Anosognosia and asomatognosia during intracarotid amobarbital inactivation

K.J. Meador; D.W. Loring; T.E. Feinberg; G.P. Lee; and M.E. Nichols

Article abstract—*Background:* Anosognosia (i.e., denial of hemiparesis) and asomatognosia (i.e., inability to recognize the affected limb as one's own) occur more frequently with right cerebral lesions. However, the incidence, relative recovery, and underlying mechanisms remain unclear. *Methods:* Anosognosia and asomatognosia were examined in 62 patients undergoing the intracarotid amobarbital procedure as part of their preoperative evaluation for epilepsy surgery. Additional questions were asked in the last 32 patients studied. *Results:* During inactivation of the non–language-dominant cerebral hemisphere, 88% of the 62 patients were unaware of their paralysis, and 82% could not recognize their own hand at some point. Only 3% did not exhibit anosognosia or asomatognosia. In general, asomatognosia resolved earlier than anosognosia. When patients could not recognize their hand, they uniformly thought that it was someone else's hand. Dissociations in awareness were seen in the second series of 32 patients. Although 23 patients (72%) thought that both arms were in the air, 31% pointed to the correct position of the paralyzed arm on the table. Despite the inability of 24 of 32 patients (75%) to recognize their own hand, 21% of these patients were aware that their arm was weak, and 38% had correctly located their paralyzed arm on the angiography table. *Conclusions:* Anosognosia and asomatognosia are both common during acute dysfunction of the non–language-dominant cerebral hemisphere. Dissociations of perception of location, weakness, and ownership of the affected limb are frequent, as are misperceptions of location and body part identity. The dissociations suggest that multiple mechanisms are involved.

NEUROLOGY 2000;55:816–820

Pick has been credited as the first to report unawareness of hemiplegia,[1] and Babinski first coined the term "anosognosia" for this phenomenon.[2] Subsequently, the term anosognosia has been applied to a broader range of impairments, indicating the inability of a patient to recognize the presence of his or her disease or deficit.[3] Asomatognosia is the inability to recognize one's own body parts.[3] Anosognosia for hemiplegia and asomatognosia for the affected limb have been noted to occur more frequently following right cerebral lesions.[4,5] Studies examining recall of hemiparetic deficits following resolution of unilateral cerebral inactivation via intracarotid barbiturate (i.e., methohexital[6-8] or amobarbital[9,10] in the Wada test support this left/right dichotomy. This left/right asymmetry cannot be explained by aphasia during left cerebral anesthesia.[7] Although the apparent incidence of anosognosia as assessed during recall is altered by amobarbital effects on memory, impairments in recall do not explain the left/right cerebral asymmetry.[9,10] However, the effect of amobarbital in conjunction with temporal lobe memory asymmetries in the epilepsy patients probably produced the lack of left/right asymmetry for recall of anosognosia in a few amobarbital studies.[11,12]

Although evaluation of anosognosia and asomatognosia during left cerebral inactivation is complicated by the presence of aphasia, the effects of right cerebral inactivation via amobarbital are readily assessable. In two studies using methohexital, 100% of the patients exhibited anosognosia during right cerebral inactivation.[13,14] Only one study has examined anosognosia during right cerebral inactivation via amobarbital.[10] Five (56%) of these nine patients were not aware of their left hemiplegia, and three of the four others could not recall their weakness after recovery from the amobarbital. No study has examined asomatognosia during the Wada test. Thus, the relative incidence of these phenomena during acute inactivation by intracarotid amobarbital is unclear. Therefore, we examined the incidence and relative recovery of anosognosia and asomatognosia during right cerebral inactivation by intracarotid amobarbital. In addition, we asked questions in a subset of patients to determine if there was spontaneous recognition of the hemiplegia, awareness of the position of the affected limb, and the presence of confabulations (i.e., misperception and erroneous attribution of limb location or body part identity). These questions were designed to examine the relationship of other forms of awareness to denial of weakness or body part. Specific underlying mechanisms might be implicated if consistent relationships existed between anosognosia and asomatognosia or between these deficits and awareness of limb position or the presence of confabulations.

