Alzheimer’s Disease and Driving: From Preclinical to Postmortem

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DISCLOSURES (2015-Present)

- Research Funding Support
  - NIA/NEI
  - Missouri Department of Transportation
  - The Rehabilitation Institute St. Louis
  - State Farm
- Consulting Relationships
  - AAAFTS
  - TIRF
  - Medscape
  - University of Toronto
  - AGS
- Speakers Bureau
  - St. Louis Alzheimer’s Association
- Medical Director
  - The Rehabilitation Institute of St. Louis/Parc Provence
- Drug Industry Trials/Investment/Stock/Equity
  - None
LECTURE OBJECTIVES

Review the prevalence and crash risk of driving with dementia

Know the recommended clinical steps in evaluating drivers with dementia

Review the latest evidence as to whether preclinical AD is associated with impaired driving
Case-Based Approach

• An 83 year old female presents with early AD
• Daughter raises concerns about driving given mother’s slowed reaction time, medications, and other medical conditions
• PMH: HTN, Type II DM, Anxiety Disorder (GAD)
• Medications:
  Atenolol 50mg BID,
  Metformin 500g BID
  Alprazolam .25 TID
  Sertraline 25mg QD
Older Driver Stats

- Aging Demographics
  - 2013
    - 46 Million Older Adults (5.5 >85)
    - 37 Million Licensed Drivers (3>85)
  - 2050
    - 86 Million Older Adults (10 >85)
    - 66 Million Licensed Drivers (6>85)

- Motor Vehicle Crashes
  - 2013
    - 5,671 older adults were killed
    - 222,000 were injured
    - 15 older adults killed and 600 injured in crashes on average every day

https://www.fhwa.dot.gov/policyinformation/pubs/hf/pl11028/chapter4.cfm
http://www.iii.org/issue-update/older-drivers
INCREASE CRASH RISK WITH AGING: WHY?

Figure 3: Accident Involvement Rate Age Group Comparison by Licensed Drivers and Vehicle Miles Traveled

Avg Crash Rate AD/dements 2x controls

http://search.cga.state.ct.us/dtSearch_lpa.html
Carr DB. Motor Vehicle crashes and drivers with DAT. Alzheimer Disease and Associated Disorders 1997; 11(S):38-41.
THE “HIGH RISK” OLDER ADULT PROFILE

Langford J, et al. 2006 Accident Analysis and Prevention, 28(3), pp. 574-578
DEMENTIA AND DRIVING: HOW COMMON?

- **DESIGN:** Retrospective cohort data community-based study of dementia.
- The Honolulu Heart Program and the Honolulu-Asia Aging Study.
- **PARTICIPANTS:** A total of 643 men who were evaluated for the presence of Alzheimer's disease or other dementia between the fourth and the fifth examination of the Honolulu Heart Program.
- **CONCLUSIONS:** Dementia is a major cause of driving cessation.


Which Lobes are Key For Driving?

How does dementia affect driving in AD?

Ott BR and Daniello LA. Aging Health 2010; 6: 77-85

Figure 1. Two major visual processing pathways of the brain.

Amy: Amygdala; Ant: Anterior; Aud: Auditory pathway; Cing: Cingulate gyus; DLF: Dorsolateral frontal cortex; EF: Frontal eye fields; Hip: Hippocampus; Hyp: Hypothalamus; IpL: Inferior parietal lobule; It: Inferotemporal visual cortex; LC: Locus ceruleus; OF: Orbital frontal cortex; Post: Posterior; RF: Reticular formation; Som: Somesthetic pathway; Vis 1: Ventral visual pathway; Vis 2: Dorsal visual pathway. Reprinted with permission from [14].
Algorithm: Evaluating Driving Risk

Fitness to Drive Steps

- **Step 1:** Driving History and Med Review
- **Step 2:** Examine Co-Morbidities
- **Step 3:** Physical Examination
- **Step 4:** Rate Primary Disease Severity
- **Step 5:** Referral, Rehab, and/or Counseling
Step 1: Driving History

- Driving Behaviors (lost)
- Informant Rating (fair)
- Exposure (low)
- Personality (no change)
- Violations (none)
- Crashes (none)
### Signs of Unsafe Driving: At the Crossroads

