Driving habits in patients with dementia: a report from Alzheimer's disease assessment units in northern Italy

Marco Mauri, MD[a]
Elena Sinforiani, MD[b]
Maria Giovanna Cuzzoni, MD[a]
Giorgio Bono, MD[a]
Chiara Zucchella, PsyD[b]

[a] Department of Neurology, Circolo Hospital, University of Insubria, Varese, Italy
[b] Alzheimer's Assessment Unit, Laboratory of Neuropsychology, C. Mondino National Neurological Institute, Pavia, Italy

Correspondence to: Elena Sinforiani
E-mail: elena.sinforiani@mondino.it

Summary

The aim of this study was to characterize the driving behavior of a sample of patients with dementia. Demographic and clinical characteristics and parameters considered to be the most significant predictors of driving ability were collected. Of the total 198 patients enrolled, 172 were still driving. Many subjects (30-65%) were found to have modified their driving habits (reducing driving time and mileage, avoiding driving at night and during rush hours, sticking to familiar routes). The patients' own rating of their driving ability was significantly higher than their caregivers' rating (51% versus 29%). Crash history was not a significant variable. The patients' restriction of their driving increased significantly ($p<0.01$) with age and increasing worsening of cognitive, functional and behavioral variables. In the absence of a gold standard for determining fitness to drive, the patients' driving habits were self-regulated and, in particular, regulated by their caregivers. Age and degree of dementia can be considered among the best predictors of driving safety.

KEY WORDS: dementia, driving habits, driving restriction

Introduction

Driving is a complex activity that requires integration of motor, sensory and cognitive circuits.

Over time, aging-related problems, such as eye diseases, hearing impairment, articular pathologies and cognitive deficits, can have a negative impact on driving ability (Carr and Ott, 2010; Ott and Daiello, 2010). With the population continuing to age in many countries, society will be faced with increasing numbers of older drivers. One of the main problems in older drivers is cognitive impairment (Park et al., 2011). Contrary to what one might expect, it has been estimated that around one-third of drivers with dementia continue to drive (Silverstein, 2008), even though they have a two-fold greater crash risk compared with drivers without cognitive impairment (Carr and Ott, 2010). As impairment of driving skills increases progressively with increasing dementia severity, dementia patients will, at some point, become unable to drive safely (Ott et al., 2008; Ott and Daiello, 2010; Barrash et al., 2010). The crucial issue is to establish exactly when and how their difficulties begin. In view of the above considerations, it is important to increase our knowledge of the driving behavior of individuals with cognitive impairment; from this perspective, Alzheimer's disease assessment units are an ideal environment for collecting relevant information and following up patients during the evolution of the disease.
In this observational paper, which is a preliminary report of a more extensive longitudinal project, we describe a set of driving habits in a northern Italian hospital-based sample of patients suffering from dementia.

Materials and methods

Subjects with cognitive disorders, referred to the Alzheimer's disease Assessment Unit at the C. Mondino National Institute of Neurology Foundation, IRCCS, in Pavia, Italy, and the Department of Neurology, Ospedale di Circolo, Varese, Italy, between January and December 2012, were included in the study.
For the purposes of this study we created, *ex novo*, a structured interview covering demographic and clinical characteristics and gathering information about driving ability; the items concerning driving ability were chosen on the basis of parameters previously suggested to be the most significant predictors of driving risk in dementia (Iverson et al., 2010). These items were: avoiding driving alone, sticking to familiar routes, reducing driving time, taking frequent breaks, avoiding driving at night, avoiding driving in rush hours and on highways,

reducing mileage (<100 km/week), impulsive behavior, and situational avoidance (avoiding driving in certain situations). For each parameter a binary choice answer (yes/no) was requested: the higher the number of positive responses, the worse the patient's driving was deemed to be. Each patient completed the interview with the help of his/her own caregiver.

