The Dementia with Lewy Bodies (DLB) Consortium last reported on diagnosis and management in December 2005, and its recommendations have been widely cited for both clinical and research use. Changes made to the diagnostic criteria at that time increased diagnostic sensitivity for DLB, but detection rates in clinical practice remain suboptimal, with many cases missed or misdiagnosed, usually as Alzheimer disease (AD). The revised DLB criteria presented here incorporate new developments since then and result from a review process that combined the reports of 4 multidisciplinary, expert working groups with a meeting that included patient and care partner participation (appendix e-1 at Neurology.org). The Consortium recognizes increasing interest in detecting early-stage disease; prodromal DLB criteria are in development and will be reported separately.

**SUMMARY OF CHANGES** While maintaining their previous structure, the revised DLB clinical diagnostic criteria improve on earlier versions by distinguishing clearly between clinical features and diagnostic

---

**ABSTRACT**

The Dementia with Lewy Bodies (DLB) Consortium has refined its recommendations about the clinical and pathologic diagnosis of DLB, updating the previous report, which has been in widespread use for the last decade. The revised DLB consensus criteria now distinguish clearly between clinical features and diagnostic biomarkers, and give guidance about optimal methods to establish and interpret these. Substantial new information has been incorporated about previously reported aspects of DLB, with increased diagnostic weighting given to REM sleep behavior disorder and 123I-metaiodobenzylguanidine (MIBG) myocardial scintigraphy. The diagnostic role of other neuroimaging, electrophysiologic, and laboratory investigations is also described. Minor modifications to pathologic methods and criteria are recommended to take account of Alzheimer disease neuropathologic change, to add previously omitted Lewy-related pathology categories, and to include assessments for substantia nigra neuronal loss. Recommendations about clinical management are largely based upon expert opinion since randomized controlled trials in DLB are few. Substantial progress has been made since the previous report in the detection and recognition of DLB as a common and important clinical disorder. During that period it has been incorporated into DSM-5, as major neurocognitive disorder with Lewy bodies. There remains a pressing need to understand the underlying neuropsychobiology and pathophysiology of DLB, to develop and deliver clinical trials with both symptomatic and disease-modifying agents, and to help patients and carers worldwide to inform themselves about the disease, its prognosis, best available treatments, ongoing research, and how to get adequate support. *Neurology® 2017;89:88-100*

**GLOSSARY**

AD = Alzheimer disease; CHEI = cholinesterase inhibitor; DAT = dopamine transporter; DLB = dementia with Lewy bodies; DSM-5 = Diagnostic and Statistical Manual of Mental Disorders, 5th edition; LB = Lewy body; MCI = mild cognitive impairment; MIBG = metaiodobenzylguanidine; MMSE = Mini-Mental State Examination; MTL = medial temporal lobe; PD = Parkinson disease; PSG = polysomnography; RBD = REM sleep behavior disorder.

The Dementia with Lewy Bodies (DLB) Consortium last reported on diagnosis and management in December 2005, and its recommendations have been widely cited for both clinical and research use. Changes made to the diagnostic criteria at that time increased diagnostic sensitivity for DLB, but detection rates in clinical practice remain suboptimal, with many cases missed or misdiagnosed, usually as Alzheimer disease (AD). The revised DLB criteria presented here incorporate new developments since then and result from a review process that combined the reports of 4 multidisciplinary, expert working groups with a meeting that included patient and care partner participation (appendix e-1 at Neurology.org). The Consortium recognizes increasing interest in detecting early-stage disease; prodromal DLB criteria are in development and will be reported separately.

**SUMMARY OF CHANGES** While maintaining their previous structure, the revised DLB clinical diagnostic criteria improve on earlier versions by distinguishing clearly between clinical features and diagnostic

---

**Author affiliations are provided at the end of the article.**

Members of the DLB Consortium are listed at Neurology.org.

Go to Neurology.org for full disclosures. Funding information and disclosures deemed relevant by the authors, if any, are provided at the end of the article.

The Article Processing Charge was paid by NIHR Newcastle Biomedical Research Centre in Ageing and Long-Term Conditions.