Methods. The subjects were 62 patients undergoing the intracarotid amobarbital procedure as part of their preop-

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Received December 30, 1999. Accepted in final form June 5, 2000.

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Table 1 *Results of early and late evaluations post right cerebral inactivation via intracarotid amobarbital*

Evaluation	n (%)
Early (n = 62)	
Anosognosia only	7 (11)
Asomatognosia only	6 (10)
Both	42 (68)
Neither	2 (3)
Not assessable	5 (8)
Late (n = 53)	
Anosognosia only	36 (68)
Asomatognosia only	0 (0)
Both	5 (9)
Neither	12 (23)

Table 2 *Relation of verbal and nonverbal knowledge of location*

	Answer to question, "Are both arms in the air?"		
Pointing to paralyzed hand	Correct (n = 7)	Incorrect (n = 23)	No response (n = 2)
Correct to hand on table	2 (29)	7 (30)	1 (50)
Incorrect position	3 (43)	11 (48)	0 (0)
No response	2 (29)	5 (22)	1 (50)

Values expressed as n (%).

erative evaluation for intractable epilepsy. The study was approved by the institutional review board, and subjects gave consent for the procedure. Demographics included: mean age = 34 years (range, 16 to 56); 38 women, 24 men; 57 dextrals, four sinistrals, one ambidextral; 60 with left cerebral language dominance, one with right cerebral language dominance, and one with mixed cerebral language dominance.

Amobarbital was injected by slow hand push into the intracarotid artery following catheterization via a transfemoral approach. The amobarbital dose was 100 mg for each injection in all patients. At the onset of injection, the patients had both hands raised in the air and were counting repetitively from 1 to 20. Eye gaze and language were initially assessed. Subsequent to the testing of anosognosia and asomatognosia described below, memory items were presented, and language was evaluated in greater detail. Further details of our Wada procedure are available elsewhere.[15]

Approximately 30 seconds (range, 20 to 45) following injection of the non–language-dominant hemisphere, the first 30 patients were asked if either arm felt weak. Then, the hand contralateral to the injection was placed into the visual field ipsilateral to the injection, and the patient was asked, "Whose hand is this?" In the second series of 32 patients, they were initially asked, "Are both your arms in the air?" Next, they were requested point to their left hand with their right hand. Then, they were asked, "Is either one of your arms weak?" and if they replied positively, they were asked, "Which one?" Finally, their left hand was placed in the right visual field, and they were asked, "What is this?" Thus, all patients were asked about weakness and identity of the paralyzed limb, but patients in the second series were also asked about limb location and about limb identity in a more open-ended manner. During the questioning, the arm contralateral to the injection was hemiplegic. Motor strength, anosognosia, and asomatognosia were reassessed in 53 of the patients at a mean of 4.3 minutes (range, 2.9 to 6.7 minutes) postinjection.

Results. See tables 1 and 2 for a summary of data. During the initial postinjection evaluation, five (8%) patients were untestable owing to agitation or depressed level of consciousness. Of the five patients who were initially untestable, three later exhibited anosognosia alone and two had both anosognosia and asomatognosia. Therefore, 88% of the patients exhibited anosognosia and 82% displayed asomatognosia at some point during inactivation of the nondominant cerebral hemisphere (i.e., right brain except for the one patient with right cerebral language dominance). When patients could not recognize their own hand, they uniformly thought that it was someone else's hand, usually the examiner's hand. Only two patients (3%) exhibited neither anosognosia nor asomatognosia, and one of these patients had mixed language dominance. During the late follow-up evaluation of 53 patients (2.9 to 6.7 minutes postinjection), the majority of patients had anosognosia alone, and none had asomatognosia alone. Motor strength at this time ranged from 0/5 to 4/5 with a median of 4/5. The distribution of deficits during the early and late evaluations was substantially different (X^2 [3] = 58.53, $p < 0.0001$). The changes in deficits from early to late evaluations were 79% to 61% for anosognosia and 77% to 8% for asomatognosia. Thus, asomatognosia resolved earlier, decreasing dramatically during this time period, whereas the decrease in anosognosia was modest.

