic voice device. The authors reported being impressed with the social interactions of chronic LIS patients and stated it was apparent that the patients were actively involved in family and personal decisions and that their presence was valued at home. Only four out of the 13 patients used computers consistently, two accessed the internet and one was able to complete the telephone interview by himself using a computer and voice synthesizer. A survey by ALIS showed that out of 17 questioned chronic LIS patients living at home, 11 (65%) used a personal computer [8].

QUALITY OF LIFE

A study conducted by the French ALIS assessed the quality of life in LIS. Chronic LIS survivors ($n = 17$, LIS duration 6±4 years) who did not show major motor recovery (i.e., used eye movements or blinking as the major mode of communication) and who lived at home were asked to fill in the Short Form-36 (SF-36) questionnaire [70] on quality of life. On the basis of this questionnaire LIS patients unsurprisingly showed maximal limitations in physical activities (all patients scoring zero). Interestingly, self-scored perception of mental health (evaluating mental well-being and psychological distress) and personal general health were not significantly lower than values from age-matched French control subjects [8, 71]. Note that the perception of mental health and the presence of physical pain was correlated to the frequency of suicidal thought [8]. This stresses the importance of managing pain in chronic LIS patients. Our results confirm earlier reports on quality of life assessments in chronic LIS patients. Leon-Carrion *et al*. [33] and the French ALIS showed that about half of the assessed patients ($n = 44$) regarded their mood as good. Similarly, Doble *et al*. [37] studied 13 LIS patients and reported that more than half note were satisfied with life in general. In 2007, we have assessed the quality of life of 11 patients (LIS duration 7±3 years) (unpublished data) using the ACSA scale (Anamnestic Comparative Self Assessment) [72]. ACSA estimates overall well-being on a scale from −5 (worst period in the respondent's life) to +5 (best period). As show in Figure 15.7, LIS patients' overall quality of life was not significantly different from healthy matched controls.

THE RIGHT TO DIE OR THE RIGHT TO LIVE?

As stated by The American Academy of Neurology (AAN), patients with profound and permanent paralysis have the right to make health care decisions about themselves including to accept or refuse life-sustaining therapy [73]. Bruno *et al*. have questioned 97 clinicians: At the affirmation: '*Being LIS is worse than being in a vegetative state or in a minimally conscious state*?', 66% said 'yes', 34% 'no' [74]. The unfortunate consequence of this might be that biased clinicians provide less aggressive medical treatment and influence families in ways not appropriate to the situation [37]. Some health care professionals who have no experience with chronic LIS survivors might believe that LIS patients want to die but many studies have shown that patients typically have a wish to live. In 1993, Anderson *et al*. [75] reported that all questioned LIS patients wanted life-sustaining treatment. A previous study by the French ALIS showed that 75% of chronic LIS patients without motor recovery rarely or never had suicidal thoughts. The question: '*would you like to receive antibiotics in*

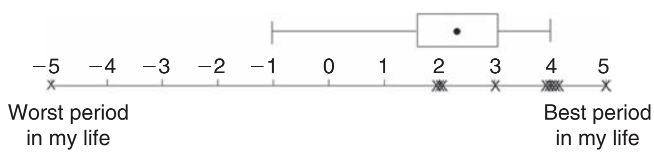

FIGURE 15.7 ACSA [72] showing self-rated quality of life in 11 LIS patients (crosses; mean age 37±6 year; eight males). Box and whiskers represent mean, SD, minimum and maximum of self-rated quality of life in 22 controls (mean age 43±10 year; eight males). Note that on average LIS patients self-rated quality of life is not significantly lower than in controls. *Source*: Adapted from Bruno, Pellas and Laureys [74].

case of pneumonia', 80% answered 'yes' and in reply to the question '*would you like reanimation to be tempted in case of cardiac arrest*', 62% said 'yes'[8]. Similarly, in a recent survey conducted by Bruno *et al*. nearly two-thirds of studied LIS patients ($n = 54$) never had suicidal thoughts (see Figure 15.8) [74]. In line with these findings, Doble *et al*. [37] reported that none of the questioned chronic LIS patients had a 'do not resuscitate' order, more than a half had never considered or discussed euthanasia. These authors also noted that none of the 15 deaths of their study cohort of chronic LIS patients ($n = 29$) could be attributed to euthanasia. Since its creation, the French ALIS has registered over 400 patients with LIS in France. Only five reported deaths were related to the patient's wish to die.