This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (CC BY), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.
Neurology 89 July 4, 2017 89

DLB fluctuations occurring as spontaneous al-

Parkinsonism in Parkinson disease (PD) is

Dementia, defined as a progressive
cognitive decline of sufficient magnitude to interfere with normal social or occupational functions, or with usual daily activities, is an essential requirement for DLB diagnosis.

Although dementia screens such as the Mini-

Visual hallucinations. Recurrent, complex visual hallucinations occur in up to 80% of patients with DLB and are a frequent clinical signpost to diagnosis. They are typically well-formed, featuring people, children, or animals, sometimes accompanied by related phenomena including passage hallucinations, sense of presence, and visual illusions. Patients are typically able to report these experiences, as are observant caregivers. Patient responses to their hallucinations vary both in degree of insight and emotional reaction to them. Assessment scales for characterizing and quantifying visual hallucinations are available.

Parkinsonism. Spontaneous parkinsonian features, not due to antiparkinsonian medications or stroke, are common in DLB, eventually occurring in over 85%. Parkinsonism in Parkinson disease (PD) is defined as bradykinesia in combination with rest tremor, rigidity, or both. Many DLB patients’ parkinsonism falls short of this, so documentation of only one of these cardinal features is required. Care should be taken particularly in older patients not to misinterpret physical signs due to comorbidity, e.g.,
If one or more of these is present, a diagnosis of DLB is dementia, defined as a progressive cognitive decline of sufficient magnitude to interfere with normal social or occupational functions, or with usual daily activities. Prominent or persistent memory impairment may not necessarily occur in the early stages but is usually evident with progression. Deficits on tests of attention, executive function, and visuospatial ability may be especially prominent and occur early.

**Core clinical features (The first 3 typically occur early and may persist throughout the course.)**

- Fluctuating cognition with pronounced variations in attention and alertness.
- Recurrent visual hallucinations that are typically well formed and detailed.
- REM sleep behavior disorder, which may precede cognitive decline.
- One or more spontaneous cardinal features of parkinsonism: these are bradykinesia (defined as slowness of movement and decrement in amplitude or speed), rest tremor, or rigidity.

**Supportive clinical features**

- Severe sensitivity to antipsychotic agents; postural instability; repeated falls; syncope or other transient episodes of unresponsiveness; severe autonomic dysfunction, e.g., constipation, orthostatic hypotension, urinary incontinence; hypersomnia; hyposomnia; hallucinations in other modalities; systematized delusions; apathy, anxiety, and depression.

**Indicative biomarkers**

- Reduced dopamine transporter uptake in basal ganglia demonstrated by SPECT or PET.
- Polysomnographic confirmation of REM sleep without atonia.

**Supportive biomarkers**

- Relative preservation of medial temporal lobe structures on CT/MRI scan.
- Generalized low uptake on SPECT/PET perfusion/metabolism scan with reduced occipital activity: the cingulate island sign on FDG-PET imaging.
- Prominent posterior slow-wave activity on EEG with periodic fluctuations in the pre-alpha/theta range.

**Probable DLB** can be diagnosed if:

- a. Two or more core clinical features of DLB are present, with or without the presence of indicative biomarkers, or
- b. Only one core clinical feature is present, but with one or more indicative biomarkers.

**Probable DLB should not be diagnosed on the basis of biomarkers alone.**

**Possible DLB** can be diagnosed if:

- a. Only one core clinical feature of DLB is present, with no indicative biomarker evidence, or
- b. One or more indicative biomarkers is present but there are no core clinical features.

**DLB is less likely:**

- a. In the presence of any other physical illness or brain disorder including cerebrovascular disease, sufficient to account in part or in total for the clinical picture, although these do not exclude a DLB diagnosis and may serve to indicate mixed or multiple pathologies contributing to the clinical presentation, or
- b. If parkinsonian features are the only core clinical feature and appear for the first time at a stage of severe dementia.

DLB should be diagnosed when dementia occurs before or concurrently with parkinsonism. The term Parkinson disease dementia (PDD) should be used to describe dementia that occurs in the context of well-established Parkinson disease. In a practice setting the term that is most appropriate to the clinical situation should be used and generic terms such as Lewy body disease are often helpful. In research studies in which distinction needs to be made between DLB and PDD, the existing 1-year rule between the onset of dementia and parkinsonism continues to be recommended.

**Biomarkers.** Although direct biomarker evidence of LB-related pathology is not yet available for clinical diagnosis, several useful indirect methods are.