(*stop driving immediately)

<table>
<thead>
<tr>
<th>Driving Behavior Warning Signs</th>
<th>When Noticed, How Often</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Decrease in confidence while driving</td>
<td>16. Uses a “copilot”</td>
</tr>
<tr>
<td>2. Difficulty turning to see when backing up</td>
<td>17. Bad judgment on making left hand turns</td>
</tr>
<tr>
<td>3. Riding the brake</td>
<td>18. Near misses</td>
</tr>
<tr>
<td>4. Easily distracted while driving</td>
<td>19. Delayed response to unexpected situations</td>
</tr>
<tr>
<td>5. Other drivers often honk horns</td>
<td>20. Moving into wrong lane</td>
</tr>
<tr>
<td>7. Difficulty parking within a defined space</td>
<td>22. Confusion at exits</td>
</tr>
<tr>
<td>8. Hitting curbs</td>
<td>23. Ticketed moving violations or warnings</td>
</tr>
<tr>
<td>9. Scratches or dents on the car, mailbox or garage</td>
<td>24. Getting lost in familiar places</td>
</tr>
<tr>
<td>10. Increased agitation or irritation when driving</td>
<td>25. Car accident</td>
</tr>
<tr>
<td>11. Failure to notice important activity on the side of the road</td>
<td>26. Failure to stop at stop sign or red light</td>
</tr>
<tr>
<td>12. Failure to notice traffic signs</td>
<td>27. Confusing the gas and brake pedals*</td>
</tr>
<tr>
<td>13. Trouble navigating turns</td>
<td>28. Stopping in traffic for no apparent reason*</td>
</tr>
<tr>
<td>14. Driving at inappropriate speeds</td>
<td>29. Other signs:</td>
</tr>
<tr>
<td>15. Not anticipating potential dangerous situations</td>
<td></td>
</tr>
</tbody>
</table>

[http://www.thehartford.com/advance50/publications-on-aging](http://www.thehartford.com/advance50/publications-on-aging)
### Table 2: Driver safety errors in Alzheimer disease (AD) and normal control groups

<table>
<thead>
<tr>
<th>Safety errors</th>
<th>AD (n = 40)</th>
<th>Controls (n = 115)</th>
<th>p Values for difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Crude</td>
<td>Age- and gender-adjusted</td>
<td></td>
</tr>
<tr>
<td>Starting and pulling away from curve</td>
<td>1.08 (0.97)</td>
<td>1.09 (0.81)</td>
<td>0.7097</td>
</tr>
<tr>
<td>Traffic signals</td>
<td>2.35 (1.56)</td>
<td>2.18 (1.56)</td>
<td>0.5101</td>
</tr>
<tr>
<td>Stop signs</td>
<td>3.80 (1.98)</td>
<td>3.61 (1.89)</td>
<td>0.7610</td>
</tr>
<tr>
<td>Other signs</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>—</td>
</tr>
<tr>
<td>Turns</td>
<td>6.50 (3.09)</td>
<td>5.44 (2.79)</td>
<td>0.0838</td>
</tr>
<tr>
<td>Lane observance</td>
<td>17.03 (11.00)</td>
<td>10.84 (7.77)</td>
<td>0.0003</td>
</tr>
<tr>
<td>Lane change</td>
<td>5.75 (2.86)</td>
<td>5.00 (2.75)</td>
<td>0.1253</td>
</tr>
<tr>
<td>Overtaking</td>
<td>0.10 (0.38)</td>
<td>0.15 (0.46)</td>
<td>0.5075</td>
</tr>
<tr>
<td>Control of speed</td>
<td>4.03 (2.71)</td>
<td>3.56 (2.79)</td>
<td>0.2634</td>
</tr>
<tr>
<td>Backing up</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>—</td>
</tr>
<tr>
<td>Parallel parking</td>
<td>0.38 (0.49)</td>
<td>0.37 (0.52)</td>
<td>0.8172</td>
</tr>
<tr>
<td>Head-in parking</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>—</td>
</tr>
<tr>
<td>Curves</td>
<td>0.00 (0.00)</td>
<td>0.01 (0.09)</td>
<td>0.5653</td>
</tr>
<tr>
<td>Railroad crossing</td>
<td>0.03 (0.16)</td>
<td>0.19 (0.58)</td>
<td>0.1115</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>0.98 (1.03)</td>
<td>0.73 (1.05)</td>
<td>0.0859</td>
</tr>
<tr>
<td>Total safety errors</td>
<td>42.00 (12.84)</td>
<td>33.18 (12.22)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Total more serious errors</td>
<td>4.35 (2.97)</td>
<td>1.90 (1.59)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Total less serious errors</td>
<td>37.65 (11.66)</td>
<td>31.26 (11.49)</td>
<td>0.0009</td>
</tr>
</tbody>
</table>