In the second series of patients who underwent additional testing (n = 32), most thought that both arms re-

Table 3 *Results of testing in subset of patients in the second series (n = 32)*

Test	n (%)
Both arms in air?	
Yes, both	23 (72)
No	7 (22)
No response	2 (6)
Point to paralyzed hand	
Correct to hand on table	10 (31)
Incorrect	14 (44)
No response	8 (25)
Arms weak? Which?	
Yes, L	7 (22)
Yes, R	5 (16)
No, neither	20 (62)
What is this?	
My hand	8 (25)
Someone else's hand	24 (75)

Table 4 *Relation of anosognosia to other factors*

Factor	Anosognosia	
	Present (n = 25)	Absent (n = 7)
Asomatognosia		
Present	19 (76)	5 (71)
Absent	6 (24)	2 (29)
Arms in air?		
Correct (i.e., not in air)	3 (12)	4 (57)
Incorrect (i.e., yes, in air)	20 (80)	3 (43)
No response	2 (8)	0 (0)
Pointing to paralyzed arm		
Correct to hand on table	6 (24)	4 (57)
Incorrect position	13 (52)	1 (14)
No response	6 (24)	2 (29)

Values expressed as n (%).

Table 5 *Relation of asomatognosia to other factors*

Factor	Asomatognosia	
	Present (n = 24)	Absent (n = 8)
Anosognosia		
Present	19 (79)	6 (75)
Absent	5 (21)	2 (25)
Arms in air?		
Correct (i.e., not in air)	6 (25)	1 (12)
Incorrect (i.e., yes, in air)	16 (67)	7 (88)
No response	2 (8)	0 (0)
Pointing to paralyzed arm		
Correct to hand on table	9 (38)	1 (12)
Incorrect position	10 (42)	4 (50)
No response	5 (21)	3 (38)

Values expressed as n (%).

mained in the air during the acute hemiplegia (table 3). When asked to point to their paralyzed left hand, a minority of patients pointed to the correct position on the table. In the 14 patients who pointed incorrectly, the positions included the original point in the air before injection in seven patients (50%), intermediate positions between the original point and the table in two patients (14%), the shoulder or elbow on the table in two patients (14%), and the right hand in one patient (7%). When asked if either arm was weak, most thought that neither arm was weak. Five (16%) stated that their right arm was weak, but left/right confusion was ruled out by having these patients visually indicate which arm they thought was weak. Thus, a total of 25 of the 32 patients (78%) in this subgroup did not think that their left arm was weak. The majority of patients thought that their left hand was someone else's hand (the examiner's hand in all but two cases).

The presence of asomatognosia did not differ between patients with and without anosognosia (X^2 [1] = 0.06, p = 0.80) (table 4). Similarly, the incidence of anosognosia was not affected by the presence of asomatognosia (X^2 [1] = 0.61, p = 0.80) (table 5). Patients with anosognosia were more likely to think that both arms were still in the air (X^2 [1] = 5.83, $p < 0.02$) and less likely to point to the correct position of the paralyzed hand on the angiography table (X^2 [1] = 3.82, $p < 0.05$) than patients without anosognosia. However, some patients who denied weakness clearly demonstrated knowledge of the altered location of their affected limb. For example, 12% of the patients with anosognosia knew that both arms were not in the air, and 24% pointed to the correct position of the affected limb on the table.

The presence of asomatognosia was not related to verbal (i.e., answering the question "Are both of your arms in the air?") (X^2 [1] = 0.72, p = 0.40) or nonverbal (i.e., pointing) (X^2 [1] = 1.22, p = 0.28) knowledge of the paralyzed limb's location. In fact, nine of the 10 patients who had previously pointed to the correct position of the paralyzed hand had asomatognosia. In contrast, of the eight patients who did recognize their own paralyzed left hand, six (75%) did not know it was weak, and only one (12%) had just been able to point to its correct position on the table. Verbal and nonverbal knowledge of location of the paralyzed limb were unrelated (X^2 [1] = 0.002, p = 0.96) (see table 2).

