

162. Dodrill CB. The Wada Test is not a useful predictor of material-specific memory change following temporal lobe surgery for epilepsy. In JW Miller & DL Silbergeld (Eds.), Epilepsy surgery: Principles and controversies. New York, Taylor & Francis, 2006, pp. 233-238.

Chapter IV-11c: The Wada Test Is Not a Useful Predictor of Material-Specific Memory Change Following Temporal Lobe Surgery for Epilepsy

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INTRODUCTION

In answering the question of predicting memory loss after surgery, one must distinguish between global amnesia and material-specific memory. The reason for the distinction between these two types of memory is because the answers to them are very different.

GLOBAL AMNESTIC SYNDROME

The original purpose of the Wada test with regard to memory was in fact to presage global amnesic losses in memory rather than material specific memory losses (1). That it is successful in this context has been demonstrated with an occasional exception (2-4). In 956 Wada procedures done by the author of this chapter using a recall memory paradigm with testing during drug presence ("Seattle procedure"), there has never been even one case of global amnesic syndrome after surgery without the Wada test clearly warning of this possibility (5). The clear warnings included dramatic failures of more than one type of memory that could hardly be missed. Therefore, it appears that the Wada test is able to presage such losses, at least in the majority of cases.

MATERIAL-SPECIFIC MEMORY LOSSES

The second type of memory pertains to material-specific memory loss, and especially with regard to verbal memory when one is operating on the same side as speech. Memory losses of this type are often very important, even if not truly devastating. This is a far more common problem than global amnesic loss, and, in the experience of the author, it is this type of loss that represents the type of loss where there is the greatest disagreement.

The controversy about whether or not the Wada test is a useful predictor of memory change in this context is best answered by a review of the world's literature on this topic, and this is provided in Table 1. A review of the table reveals that there was some positive finding reported between Wada memory scores and changes in

Table 1 A Comparison of Studies That Report Data on Changes in Material-Specific Memory After Surgery as Related to the Wada Test

Author(s), date(s) (Ref.)	Patients studied	Tests of memory	Wada procedure	Prediction of memory change after surgery using	
				Wada test alone	Wada test with other procedures
Bell et al., 2000 (6)	22 LT focus + L hippocampal sclerosis	WMS Logical Memory	Loring et al. (1994)	Changes in logical memory related to the IAP score arising from the injection <i>ipsilateral</i> to the EEG focus	Not done
Chelune et al., 1993; 1995 (7,8)	63 LT	WMS-R	Cleveland Clinic procedure	Changes in verbal memory related to the IAP score arising from the injection <i>contralateral</i> to the EEG focus	Baseline memory and IAP memory simultaneously made predictions of memory changes after surgery on the left
Chelune and Najm, 2000 (9)	39 LT, 33 RT	WMS-R Verbal Memory Index with reliable change criteria for loss	Cleveland Clinic procedure	Wada memory variables (% recall after ipsilateral and contralateral injections) not evaluated alone in relation to verbal memory loss	Multivariate procedures showed that (1) side of surgery, (2) hippocampal volume ratio, and (3) baseline verbal memory all contributed to a prediction of memory loss. Age, age at seizure onset, sex, and both Wada variables did not significantly contribute to the predictive equation.
Chiaravalloti and Glosser, 2001 (10)	42 right and 28 left	CVLT, Graduate Hospital Facial Memory Test	Glösser et al. (1995)	<i>Asymmetry</i> and IAP injection <i>ipsilateral</i> to the EEG focus related to changes on the CVLT	Not done
Dodrill and Ojemann, 1997 (5)	96 left and 76 right cases	WMS (I)	Three different IAP procedures	Change in memory related to Seattle procedure only and to injection <i>ipsilateral</i> to the EEG focus	Not done

Dodrill et al., 2002 (11)	29 LT, 19 RT (no overlap in sample with Dodrill and Ojemann, 1997)	WMS (I) and AVLT— composite score	Three different IAP procedures	Changes in verbal memory related to the Seattle procedure only, and to the injection <i>ipsilateral</i> to the EEG focus	Baseline verbal memory, side of surgery, and unilateral hippocampal sclerosis on MRI all made independent predictions of memory change (Wada test dropped out)
Jokeit et al., 1997 (12)	27 left cases	WMS-R	German version with 20 items for recognition	IAP pictorial score <i>contralateral</i> to the focus correlated with verbal memory on one story but not on another story	15 variables simultaneously considered showed that level of preoperative memory was related with both stories, and the IAP simultaneously related with one story only
Kneebone et al., 1995 (13)	32 LT, 31 RT	WMS-R	Cleveland Clinic version	LT patients passing memory testing with injection <i>contralateral</i> to EEG focus had more verbal memory loss than those who failed	Not done
Loring et al., 1995 (14)	17 LT, 17 RT, all seizure-free one year postsurgery	WMS-R, selective reminding, complex figure	Use of eight solid objects with postdrug recognition testing with 16 foils and correction for guessing	LT patients only had verbal memory losses if ipsilateral and contralateral Wada memory scores were <i>asymmetric</i>	Not done
Loring et al., 2002 (15)	44 LT patients	WMS-R Logical Memory	Same as Loring (1995)	<i>Asymmetry</i> in Wada memory scores predicted memory change after surgery	Preoperative memory level and Wada asymmetry scores both contributed to changes in memory after surgery
Ojemann and Dodrill, 1987 (16)	20 LT	WMS (I)	Seattle procedure (Dodrill and Ojemann, 1997)	No significant relationship between Wada scores and memory change	Preoperative verbal memory level was related to loss with higher preoperative memory