Groups were compared using Wilcoxon rank sum for crude p values and multiple linear regression for adjusted p values.
Step 1: MEDICATION REVIEW

- Narcotics
- Barbituates
- Benzo’s (present)*
- Antihistamines
- Antidepressants
- Antipsychotics
- Hypnotics
- Alcohol
- Muscle Relaxants
- Antiemetics
- Antiepileptic

Hetland A, Carr DB. Medications and Impaired Driving. Annals of Pharmacology 2014; 48(4): 494-506,
Step 2: Co-Morbid Conditions
Clinician Medical Guidelines

Updated, Evidenced-Based
Also Refer to Your Own State Laws/Statutes

Hypersomnolence/Epworth Sleepiness Scale >10,
Depression/PHQ >10, Visual Acuity OU 20/40

OUR CASE: ESS 8, PHQ 12, VA 20/40 corr, HgbA1C 6.5

http://www.cma.ca/driversguide
http://geriatricscareonline.org
http://www.austroads.com.au
Step 3: Physical Examination

- Visual Acuity
- Visual Fields
- Motor Examination
  - Muscle Strength
  - Range of Motion
- Cognitive/Functional Testing
  - Clock Drawing Task
  - Trail Making Tests A/B
- Functional History
  - IADL’s/AD-8
## Computerized Tests of Driving Performance

The DrivingHealth Inventory with UFOV/DriveABLE

<table>
<thead>
<tr>
<th>Task Description</th>
<th>Peak Validity Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visualization of missing information (MFVPT; Visual Closure)</td>
<td>4.96</td>
</tr>
<tr>
<td>Directed visual search (Trail-Making B)</td>
<td>3.50</td>
</tr>
<tr>
<td>Working memory (Delayed Recall)</td>
<td>2.92</td>
</tr>
<tr>
<td>Information processing speed (Useful Field of View, subtest 2)</td>
<td>2.48</td>
</tr>
<tr>
<td>Lower limb strength (Rapid Pace Walk)</td>
<td>2.64</td>
</tr>
<tr>
<td>Head/neck flexibility (Recognizing Clock Time)</td>
<td>2.56</td>
</tr>
</tbody>
</table>

Staplin L, et al. MaryPODS revisited.  

Dobbs AR. Accuracy of DriveABLE.  
*Canadian Family Practice 2013: 59: e158-161.*
## Probability of Failing Road Test: Dementia

### Table 4. Predictive Values of Neuropsychological Tests and Test Batteries for Road Test Performance

<table>
<thead>
<tr>
<th>Test(s)</th>
<th>Sample</th>
<th>Outcome measure</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computerized mazes&lt;sup&gt;104&lt;/sup&gt;</td>
<td>Normal + AD (CDR .5-1)</td>
<td>Road test</td>
<td>NA</td>
<td>NA</td>
<td>68.6</td>
</tr>
<tr>
<td>Computerized mazes + Hopkins Verbal Learning+Age&lt;sup&gt;104&lt;/sup&gt;</td>
<td>Normal + AD (CDR .5-1)</td>
<td>Road test</td>
<td>NA</td>
<td>NA</td>
<td>81.0</td>
</tr>
<tr>
<td>Maze Navigation&lt;sup&gt;105&lt;/sup&gt;</td>
<td>Normal + AD (CDR .5)</td>
<td>Road test</td>
<td>NA</td>
<td>NA</td>
<td>80.0</td>
</tr>
<tr>
<td>Maze Task&lt;sup&gt;106&lt;/sup&gt;</td>
<td>MCI + mild AD</td>
<td>Road test</td>
<td>77.8</td>
<td>82.4</td>
<td>77.4</td>
</tr>
<tr>
<td>Driving Scenes of Neuropsychological Assessment Battery&lt;sup&gt;107&lt;/sup&gt;</td>
<td>Normal + AD (CDR .5)</td>
<td>Road test</td>
<td>NA</td>
<td>NA</td>
<td>66.0</td>
</tr>
<tr>
<td>Eight test battery&lt;sup&gt;108&lt;/sup&gt;</td>
<td>Mixed dementia</td>
<td>Road test</td>
<td>80.0</td>
<td>61.5</td>
<td>76.2</td>
</tr>
</tbody>
</table>