All the patients underwent a standardized neuropsychological examination for the diagnosis of dementia; only the following measures were considered for the data analysis:

- Mini-Mental State Examination (MMSE) (Folstein et al., 1975), to obtain a global cognitive evaluation (scores range from 0 to 30, with lower scores corresponding to higher cognitive impairment);
- Activities of Daily Living (ADL) (Lawton, 1988), to evaluate autonomy in basic everyday activities (scores range from 0 to 6, with higher scores corresponding to higher levels of autonomy);
- Instrumental Activities of Daily Living (IADL) (Lawton and Brody, 1969), to evaluate autonomy in more complex activities (scores range from 0 to 8, with higher scores corresponding to higher levels of autonomy);
- Neuropsychiatric Inventory (NPI) (Cummings et al., 1994), to evaluate the presence and severity of behavioral disorders (scores range from 0 to 144, higher scores corresponding to more severe behavioral disorders);
- Clinical Dementia Rating (CDR) (Hughes et al., 1982), to obtain an index of disease severity (scores range from 0 to 5, with higher scores corresponding to greater severity).

For the ADL and IADL assessments we considered the patients' maintained functions.

The study was carried out in accordance with the code of ethics of the World Medical Association (Declaration of Helsinki).

Statistical analysis

Descriptive statistics such as means and standard deviations were used to characterize the demographic and clinical data. Analysis of variance (ANOVA) and Chi square test were applied to compare patients who were still driving and those who had stopped driving. The relationship between clinical variables and driving behavior was explored using a single multivariate logistic regression analysis. The critical value for statistical significance was set at p=0.05. The Hosmer-Lemeshow goodness-of-fit test for logistic regression was also used. All analyses were carried out using the statistical package SPSS, version 17.0 for Windows (SPSS Inc., Chicago, IL).

Results

Between January and December 2012, 390 subjects with cognitive disorders were observed. Of these, 192 (M/F: 51/141, mean age: 74.8±7.1 years) were excluded from the study because they had never held a driving license, while 198 (M/F: 142/56; mean age: 73.8±8.2 years) had a driving license and were therefore enrolled. Of these, 184 (93%) were retired, while 14 (7%) were housewives. They had the following diagnoses: Alzheimer's disease: 106 cases; Alzheimer's disease plus vascular signs: 37 cases; Lewy body dementia and other parkinsonisms: 30 cases; frontotemporal dementia: 7 cases; vascular dementia: 18 cases. Eighteen patients (9%) had motor deficits and 12 (6%) had sensory deficits (hearing loss and reduction of visual acuity), even though these were not severe enough to compromise their ability to drive. Only three patients had a history of alcohol abuse. The patients had held a driving license for a mean of 45.8±6.9 years.

Of the 198 patients included in the study, 159 (80%), all with Alzheimer's disease or Lewy body dementia, were receiving acetylcholinesterase inhibitors and/or memantine; only 10% were taking centrally acting drugs (benzodiazepines, antidepressants, antipsychotics).

Of the 198 patients, 172 (87%; M/F: 122/50) (group 1) were still driving, while 25 (13%; M/F: 19/6) (group 2) had stopped driving spontaneously. A single subject, whose driving license had been revoked, was excluded from the study. The main clinical characteristics of groups 1 and 2 are reported in table I. The group 2

Table I - Clinical characteristics of a population of elderly dementia patients divided into those still driving (group 1) and those no longer driving (group 2): ANOVA results (mean±SD).

	Group 1 172 cases	Group 2 25 cases	F	p
Males/Females	122/50	19/6	–	–
Age (years)	73.2±6.2	76.3±4.0	15.636	0.00001
Schooling (years)	7.3±3.2	7.2±3.2	0.021	n.s.
Disease duration (months)	23.2±12.8	37.8±20.7	24.446	0.00001
Concomitant pathologies	1.2±0.9	1.6±1.1	4.381	0.03
MMSE	21.8±3.5	16.4±1.1	45.876	0.00001
CDR	1.2±0.4	1.5±0.5	34.584	0.00001
ADL	5.7±0.6	5.2±0.8	13.131	0.00001
IADL	5.6±1.4	4.4±1.6	15.473	0.00001
NPI	4.8±2.6	4.7±2.9	0.043	n.s.