In accordance with the principle of patient autonomy, physicians should respect the right of LIS patients to accept or refuse any treatment. At least two conditions are necessary for full autonomy, patients need to have intact cognitive abilities and they must be able to communicate their thoughts and wishes.

Likewise, in amyotrophic lateral sclerosis, ill-informed patients are regularly advised by physicians to refuse intubation and withhold life-saving interventions [76, 77]. However, ventilator users with neuromuscular disease report meaningful life satisfaction [78]. Bach [79] warns that 'virtually no patients are appropriately counselled about all therapeutic options' and states that advance directives, although appropriate for patients with terminal cancer, are inappropriate for patients with severe motor disability.

Katz *et al*. [36] cite the Hastings Centre Report, 'Who speaks for the patient with LIS?'. With the initial handicap of communicating only through eyeblink who can decide whether the patient is competent to consent or to refuse treatment? [80]. With regard to end-of-life decisions taken in LIS patients, an illustrative case is reported by Fred [81]. His 80-year old mother became locked-in. In concert with the attending physician, without consent of the patient herself, the decision was made to 'have her senses dulled' and provide supportive care only. She died shortly thereafter with a temperature of 109°F (43°C). In the accompanying editorial, Stumpf [82] commented that 'human life is to be preserved as long as there is consciousness and cognitive function in contrast to a vegetative state or neocortical death'.

CONCLUSION

The discussed data stress the need for critical care physicians who are confronted to acute LIS to recognize this infrequent syndrome as early as possible. Health care workers who take care of acute LIS patients need a better understanding of the long-term outcome of LIS. Opposite to the beliefs of many physicians, LIS patients self-report a meaningful quality

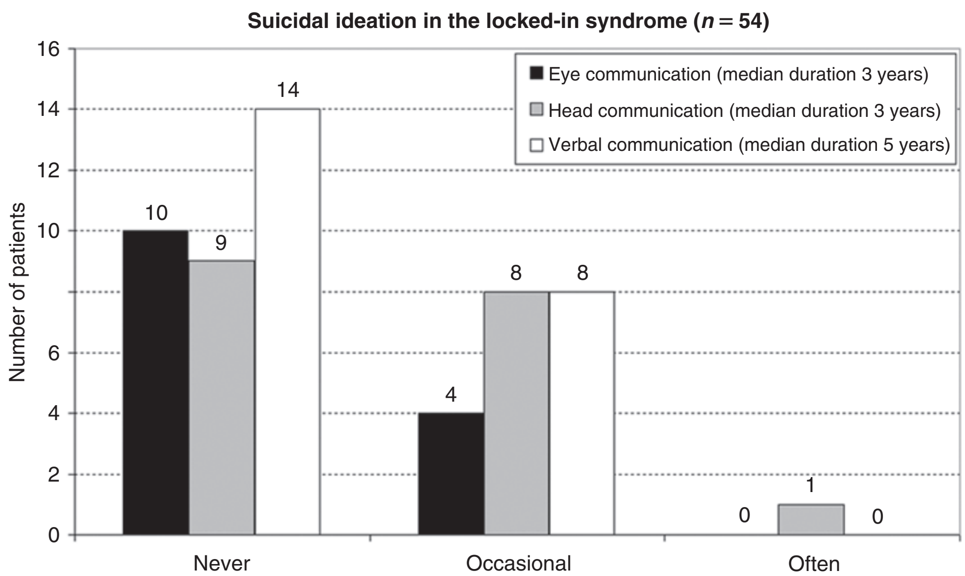

FIGURE 15.8 Frequency of suicide thoughts in 54 patients with chronic LIS (age 22–60 years), 14 communicate with their eyes, 18 have recovered some communication using their head, and 22 have recovered some verbal communication. Note that 33 patients never had suicidal thoughts, 20 had some occasionally and only one patient presented frequent suicide thoughts. *Source*: Adapted from Bruno, Pellas and Laureys [74].

of life and the demand of euthanasia existing but is uncommon. Studies emphasize LIS patients' right to autonomy and demonstrate their ability to exercise it, including taking end-of-life decisions. The strength of medical and communication-technological progress for patients with severe neurological conditions is that it makes them more and more like all the rest of us [83]. Clinicians should realize that quality of life often equates with social rather than physical interaction. It's important to emphasize that only the medically stabilized, informed LIS patient is able to accept or to refuse life-sustaining treatment. LIS patients should not be denied the right to die –and to die – but also, and more importantly, they should not be denied the right to live – and to live with dignity and the best possible care.

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