Carr DB, Ott B. *JAMA*, 2011

SYSTEMIC REVIEWS/META-ANALYSIS

Systematic review of the evidence for Trails B cut-off scores in assessing fitness-to-drive

Mononita Roy, MD, FRCPC,1,2 Frank Molnar, MSc, MDCM, FRCPC1-6

Review of 47 Driving Studies Using Trailmaking B “Verified” use of 3 minutes or 3 errors rule


The Clinical Utility of the Trail Making Tests As Predictors of Driving Performance in Older Adults

George D. Papandonatos, PhD1, Brian R. Ott, MD2, Jennifer D. Davis, PhD3, Peggy P. Barco, OTD4, and David B. Carr, MD5

Review of 3 datasets between Brown Research and WU OT database suggests referral > TMT-A 70 secs
**STEP 4: Rating Dementia Severity**

<table>
<thead>
<tr>
<th>Clinical Measure of Dementia Severity</th>
<th>No Dementia (CDR=0)</th>
<th>Questionable or Very Mild Dementia (CDR=0.5)</th>
<th>Mild Dementia (CDR=1.0)</th>
<th>Moderate to Severe Dementia (CDR=2.0)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>For the Dementia Specialist:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clinical Dementia Rating</td>
<td>No memory loss or inconsistent memory loss</td>
<td>Consistent slight forgetfulness</td>
<td>Memory loss interferes with everyday activities</td>
<td>Severe memory loss</td>
</tr>
<tr>
<td></td>
<td>Fully oriented Judgment intact</td>
<td>Slight difficulty with orientation or judgment</td>
<td>Geographic disorientation</td>
<td>Severe difficulty with time relationships and judgment</td>
</tr>
<tr>
<td></td>
<td>Function intact</td>
<td>Slight impairment in community activities or home activities</td>
<td>Moderate impairment in judgment</td>
<td>No longer independent in activities</td>
</tr>
<tr>
<td></td>
<td>Personal care intact</td>
<td>Personal care intact</td>
<td>Mild but definite impairment of community or home activities</td>
<td>Only simple chores preserved</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Needs prompting for personal care</td>
<td>Needs assistance in personal effects</td>
</tr>
</tbody>
</table>

| **For the Clinician:**               |                     |                                           |                         |                                      |
| Short Blessed Test                   | 1.2 (1.9)*          | 4.8 (5.9)##                              | 15.4 (5.2)#             | 18.5 (5.5)#                          |
| Mini-Mental Status Exam              | 28.9 (1.3)#         | 23.1 (2.5)@                              | 20 (3.9)#               | 16.1 (4.7)#                          |

| **For the Neuropsychologist:**       |                     |                                           |                         |                                      |
| Logical Memory                       | 8.8 (2.9)*          | 4.3 (2.7)+                               | 1.9 (1.7)+              | 1.5 (2.3)**                          |
| Block Design                         | 30.1 (8.6)*         | 22.2 (9.8)                               | 12.0 (9.6)              | 3.2 (6.6)##                          |
| Digit Symbol                         | 45.6 (11.5)*        | 31.7 (13.6)                              | 17.0 (13.3)+            | 8.3 (8.7)##                          |
| Trailmaking A                        | 40.9 (20.0)*        | 70.2 (39.2)+                             | 108.3 (50.5)+           | XXX                                  |
| Benton Copy                          | 9.6 (.88)*          | 9.1 (1.6)+                               | 7.3 (2.7)+              | XXX                                  |

**Our Case:**

MMSE 24, Short Blessed Test 10, TMA 63 secs, TMB 195 secs

CDR=0.5 Very Mild Dementia
What Are The Next Steps?