Abbreviations: MMSE=Mini-Mental State Examination; CDR=Clinical Dementia Rating; ADL=Activities of Daily Living (maintained functions); IADL=Instrumental Activities of Daily Living (maintained functions); NPI=Neuropsychiatric Inventory

subjects were older and had a longer disease duration and a more severe degree of dementia than the group 1 patients; no patient in group 2 had a crash history.

The driving behavior of the group 1 subjects was analyzed using the structured interview, considering whether or not the patients adopted avoidance behaviors or practices that restricted their driving. It emerged that 60 patients (35%) never drove alone, 98 (57%) only drove familiar routes, 94 (54%) had reduced their driving time, 32 (18%) took frequent breaks when driving, 112 (65%) avoided driving at night, 46 (27%) avoided driving during rush hours and 93 (54%) on highways, 125 (73%) had reduced their mileage (<100 km/week), 46 (27%) showed impulsive behavior when driving and 48 (28%) situational avoidance. Table II shows the mean scores recorded on the different scales (MMSE, ADL, IADL, NPI, CDR) which investigated whether (yes) or not (no) the patients adopted avoidance behaviors or driving restriction practices; the results of the ANOVA showed that the subjects who adopted such behaviors and practices were significantly more impaired on the cognitive, functional and

Table II - ANOVA results (mean±SD) in elderly dementia patients who still drive (group 1).

	MMSE		ADL		IADL		NPI		CDR	
	yes	no	yes	no	yes	no	yes	no	yes	no
Never driving alone (60/112)	21.3±3.4	22.2.±3.5	5.6±0.5	5.7±0.6	5.4±1.3	5.7±1.4	5.3±2.3	4.5±2.7	0.97±0.3	0.91±0.3
Sticking to familiar routes (94/78)	21.3±3.4°	22.5±3.5	5.6±0.6	5.8±0.6	5.5±1.4	5.7±1.4	5.4±2.6#	4.1±0.6	1.00±0.3°	0.85±0.3
Reducing driving time (94/78)	20.9±3.3*	23.1±3.4	5.6±0.5	5.8±0.6	5.4±1.3	5.7±1.3	5.4±2.5°	4.2±2.6	1.10±0.3*	0.77±0.3
Taking frequent breaks (32/140)	19.6±3.1*	22.4±3.4	5.4±0.6	5.7±0.6	4.7±1.2*	6.0±1.3	5.5±2.3	4.7±2.6	1.21±0.3*	0.87±0.3
Avoiding driving at night (112/60)	21.2±3.7*	23.3±2.7	5.6±0.5	5.8±0.6	5.6±1.5	5.8±0.9	5.0±2.5	4.4±2.7	1.04±0.3*	0.74±0.3
Avoiding driving in rush hours (46/126)	19.2±2.9*	22.9±3.2	5.5±0.5	5.8±0.6	4.6±1.2*	6.2±1.2	4.9±2.0	4.8±2.8	1.20±0.3*	0.84±0.3
Avoiding driving on highways (93/79)	21.2±3.4°	22.7±3.5	5.6±0.6	5.8±0.5	5.3±1.4#	6.1±1.3	5.4±2.5#	4.2±2.6	1.03±0.3*	0.82±0.3
Reducing mileage (<100 km/week) (125/47)	21.6±3.7	22.7±2.6	5.6±0.6	5.8±0.5	5.6±1.5	5.7±0.8	4.9±2.5	4.6±2.9	0.98±0.3°	0.81±0.3
Impulsive behavior (46/126)	21.7±3.0	21.9±3.6	5.5±0.6	5.7±0.6	5.1±1.2§	5.8±1.4	5.5±2.6	4.6±2.6	0.94±0.4	0.93±0.3
Situational avoidance (48/124)	20.8±2.8§	22.3±3.7	5.4±0.7	5.8±0.6	4.8±1.2*	6.0±1.4	5.9±2.5#	4.4±2.6	1.12±0.2*	0.86±0.4
Crash history (9/163)	21.8±1.5	21.8±3.6	5.5±0.7	5.7±0.6	5.0±1.4	5.7±1.4	6.7±2.4§	4.7±2.6	1.00±0.2	0.94±0.4