Discussion. Anosognosia for hemiplegia and asomatognosia are two of the most dramatic behavioral disorders encountered in clinical neurology. As seen in the current study, both are common with acute inactivation of the non–language-dominant cerebral hemisphere. Only two patients (3%) exhibited neither phenomenon during the Wada test, and one of these patients had atypical cerebral lateralization with mixed left/right language representation. Anosognosia and asomatognosia occurred together in most patients, but they were clearly dissociable. Anosognosia was more common than asomatognosia, especially when the hemispheric anesthesia was less dense later in the Wada procedure. When both phenomena were present initially, asomatognosia resolved first and thus appears to usually require a more widespread or complete dysfunction of the nonlanguage cerebral hemisphere. However, asomatognosia did occur in the absence of anosognosia.

Various mechanisms have been postulated to underlie anosognosia. Psychological denial mechanisms[16] based on premorbid personality do not account for the left/right cerebral asymmetries.[4] A simple disconnection hypothesis[17] seems inadequate given that placing the paralyzed left hand into the right visual field does not alleviate the anosognosia.[4] However, performance of the left brain in patients post–corpus callosotomy may not benefit from observing performance of the right brain as evidenced by actions of the left hand.[18] Thus, there may be a special role of the right brain in self-awareness.

Confabulations have been postulated to contribute to anosognosia because they occur frequently in stroke patients with anosognosia.[19,20] Furthermore,

illusory limb movements are associated with degree of anosognosia, hemispatial neglect, and asomatognosia.[20] In the current study, confabulations (i.e., misperceptions and erroneous attribution) of limb position and body part identity were frequent. Also, they were significantly more common in patients with anosognosia, though they occurred in patients without anosognosia as well. Verbal confabulations appeared to be more common than nonverbal confabulations. During the acute hemiplegia, 72% of the patients stated that both arms were still in the air. This phenomenon could be due to a lack of awareness. However, the patients had been informed before the Wada test to expect weakness, and the time of the injection was indicated aloud during the procedure. Nonverbal confabulations were seen in the 44% of patients who pointed incorrectly to the paralyzed hand. Confabulated locations included the original position in the air, intermediate positions between the original position and the table, the contralateral shoulder, and the contralateral elbow on the table. Confabulations concerning the ownership of the paralyzed hand were seen in 75% of patients. When patients could not recognize their hand, they uniformly thought that it was someone else's hand. In contrast, the confabulated identity of the affected hand in stroke patients may be more variable in content. Confabulations cannot be the sole cause of denial, but they may play a role in these phenomena by offering an explanation to the conscious mind, which is unaware of the deficits.

A defect in body schema may contribute to anosognosia and asomatognosia.[21] Neglect syndrome and inattention to the left hemibody and hemispace probably play an important role. Stroke patients have rarely been reported to have denial of hemiplegia without neglect of the left hemibody.[22] In the current study, anosognosia and asomatognosia were frequently concurrent, but they were also dissociable. For example, only 79% of patients with asomatognosia had anosognosia. In addition, 71% of patients without anosognosia had asomatognosia. Such dissociations are much rarer in stroke patients.[20] The differences between Wada and stroke patients may be due to differences in acuteness of the lesion, age of the patients, or exam time allocated for the patient to think about their response.

Knowledge of location, weakness, and personal identity of the affected limb were dissociable. Despite believing that both arms were still in the air during the acute hemiplegia, 30% demonstrated a separate knowledge of the location of the paralyzed hand by pointing to the correct position on the table. Verbal knowledge that both arms were not still in the air was present in 12% of patients with anosognosia. Even more patients had nonverbal knowledge of the paralyzed limb's location: 24% of patients with anosognosia could point to the correct position of the paralyzed hand on the angiography table. In patients who could recognize their own hand, 75% did not know it was weak, 88% thought that both arms were still in the air, and 50% had pointed to an incorrect location of the paralyzed hand. An opposite dissociation was also seen. In the presence of asomatognosia, 21% knew that their arm was weak, 25% knew that both arms were not still in the air, and 38% had previously demonstrated knowledge of location by pointing correctly to the paralyzed hand. In the case of asomatognosia, the knowledge of location was for the position before movement into the opposite visual field. Thus, a lack of proprioceptive feedback might contribute to a patient's inability to recognize their own hand.