- **Green Light**
  - No red flags
  - Monitor at intervals
  - Full speed ahead!
- **Yellow Light**
  - Red flags/co-morbid illnesses
  - Decline in traffic skills
  - Deficits on office screening
  - Consider referral and caution!
- **Red Light**
  - Driving Retirement/Counseling
  - Stop!
Step 5: REFERRAL SOURCES

- Primary Care Physician
- Subspecialist
- Neuropsychologist
- Occupational Therapists
- Physical Therapists
- Speech Therapists
- Case Managers
- Others

Driving ability after a stroke: evaluation and recovery. [Review]
Murie-Fernandez M; Iturralde S; Ceno M; Casado M; Teasell R.
A Driver Rehabilitation Specialist

• One who plans develops, coordinates and implements driving services for individuals with disabilities

• These individuals are often Occupational Therapists with specialized training in driver assessment and rehabilitation
Mobility Counseling
Transportation Alternatives

- St. Louis Options
- Social Work Referral
- CORP
- Call-A-Ride
- Good Shepherd
- Metro
- Bus
- Taxi
- ITNAmerica
- Uber/Lyft/Curb
- Other
REMOVING THE RESISTANT DRIVER

- Ask physician to “prescribe” driving retirement orally/writing
- Focus on other medical conditions as the reason to stop driving
  - (e.g. vision too impaired, reaction time too slow)
- Use a contract (see THE HARTFORD At the Crossroads guide)
- Vehicle-Related Tactics
  - Hiding/filing down keys
  - Replacing keys
  - Do not repair the car/ send car for “repairs” but do not return
  - Remove the car by loaning, giving or selling
  - Disable the car
- Discuss financial implications of crash or injury
- Revoke license
When Should You Refer to the State?

Missouri reporting law provides civil immunity, anonymity, and is voluntary.

<table>
<thead>
<tr>
<th>DRIVER OR PATIENT SECTION</th>
<th>PATIENT NAME (LAST, FIRST, MIDDLE)</th>
<th>SOCIAL SECURITY NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>_ _ _ _ _ _ _ _ _ _ _ _</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>DATE OF BIRTH (MM/ DD/ YYYY)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>_ _ / _ _ / _ _ _ _ _ _ _ _ _ _ _</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>PATIENT'S MAILING ADDRESS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CITY</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>STATE</th>
<th>ZIP CODE</th>
</tr>
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<tbody>
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<td></td>
</tr>
</tbody>
</table>

I hereby authorize and accept that:

- My physician will conduct a medical examination to determine my fitness to operate a motor vehicle safely and responsibly.
- My physician will respond to any additional questions from the Driver License Bureau (DLB) and, if necessary, he or she may submit copies of my medical records to the DLB.
- The DLB will make a final decision concerning my eligibility for driver licensure based on all available information.

Signature of Driver or Patient ______________________________ Date (MM/DD/YYYY) __________________

Washington University in St. Louis • School of Medicine
Department of Medicine and Neurology
Division of Geriatrics and Nutritional Science/Knight ADRC
Case Resolution

- No history of prior poor driving performance
- Alprazolam was tapered off and sertraline
- Visual acuity was 20/40 corrected with no visual field cuts
- She passed her initial road test at CDR=0.5
- At her one year follow-up she had progression of her disease (CDR=1) and one minor accident of backing into a car
- It was recommended that she stop driving and she reluctantly complied
- The daughter provides transportation
Understanding the Future of Mobility

On-Demand Mobility/Driverless Cars/Electric Cars

- 80% reduction in cost of transportation
- Reduced pollution
- Reduced stress and road rage
- Dramatic decrease in accidents and traffic deaths
- Gaining back lost time to commuting
- Increase productivity
- Freeing up lanes by eliminating park cars
- Reclaiming home space allocated to home garages
- Leaders of on-demand mobility need to build trust with; consumers, regulators, insurers, investors

https://techcrunch.com/2015/08/08/understanding-the-future-of-mobility/
Different Perspectives

http://www.garageconversion.org/garage-conversion-gallery/garage-to-room/

https://mysonisdreaming.com