The numbers in brackets in the first column refer to the numbers of patients answering yes/no. ° p<0.005; § p<0.01; # p<0.001; * p<0.0001

behavioral measures than the subjects who did not adopt them; no significance was reported for ADL. Only nine subjects (5%) had a previous crash history, in all cases without significant consequences. These crashes had been caused by: topographical disorientation (1 case), lane deviation (2 cases), decreased comprehension of traffic signs (3 cases), incorrect turning (2 cases), incorrect signaling (1 case).

The relationship between clinical variables and driving habits was evaluated using a single multivariate logistic regression analysis. The results (significance, odds ratio and 95% confidence interval) are reported in table III. None of the variables analyzed using the Hosmer-Lemershov test reached statistical significance (Table IV).

In order to obtain a global index of driving difficulties, we selected the cases with positive responses on more than three of the interview items (parameters indicated as the most significant predictors of driving ability); significant correlations were found with age, and with MMSE, CDR, IADL and NPI scores, as reported in tables III and IV.

The decision to avoid certain situations or adopt driving restriction behaviors was taken mainly by caregivers (in about 65% of all the cases). The patients' own rating of their driving ability was significantly high-

Table III - Single multivariate logistic regression. Driving behavior versus clinical and demographic variables: level of significance/OR and (95% CI).

	Age	Sex	CDR	MMSE	IADL	NPI
Never driving alone	0.02/1.22 (1.07-1.38)	n.s.	0.01/1.26 (1.13-1.57)	0.02/1.21 (1.11-1.42)	0.006/1.52 (1.30-2.23)	n.s.
Sticking to familiar routes	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Reducing driving time	0.006/1.71 (1.4-2.45)	0.02/1.18 (1.06-1.55)	n.s.	n.s.	n.s.	0.04/1.12 (1.06-1.41)
Taking frequent breaks	0.04/1.14 (1.05-1.31)	0.03/1.30 (1.04-2.06)	n.s.	n.s.	0.03/1.16 (1.08-1.52)	n.s.
Avoiding driving at night	n.s.	n.s.	0.03	0.04	n.s.	0.04/1.26 (1.02-1.45)
Avoiding driving in rush hours	0.02/1.19 (1.07-1.28)	n.s.	n.s.	n.s.	0.01/1.46 (1.16-1.97)	n.s.
Avoiding driving on highways	0.02/1.13 (1.02-1.24)	n.s.	n.s.	0.04	0.01/1.42 (1.11-1.94)	0.006/1.66 (1.24-2.35)
Reducing mileage (<100 km/week)	n.s.	n.s.	0.04/1.12 (1.04-1.54)	n.s.	n.s.	0.04/1.14 (1.06-1.53)
Impulsive behavior	n.s.	n.s.	n.s.	n.s.	0.04/1.18 (1.12-1.54)	n.s.
Situational avoidance	0.01/1.20 (1.08-1.49)	n.s.	n.s.	n.s.	n.s.	n.s.
Crash history	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
More than 3 positive variables	0.04/1.19 (1.03-1.31)	n.s.	0.02 /1.30 (1.19-1.93)	0.03/1.18 (1.13-1.42)	0.04/1.20 (1.15-1.44)	0.01/1.40 (1.17-1.82)

Table IV - Results of the Hosmer-Lemershov test.

	Chi-square	Sig
Never driving alone	7.42	.492
Sticking to familiar routes	9.84	.276
Reducing driving time	6.15	.631
Taking frequent breaks	5.83	.666
Avoiding driving at night	7.32	.502
Avoiding driving in rush hours	0.75	.999
Avoiding driving on highways	7.1	.526
Reducing mileage (<100 km/week)	9.06	.337
Impulsive behavior	10.64	.223
Situational avoidance	3.61	.890
Crash history	0	1

er than the caregivers' rating: 87 patients and 49 caregivers did not report any problems with the patients' driving (51% versus 29%).
Pharmacological treatment did not significantly interfere with driving ability.