**Indicative biomarkers.** If one or more of these is found, associated with one or more core clinical features, probable DLB should be diagnosed. Dementia without any core clinical features, but with one or more indicative biomarkers, may be classified as possible DLB. Probable DLB should not be diagnosed on the basis of biomarkers alone.

**Reduced DAT uptake in basal ganglia demonstrated by SPECT or PET imaging.** The utility of DAT imaging in distinguishing DLB from AD is well-established, with sensitivity (78%) and specificity (90%). Figure 1 shows 123Iodine FP-CIT SPECT images in patients with AD, patients with DLB, and normal controls. When parkinsonism is the only core clinical feature of DLB in a patient with dementia, reduced DAT uptake warrants a probable DLB diagnosis provided that other disorders associated with cognitive impairment and reduced DAT uptake can be excluded, e.g., progressive supranuclear palsy, multisystem atrophy, corticobasal degeneration, and frontotemporal dementia. Normal DAT uptake may be reported in autopsy-confirmed DLB arthritis, or inability to comply with neurologic examination because of cognitive impairment. If parkinsonism is clinically equivocal, a DAT uptake scan may be helpful.

**REM sleep behavior disorder.** RBD is a parasomnia manifested by recurrent dream enactment behavior that includes movements mimicking dream content and associated with an absence of normal REM sleep atonia. It is particularly likely if dreams involve a chasing or attacking theme, and if the patient or bed partner has sustained injuries from limb movements. RBD is now included as a core clinical feature because it occurs frequently in autopsy-confirmed cases compared with non-DLB (76% vs 4%). It often begins many years before other symptoms, may become less vigorous or even quiescent over time, and should be screened for using a scale that allows for patient or bed partner report. Conditions mimicking RBD are common in people with dementia, e.g., confusional awakenings, severe obstructive sleep apnea, and periodic limb movements, all of which must be excluded by careful supplementary questioning to avoid a false-positive diagnosis. If there is any doubt whether a sleep disturbance is due to RBD, referral to a specialist sleep clinic should be made, or polysomnography (PSG) requested.

**Supportive clinical features.** These are clinical features that are commonly present, sometimes early. Although lacking diagnostic specificity, such symptoms may indicate DLB in a patient with dementia, particularly when they persist over time or if several occur in combination. New to this list is hypersomnia, usually presenting as excessive daytime sleepiness. Also new is hyposmia, which occurs earlier in DLB than in AD. Transient episodes of unresponsiveness may represent an extreme form of cognitive fluctuation, difficult to distinguish from true syncope. Severe antipsychotic sensitivity is now listed as supportive, because reduced prescribing of D2 receptor blocking antipsychotics in DLB limits its diagnostic usefulness. Caution about their use remains unchanged.
either because of minimal brainstem involvement and limited nigral neuron loss or a balanced loss of dopamine across the whole striatum, rather than predominantly in the putamen.

Reduced uptake on metaiodobenzylguanidine myocardial scintigraphy. Iodine-MIBG myocardial scintigraphy quantifies postganglionic sympathetic cardiac innervation, which is reduced in LB disease. Images from patients with AD, DLB, and age-matched normal controls are shown in figure 2. Useful sensitivity (69%) and specificity (87%) values for discriminating probable DLB from probable AD rise to 77% and 94% in milder cases (MMSE >21). Studies have generally excluded patients with comorbidities, or taking medicines, which can produce abnormal MIBG images. Clinicians should carefully interpret MIBG results in the light of possible confounding causes, including ischemic heart disease, heart failure, diabetes mellitus, peripheral neuropathies, and medications that may cause reduced uptake including labetalol, reserpine, tricyclic antidepressants, and over-the-counter sympathomimetics.

PSG confirmation of REM sleep without atonia. PSG demonstration of REM sleep without atonia is desirable whenever feasible, since it is a highly specific predictor of Lewy-related pathology. If the PSG shows REM sleep without atonia in a person with dementia and a history of RBD, there is a ≥90% likelihood of a synucleinopathy, sufficient to justify a probable DLB diagnosis even in the absence of any other core feature or biomarker (figure 3).

Supportive biomarkers. These are biomarkers consistent with DLB that help the diagnostic evaluation, but without clear diagnostic specificity.