(Continued)

Table 1 A Comparison of Studies That Report Data on Changes in Material-Specific Memory After Surgery as Related to the Wada Test (*Continued*)

Author(s), date(s) (Ref.)	Patients studied	Tests of memory	Wada procedure	Prediction of memory change after surgery using	
				Wada test alone	Wada test with other procedures
Rausch and Langfitt, 1991 (17)	11 LT, 12 RT	WMS (I)	Procedure with verbal, visual, and general memory items	Wada memory scores obtained with the injection <i>ipsilateral</i> to the EEG focus related to verbal memory change in LT patients only	associated with greater loss; Wada not related to changes in verbal memory Not done
Sabsevitz et al., 2001 (18)	21 LT	WMS-R, Selective Reminding	Loring et al. (1994)	<i>Ipsilateral, contralateral, and asymmetric</i> Wada scores related to SR but not to WMS; <i>asymmetry</i> strongest	Not done
Stroup et al., 2003 (19)	58 LT, 74 RT	CVLT, WMS-R with reliable change criteria for loss	Six solid objects and two pictured objects in a multiple choice recall/recognition paradigm	Wada results not evaluated alone in the prediction of memory loss	Strongest to weakest (but statistically significant) predictors: (1) side of surgery; (2) MRI; (3) delayed verbal memory; (4) Wada (score obtained <i>contralateral</i> to EEG focus); (5) immediate verbal memory
Wyllie et al. (20)	20 L, 17 R	WMS-R	Usual procedure but with an asymmetry memory score in addition to unilateral memory scores	No Wada memory score was significantly related to memory change	Not done

Abbreviations: WMS, Wada memory scores; EEG, electroencephalogram; LT, left temporal; RT, right temporal; SR, selective reminding.

memory after surgery in 12 of the 15 empirical studies found. However, the following observations were also made:

1. In 10 of the 12 studies where a positive finding was reported, only a single positive relationship was found even though several Wada variables and several memory variables had typically been evaluated. In most instances, the positive findings were not clearly beyond those expected by chance.
2. Groups with EEG foci on the right never showed a change in memory after surgery related to a Wada variable.
3. No visual-spatial measure was ever shown to be related to a Wada measure. The only exception was Jokeit et al. (12), but this finding appeared to be the product of chance because of a large number of predictors and a small number of subjects.
4. Regarding the lateralization of the Wada memory variables, there is little consensus with the important variable found to be the injection *contralateral* to the surgery in four studies, *ipsilateral* in four studies, *asymmetry* between the two injections in two studies, and a combination of more than one of these possibilities in two studies. In the remaining three investigations, no relationship between any Wada score and memory change could be demonstrated. Thus, while a number of studies report a relationship between the Wada and memory change after surgery, it is evident that consensus is lacking even as to which injection(s) provide scores that will predict memory change.
5. When the relative potency of the Wada variables and other variables were compared in the prediction of memory change after surgery, the Wada variables were routinely less potent than other variables. In just three papers did the Wada test demonstrate any predictive capability in the presence of even one other predictive variable, and in each of these cases the Wada variables were secondary in predictive power to other non-invasively obtained variables, especially including (i) preoperative memory level, (ii) MRI findings, and (iii) side of surgery (8,15,19). In the other four cases where a comparison had been made between the Wada test and one or more noninvasive variables, the Wada test was inferior to the noninvasive variables. In no case was it shown that the Wada test provided a practically useful enhancement of prediction of memory loss after surgery (such as even a 5% improvement in the identification of at risk patients) when the three noninvasive variables just mentioned were also used.

CONCLUSIONS

The evidence shows that the Wada test likely does help to presage the possibility of a global amnesic syndrome, and in that sense it is useful in the area of memory, even if that adverse outcome rarely occurs. However, in the much more common instance of material-specific memory loss after surgery, there is no convincing evidence that the Wada test is of any practical value, and especially so when its predictive capability is compared with other easily obtained variables. Especially in view of the invasive nature of the Wada test, it is incumbent upon people taking other positions on this point to supply data supporting the contention that the Wada test provides additional useful predictive information when better and noninvasively obtained variables are readily available.