A feed-forward or intentional theory of anosognosia posits that there is a failure of detection due to a loss of motor intention and expectancy of movement.[23] Although failure of intention probably contributes to anosognosia, the multiple contrasting dissociations for knowledge of weakness, location, and body part identity seen our study are consistent with the concept that anosognosia may be caused by multiple mechanisms.[19,24] Thus, normal self-awareness appears to be dependent on several parallel processes.[24] In acute hemiplegia, these processes may include inattention to the left hemibody, reduced sensory feedback, impaired intentional mechanisms, a defect in body schema, and a special role of the right brain in self-awareness.

References

1. Gerstmann J. Problem of imperception of disease and of impaired body territories with organic lesions: relation to body scheme and its disorders. Arch Neurol & Psychiat 1942;48: 890–913.
2. Babinski MJ. Contributions a l'etude des troubles mentaux dans l'hemiplegie organique cerebrale (anosognosie). Rev Neurol 1914;12:845–847.
3. Loring DW, ed. INS Dictionary of neuropsychology. New York, NY: Oxford University Press 1999.
4. Heilman KM, Watson RT, Valenstein E. Neglect and related disorders. In: Heilman KM, Valenstein E, eds. Clinical neuropsychology, 3rd edition. New York, NY: Oxford University Press, 1993:279–336.
5. Feinberg TE, Haber LD, Leeds NE. Verbal asomatognosia. Neurology 1990;40:1391–1394.
6. Gilmore RL, Heilman KM, Schmidt RP, Fennell EM, Quisling R. Anosognosia during Wada testing. Neurology 1992;42:925–927.
7. Breier JI, Adair JC, Gold M, Fennell EB, Gilmore RL, Heilman KM. Dissociation of anosognosia for hemiplegia and aphasia during left hemisphere anesthesia. Neurology 1995; 45:65–67.
8. Adair JC, Gilmore RL, Fennell EM, Gold M, Heilman KM. Anosognosia during intracarotid barbiturate anesthesia: unawareness or amnesia for weakness. Neurology 1995;45:241–243.
9. Durkin MW, Meador KJ, Nichols ME, Lee GP, Loring DW. Anosognosia and the intracarotid amobarbital procedure (Wada test). Neurology 1994;44:978–979.
10. Carpenter K, Berti A, Oxbury S, Molyneux AJ, Bisiach E, Oxbury JM. Awareness of and memory for arm weakness during intracarotid sodium amytal testing. Brain 1995;118: 243–251.
11. Terzian H. Behavioral and EEG effects of intracarotid sodium amytal injection. Acta Neurochir (Wein) 1964;12:230–239.
12. Dywan CA, McGlone J, Fox A. Do intracarotid barbiturate injections off a way to investigate hemispheric models of anosognosia. J Clin Exp Neuropsychol 1995;17:431–438.
13. Adair JC, Na DL, Schwartz RL, Fennell EM, Gilmore RL,