Relative preservation of medial temporal lobe structures on CT/MRI scan. Patients with AD show greater atrophy of medial temporal lobe (MTL) structures than patients with DLB (figure 1), particularly the hippocampus, which is strongly correlated at autopsy with atrophy rather than plaque or LB-related pathology. Absent or minimal MTL atrophy is therefore consistent with DLB, but unusual in AD. A multisite study with autopsy confirmation found sensitivity (64%) and specificity (68%) for separating AD from DLB. MTL atrophy in DLB may, however, signal substantial additional AD neuropathologic change, and predict a more rapid clinical course.

Generalized low uptake on SPECT/PET perfusion/metabolism scan, reduced occipital activity, and the posterior cingulate island sign on FDG-PET imaging. FDG-PET occipital hypometabolism correlates with visual cortex neuropathology in DLB and a small, autopsy-confirmed study suggested this could distinguish DLB from AD with...
high accuracy.\textsuperscript{34} Larger studies, earlier in disease, suggest sensitivity (70%) and specificity (74%) slightly lower than needed for an indicative biomarker, although better than that reported for HMPAO-SPECT (65% and 64%).\textsuperscript{35,36} Relative preservation of posterior or midcingulate metabolism on FDG-PET (the cingulate island sign) has been described in DLB,\textsuperscript{37} associated with less concurrent neurofibrillary pathology, but with no difference in A\textsubscript{B} load relative to AD (figure 4).\textsuperscript{38} Prominent posterior slow-wave EEG activity with periodic fluctuations in the pre-alpha/beta range. Evidence is building to support quantitative EEG as a DLB biomarker, characterized by specific abnormalities in posterior derivations. These include a pre-alpha-dominant frequency, either stable or intermixed with alpha/theta/delta activities in pseudoperiodic patterns,\textsuperscript{39} which together have a predictive value $>90\%$ for the diagnosis of DLB compared with AD.\textsuperscript{41} These specific EEG patterns also correlate positively with the severity of clinically observed cognitive fluctuations\textsuperscript{42} and may be seen at the MCI stage.\textsuperscript{43}

Other imaging biomarkers. PET imaging shows increased A\textsubscript{B} brain deposition in $>50\%$ of patients with DLB, limiting its value to distinguish between AD and DLB.\textsuperscript{40} Combining biomarkers in a multimodal approach can improve diagnostic accuracy in distinguishing DLB and AD\textsuperscript{44} and provides information about mixed pathology and multisystem involvement. Tau PET imaging may have an important role, along with MTL atrophy, as a key indicator of coexisting AD pathology in DLB, predictive of clinical phenotype and progression.

Genetic and fluid biomarkers. The development of broadly applicable CSF, blood, peripheral tissue, or genotypic biomarkers for DLB remains elusive. Although it is clear that there is a substantial genetic contribution to DLB\textsuperscript{42,43} and that different genetic markers even within the $\alpha$-synuclein gene (SNCA) may be associated with different LB syndromes,\textsuperscript{44} our understanding of the core genes involved remains limited. CSF $\alpha$-synuclein is not yet proven as a biomarker, while A\textsubscript{B}, tau, and phospho-tau measurements may be more useful in determining concomitant AD pathology or predicting cognitive decline.\textsuperscript{45} Glucocerebrosidase (GBA) mutations are overrepresented in DLB\textsuperscript{46} but most individuals with DLB do not have them. It is premature to recommend genetic testing in a clinical setting, either for confirmation of diagnosis or for prediction of disease, and genetic studies should currently be limited to research settings.
Clinical management. The management of patients with DLB is complex, requiring a multifaceted approach. Key elements include a thorough initial evaluation to ensure accurate diagnosis; early identification of signs and symptoms requiring intervention; engagement, education, and support of care providers; and a multidisciplinary team approach. Patients with DLB are prone to mental status worsening, including delirium, in the face of comorbid medical disorders. Dopaminergic therapies and anticholinergic medications can adversely affect cognition and behavior, leading to confusion and psychosis.

Treatment of DLB is focused on the cognitive, psychiatric, motor, and other nonmotor symptoms that represent the core or most common features of the disorder. A combination of pharmacologic and nonpharmacologic approaches is optimal. As the evidence base to support particular treatments remains limited, the recommendations outlined below remain based, in part, upon consensus expert opinion.