Discussion

This aim of this study, which set out to characterize the driving habits of a sample of cognitively impaired subjects, showed that most patients with dementia continue to drive, albeit with some limitations. The second finding is that, in the absence of standardized rules, the decision to restrict patients' driving is made mainly by their caregivers. Self-regulation has often been suggested to be a coping strategy that may allow older drivers to drive safely for longer (Wong et al., 2012). Many factors have been found to affect self-regulation of driving and these include age, sex, physical functioning, and driving-related discomfort (Kostyniuk and Molnar, 2008; Meng and Siren, 2012). A linear relationship between discomfort in driving and avoidance has been found and it tended to be stronger for drivers recognizing their own cognitive problems (Meng and Siren, 2012). On the other hand, it is well known that patients' insight is inversely related to their degree of cognitive impairment; indeed, the patients in our sample overestimated their driving ability. These data further confirm the importance of the caregiver's role: the caregiver's risk estimate is probably one of the key factors (more important than previous accidents or losing one's license) determining whether or not patients give up driving or modify their driving behavior (Seiler et al., 2012).
Driving avoidance/restriction correlated significantly with age and cognitive, functional and behavioral parameters, but not with ADL-rated functional ability, which was almost completely preserved given that our patients were in the mild-moderate stages of the disease. Moreover, our patients did not present severe behavioral disorders, as shown by the low scores on the NPI. Taken together, these data may explain why we found a very low rate of crashes and only one case in which a driving license had been revoked. As a consequence, in accordance with literature data (Ott et al., 2008; Carr and Ott, 2010; Ott and Daiello, 2010), we argue that age and dementia severity can be considered among the best predictors of driving ability.
As recently reported in another Italian population (Rozzini et al., 2013) and confirmed by epidemiological reports (Ministry of Transport data divulged by the Press Office, Italian Automobile Club of Milan, 2008), we found a very marked prevalence of males among the subjects who had previously obtained a driving license, while the majority of those who had never held a driving license were females. These data, related to demographic and social factors, reflect the situation of Italian people born in the 1920s, 1930s and early 1940s, and are obviously destined to change over the coming years: the number of elderly women holding a driving license and still driving will increase significantly, as will the age of subjects still driving; moreover, there will be an increasing number of elderly people needing to continue driving for as long as possible. Therefore, we should already be preparing to manage situations different from those we see today.
In elderly subjects, and in dementia patients in particular, the crucial issue is to address when and how difficulties begin and therefore to establish whether or not restrictive measures should be applied. A recent Cochrane review (Martin et al., 2009) concluded that the available literature failed to demonstrate the benefit of driver assessment either for preserving mobility or for reducing motor vehicle accidents. Many authors have tried to identify predictors of safe driving and a correlation between car crash involvement and impaired executive skills has been reported (Brown et al., 2005; Grace et al., 2005; Dawson et al., 2009; Carr and Ott, 2010; Barrash et al., 2010, Ott et al., 2013). Recently, Rozzini et al. (2013) proposed a simple and standardized neuropsychological battery as a good diagnostic instrument for reducing risks associated with driving in the elderly. In 2010, after a review of the literature, the Quality Standards Subcommittee of the American Academy of Neurology published a practice parameter update on driving and dementia (Iverson et al., 2010), on which we based the structured interview used in this study. However, there are still no commonly used methods of assessing dementia severity in relation to driving, no consensus on the assessment of older drivers with cognitive impairment, and no gold standard for determining fitness to drive. Consequently, there is a need for specific instruments and structured interviews capable of selecting subjects cognitively competent enough to continue driving safely, albeit subject to certain restrictions.
As mentioned in the introduction, this study is a preliminary report. Despite some weaknesses (the use of a new structured interview and the subjective criterion adopted to quantify driving difficulties), the study contributes to this area of research by providing additional information about the current situation of people with dementia in the mild-moderate stages. This study is ongoing: further aims are to obtain a well-defined cognitive profile of these patients and to identify a common diagnostic procedure.