REFERENCES

1. Jones-Gotman M. Commentary: psychological evaluation—testing hippocampal function. In: Engel J Jr, ed. *Surgical Treatment of the Epilepsies*. New York: Raven Press, 1987:203–211.
2. Loring DW, Hermann BP, Meador KJ, Lee GP, Gallagher BB, King DW, Murro AM, Smith JR, Wyler AR. Amnesia after unilateral temporal lobectomy: a case report. *Epilepsia* 1994; 35:757–763.
3. Rausch R, Babb TL, Brown WJ. A case of amnesic syndrome following selective amygdalahippocampectomy. *J Clin Exp Neuropsychol* 1985; 7:643.
4. Barr WB, Schaul N, Decker R, Lantos G. Post-operative amnesia after “passing” memory testing during the intracarotid amytal procedure. *Epilepsia* 1992; 33:138.
5. Dodrill CB, Ojemann GA. An exploratory comparison of three methods of memory assessment with the intracarotid amobarbital procedure. *Brain Cogn* 1997; 33:210–223.
6. Bell BD, Davies KG, Haltiner AM, Walters GL. Intracarotid amobarbital procedure and prediction of postoperative memory in patients with left temporal lobe epilepsy and hippocampal sclerosis. *Epilepsia* 2000; 41:992–997.
7. Chelune GJ, Kneebone AC, Dinner D, Awad IA, Naugle RI. Contributions of the IAP and baseline neuropsychological testing for predicting memory outcome following epilepsy surgery: further support for the “functional adequacy” model of hippocampal function. *J Clin Exp Neuropsychol* 1993; 15:24.
8. Chelune GJ. Hippocampal adequacy versus functional reserve: predicting memory functions following temporal lobectomy. *Arch Clin Neuropsychol* 1995; 10:413–432.
9. Chelune GJ, Najm IM. Risk factors associated with postsurgical decrements in memory. In: Luders HO, Comair Y, eds. *Epilepsy Surgery*. 2nd ed. Philadelphia, PA: Lippincott-Raven, 2000:497–504.
10. Chiaravalloti ND, Glosser G. Material-specific memory changes after anterior temporal lobectomy as predicted by the intracarotid amobarbital test. *Epilepsia* 2001; 42:902–911.
11. Dodrill CB, Ojemann GA, Gordon DS. A simplified method for the prediction of verbal memory change after resection surgery for epilepsy. *Epilepsia* 2002; 43(suppl 7):321.
12. Jokeit H, Ebner A, Holthausen H, Markowitsch HJ, Moch A, Pannek H, Schulz R, Tuxhorn I. Individual prediction of change in delayed recall of prose passages after left-sided anterior temporal lobectomy. *Neurology* 1997; 49:481–487.
13. Kneebone AC, Chelune GJ, Dinner DS, Naugle RI, Awad IA. Intracarotid amobarbital procedure as a predictor of material-specific memory change after anterior temporal lobectomy. *Epilepsia* 1995; 36:857–865.
14. Loring DW, Meador KJ, Lee GP, King DW, Nichols ME, Park YD, Murro AM, Gallagher BB, Smith JR. Wada memory asymmetries predict verbal memory decline after anterior temporal lobectomy. *Neurology* 1995; 45:1329–1333.
15. Loring DW, Meador KJ, Lee GP, Murro A, Park YD, King DW, Lee K, Lee M, Smith JR. Baseline neuropsychological memory performance and Wada memory are independent predictors of memory change after left anterior temporal lobectomy. *Epilepsia* 2002; 43:178.
16. Ojemann GA, Dodrill CB. Intraoperative techniques for reducing language and memory deficits with left temporal lobectomy. In: Wolf P, Dam M, Janz D, Dreifuss FE, eds. *Advances in Epileptology*. New York: Raven Press, 1987; 16:327–330.
17. Rausch R, Langfitt JT. Memory evaluation during the intracarotid sodium amobarbital procedure. In: Luders H, ed. *Epilepsy Surgery*. New York: Raven Press, 1991:507–514.
18. Sabsevitz DS, Swanson SJ, Morris GL III, Mueller WM, Seidenberg M. Memory outcome after left anterior temporal lobectomy in patients with expected and reversed Wada memory asymmetry scores. *Epilepsia* 2001; 42:1408–1415.
19. Stroup E, Langfitt J, Berg M, McDermott M, Pilcher W, Como P. *Neurology* 2003; 60:1266–1273.
20. Wyllie E, Naugle R, Awad I, Chelune G, Luders H, Dinner D, Skibinski C, Ahl J. Intracarotid amobarbital procedure: I. Prediction of decreased modality-specific memory scores after temporal lobectomy. *Epilepsia* 1991; 32(6):857–864.