Nonpharmacologic interventions. Given both the limited evidence for efficacy and the potential increased morbidity and mortality risks associated with pharmacologic treatments in DLB, there is a need to develop and test nonpharmacologic management strategies. Interventions can be patient- or caregiver-focused, or both. More research in this area has been conducted in AD and PD than in DLB, with promising preliminary evidence for exercise (both motor and cognitive benefits), cognitive training, and caregiver-oriented education and training to manage psychiatric symptoms including agitation and psychosis.

Pharmacologic management. Cognitive symptoms. Meta-analyses of Class I clinical trials of rivastigmine and donepezil support the use of cholinesterase inhibitors (CHEIs) in DLB for improving cognition, global function, and activities of living, with evidence that even if patients do not improve with CHEIs they are less likely to deteriorate while taking them. The efficacy of memantine in DLB is less clear, but it is well-tolerated and may have benefits, either as monotherapy or adjunctive to a CHEI.

Neuropsychiatric symptoms. CHEIs may produce substantial reduction in apathy and improve visual...
hallucinations and delusions in DLB. Since anxiety and agitation are sometimes driven by psychosis, there may be secondary benefits in these. The use of antipsychotics for the acute management of substantial behavioral disturbance, delusions, or visual hallucinations comes with attendant mortality risks in patients with dementia, and particularly in the case of DLB they should be avoided whenever possible, given the increased risk of a serious sensitivity reaction. Low-dose quetiapine may be relatively safer than other antipsychotics and is widely used, but a small placebo-controlled clinical trial in DLB was negative. There is a positive evidence base for clozapine in PD psychosis, but efficacy and tolerability in DLB have not been established. Newer drugs targeting the serotonergic system, such as pimavanserin, may be alternatives, but controlled clinical trial data in DLB are needed. Although depressive symptoms are common in DLB, trial data are scant. In alignment with general advice on depression in dementia, selective serotonin reuptake inhibitors, serotonin-norepinephrine reuptake inhibitors, and mirtazapine are options in DLB with treatment guided by individual patient tolerability and response.

Motor symptoms. Parkinsonism is often less responsive to dopaminergic treatments in DLB than in PD and their use may be associated with an increased risk of psychosis, although some patients may benefit from levodopa preparations introduced at low doses and increased slowly to the minimum required to minimize motor disability without exacerbating psychiatric symptoms. Patients at risk of falling may benefit from safety assessments, as well as bone mineral density screening, and assessment of vitamin D status, to manage risk of traumatic fractures.

Other symptoms. A wide range of other symptoms can occur in DLB, including autonomic and sleep/wakefulness disturbances, which have profound negative sequelae for quality of life in both patients and their families. In the absence of DLB-specific trial data for these symptoms, clinicians base their treatment decisions on clinical experience, expert opinion, or evidence-based recommendations developed in other diseases, e.g., cautious bedtime use of clonazepam may reduce the risk of sleep-related injuries in...
patients with DLB with RBD but carries a risk of worsening cognition and gait impairment, melatonin being a possibly safer option.44

Pathology. Pathologic assessment and diagnostic criteria for DLB. The previously published methods for pathologic assessment and diagnosis of DLB should continue to be used with only a few modifications, shown in table 2, which predicts the likelihood that the pathologic findings will be associated with a typical DLB clinical syndrome, i.e., cases with high likelihood are expected to fulfil clinical criteria for probable DLB, whereas low likelihood cases may have few or no DLB clinical features.

Table 2 assigns categories of AD neuropathologic change according to National Institute on Aging–Alzheimer’s Association criteria (no, low, intermediate, and high),55 and adds previously omitted categories of Lewy-related pathology including olfactory bulb only,56 and amygdala predominant.57,58 Both of these are considered to be low-likelihood DLB but may in the future be useful in assessing prodromal disease. Further efforts are required to develop better interrater reliability59 for Lewy-related disease subtypes (olfactory bulb only, amygdala predominant, brainstem, limbic [transitional], and diffuse neocortical). Table 2 also includes an assessment of substantia nigra neuronal loss (none, mild, moderate, and severe) in order to subclassify cases into those likely or not to have parkinsonism (DLB-P and DLB-no P).60