References

Barrash J, Stillman A, Anderson SW, et al (2010). Prediction of driving ability with neuropsychological tests: demographic adjustment diminish accuracy. J Int Neuropsychol Soc 16:679-686.

Brown LB, Ott BR, Papandonatos GD, et al (2005). Prediction of on-road driving performance in patients with early Alzheimer's disease. J Am Geriatr Soc 53:94-98.

Carr DB, Ott BR (2010). The older adult driver with cognitive impairment. "It's a very frustrating life". JAMA 303: 1632-1641.

Cummings JL, Mega M, Gray K, et al (1994). The Neuropsychiatric Inventory: comprehensive assessment of psychopathology in dementia. Neurology 44:2308-2314.

Dawson JD, Anderson SW, Uc EY, et al (2009). Predictors of driving safety in early Alzheimer disease. Neurology 72:521-527.

Folstein MF, Folstein SE, McHugh PR (1975). "Mini-mental state." A practical method for grading the cognitive status of patients for the clinician. J Psychiatr Res 12:189-198.

Grace J, Amick MM, D'Abreu A, et al (2005). Neuropsychological deficits associated with driving performance in Parkinson's and Alzheimer's disease. J Int Neuropsychol Soc 11:766-775.

Hughes CP, Berg L, Danziger WL, et al (1982). A new clinical scale for the staging of dementia. Br J Psychiatry 140:566-572.

Iverson DJ, Gronseth GS, Reger MA, et al (2010). Practice parameter update: evaluation and management of driving risk in dementia: report of the Quality Standards Subcommittee of the American Academy of Neurology. Neurology 74:1316-1324.

Kostyniuk LP, Molnar LJ (2008). Self-regulatory driving practices among older adults: health, age and sex effects. Accid Anal Prev 40:1576-1580.

Lawton MP (1988). Scales to measure competence in everyday activities. Psychopharmacol Bull 24: 609-614.

Lawton MP, Brody EM (1969). Assessment of older people: self-maintaining and instrumental activities of daily living. Gerontologist 9:179-186.

Martin AJ, Marottoli R, O'Neill D (2009). Driving assessment for maintaining mobility and safety in drivers with dementia. Cochrane Database Syst Rev (1): CD006222.

Meng A, Siren A (2012). Cognitive problems, self-rated changes in driving skills, driving-related discomfort and self-regulation of driving in old drivers. Accid Anal Prev 49:322-329.

Ott BR, Heindel WC, Papandonatos GD, et al (2008). A longitudinal study of drivers with Alzheimer disease. Neurology 70:1171-1178.

Ott BR, Daiello LA (2010). How does dementia affect driving in older patients? Aging Health 6:77-85.

Ott BR, Davis JD, Papandonatos GD, et al (2013). Assessment of driving-related skills prediction of unsafe driving in older adults in the office setting. J Am Geriatr Soc 61:1164-1169.

Park SW, Choi ES, Lim MH, et al (2011). Association between unsafe driving performance and cognitive-perceptual dysfunction in older drivers. PM R 3:198-203.

Rozzini L, Riva M, Zanetti M, et al (2013). The impact of cognitive deficit on self-reported car crashes in ultra-octogenarian population: data of an Italian population-based study. Int J Geriatr Psychiatry 28:562-566.

Seiler S, Schmidt H, Lechner A, et al (2012). Driving cessation and dementia: results of the prospective registry on dementia in Austria (PRODEM). PLoS One 7:e52710.

Silverstein NM (2008). Alzheimer's disease and fitness to drive. In: Eby DW, Molnar LJ (Eds.), North American License Policies Workshop Proceedings. Washington, DC, AAA Foundation for Traffic Safety, pp. 71-85.

Wong IY, Smith SS, Sullivan KA (2012). The relationship between cognitive ability, insight and self-regulatory behaviors: findings from the older driver population. Accid Anal Prev 49:316-321.