Heilman KM. Anosognosia for hemiplegia: test of the personal neglect hypothesis. Neurology 1995;45:2195–2199.
14. Adair JC, Schwartz RL, Na DL, Fennell EB, Gilmore RL, Heilman KM. Anosognosia: examining the disconnection hypothesis. J Neurol Neurosurg Psychiatry 1997;63:798–800.
15. Loring DW, Meador KJ, Lee GP, King DW. Amobarbital effects and lateralized brain function. The Wada test. New York, NY: Springer–Verlag, 1992.
16. Weinstein EA, Kahn RL. Denial of illness. Symbolic and physiological aspects. Springfield, IL: CC Thomas, 1955.
17. Geschwind N. Disconnexion syndromes in animals and man. Brain 1965;88:237–294.
18. Loring DW, Meador KJ, Lee GP. Differential handed response to verbal and visual spatial stimuli: evidence of specialized hemispheric processing following callosotomy. Neuropsychologia 1989;27:818–827.
19. Feinberg TE, Roane DM, Kwan PC, Schindler RJ, Haber LD. Anosognosia and visuoverbal confabulation. Arch Neurol 1994;51:468–473.
20. Feinberg TE, Roane DM, Ali J. Illusory limb movements in anosognosia for hemiplegia. J Neurol Neurosurg Psychiatry 2000;68:511–513.
21. Head H, Holmes G. Sensory disturbances from cerebral lesions. Brain 1911;34:102–254.
22. Bisiach E, Vallar G, Perani D, Papagno C, Buti A. Unawareness of disease following lesions of the right hemisphere: anosognosia for hemiplegia and anosognosia for hemianopsia. Neuropsychologia 1986;24:471–482.
23. Gold M, Adair JC, Jacobs DH, Heilman KM. Anosognosia for hemiplegia: an electrophysiologic investigation of the feedforward hypothesis. Neurology 1994;44:1804–1808.
24. Heilman KM, Barrett AM, Adair JC. Possible mechanisms of anosognosia: a defect in self-awareness. Philos Trans R Soc Lond B Biol Sci 1998;353:1903–1909.

Serum androgens return to normal after temporal lobe epilepsy surgery in men

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Article abstract—*Background:* Epileptic discharges from the temporal lobe may influence the release of hormones from the hypothalamic–pituitary axis. If epilepsy surgery influences the underlying epileptic disorder one might expect serum hormone concentrations to return to normal following surgery. *Patients:* Twenty-two men with epilepsy aged 25 to 48 years (mean, 34.9 years) were investigated before surgery and at 3, 6, and 12 months after surgery. Medication (all patients received carbamazepine) was maintained following surgery. *Methods:* Hormone measurements included luteinizing hormone, follicle stimulating hormone, estradiol, testosterone, free testosterone, androstenedione, prolactin, dehydroepiandrosterone sulfate, cortisol, growth hormone, and sex hormone–binding globulin. These hormone levels were compared with those of 105 healthy men (mean age, 33.9 years). *Results:* Fourteen of the 22 patients (63.6%) achieved total seizure control following epilepsy surgery. The 14 patients with successful seizure control entered further analysis. Before surgery these patients' free testosterone and androstenedione concentrations were significantly lower compared with healthy men. In seven of the 14 patients a significant increase of hormone serum concentrations could be demonstrated for testosterone, free testosterone, and androstenedione. Laterality of epileptic focus, enzyme-inducing medication, stress, and the decreasing number of patients during the follow-up did not correlate with the finding of a normalization of serum androgens. Patients without complete seizure control did not show an increase in serum androgen concentrations. *Conclusion:* Successful temporal lobe epilepsy surgery may lead to a normalization of serum androgen concentrations in men with epilepsy.

NEUROLOGY 2000;55:820–824

Epileptic discharges from the temporal lobe may have influence on the release of hormones from the hypothalamic–pituitary axis.[1,2] This may cause endocrine dysfunction of the peripheral glands.[3] Epilepsy surgery is a well-established therapy for chronic focal epilepsy.[4] Total seizure control is achieved in successfully treated patients.[5] If epilepsy surgery influences the epileptic disorder beyond the manifestation of seizures, one would expect increased or decreased hormone serum concentrations to return to normal following surgery. In order to prove this hypothesis we investigated men with epilepsy prior to surgery and 3, 6, and 12 months after surgery.

Patients and methods. All 22 patients had chronic focal epilepsy intractable to anticonvulsant treatment. All were men, between 25 and 48 years of age (mean, 34.9 years), and received carbamazepine, which was maintained following surgery. Seizure type, type of surgery, and outcome are listed in table 1. Clinical and laboratory inves-

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Received January 20, 2000. Accepted in final form June 5, 2000.

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