FUTURE DIRECTIONS. Since publication of the 2005 consensus report, DLB has been confirmed as a major dementia subtype, categorized in DSM-562 as neurocognitive disorder with LB, and distinguished from neurocognitive disorder due to PD. The consensus group remains supportive of the 1-year rule distinguishing DLB from PD dementia, because as originally stated1,2 this arbitrary cutoff remains useful, particularly in clinical practice. Based as it is on expert opinion, the time period may need modification when the genetic underpinnings, pathophysiologic mechanisms, and prodromal states of these disorders are sufficiently understood to enable a data-driven solution.62,63

There is an urgent need to develop guidelines and outcome measures for clinical trials in DLB, both symptomatic and disease-modifying, nonpharmacologic and pharmacologic. DLB researchers can build upon experience gained in AD and PD; additional issues for them to consider include subtyping of patients on the basis of clinical or biomarker criteria and selecting target symptoms and outcome measures appropriate to DLB. It will be necessary to manage potential confounding factors that are common in DLB, e.g., fluctuations in alertness and fatigue, active hallucinations, and concomitant use of cognitive enhancing and psychiatric medications. Such considerations will need to be applied when designing clinical trials across the spectrum of clinical syndrome of DLB from prodromal and presymptomatic stages, still to be identified, to overt dementia.

Suggested strategies to progress critical areas of biological research include collecting samples from large population-based cohorts and developing a publicly available DLB genetic database and a repository for DLB exome data. Family studies are needed to find and confirm genes, requiring clinicians to take detailed family histories seeking evidence not only of DLB, PD, and AD and other dementias, but also of RBD and supportive features.

In order to make progress in deciphering biological mechanisms at play in DLB including GBA64 and inflammatory pathways,65 it will be necessary to develop robust animal models that capture the true neuropathologic and behavioral abnormalities of DLB, and to identify possible disease-specific

<table>
<thead>
<tr>
<th>Alzheimer disease neuropathologic change</th>
<th>NIA-AA none/low (Braak stage 0-II)</th>
<th>NIA-AA intermediate (Braak stage III-V)</th>
<th>NIA-AA high (Braak stage V-VI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lewy-related pathology</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diffuse neocortical</td>
<td>High</td>
<td>High</td>
<td>Intermediate</td>
</tr>
<tr>
<td>Limbic (transitional)</td>
<td>High</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td>Brainstem-predominant</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Amygdala-predominant</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Olfactory bulb only</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Substantia nigra neuronal loss to be assessed (as none, mild, moderate, and severe)69 in order to subclassify cases into those likely or not to have parkinsonism</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abbreviation: NIA-AA = National Institute on Aging-Alzheimer’s Association guidelines for the neuropathologic assessment of Alzheimer disease.55
molecular differences in α-synuclein, tau, and Aβ among DLB, PD, PD dementia, and AD. The latter includes characterization of possible molecular strings of misfolded or pathologic α-synuclein, posttranslational modifications in degradation and clearance processes, and transmission and propagation. It will be increasingly important to study protein interactions among α-synuclein, Aβ, and tau. Finally, there is an unmet need to characterize biological effects of identified genetic risk factors, including APOE, GBA, and SNC, as well as to model and analyze gene–environmental interactions.

In order to advance DLB research, global harmonization efforts are required to create networks of researchers and research participants who share common platforms for data and biomarker collection, outcome measures for clinical–translational research, and shared terminology across language, cultures, and traditions. Consideration might be given to creating an international patient and caregiver association to serve as advocates for private and public funding; identifying obstacles to the pharmaceutical industry sponsoring DLB research; bridging relationships with the PD and AD research communities; creating a plan for reimbursement for DLB clinical care, drugs/devices, and biomarkers; and increasing interdisciplinary and interprofessional communication regarding the challenges facing clinicians, patients, and caregivers. Finally, priority needs to be given to helping patients and caregivers to inform themselves about the disease, its prognosis, best available treatments, ongoing research, and how to get adequate support.

AUTHOR AFFILIATIONS
From the Institute of Neuroscience (I.G.M., J.P.T., J.A., D.B., A. Thomas), Newcastle University, UK; Departments of Neurology (B.F.B.) and Radiology (K. Kantarci), Mayo Clinic (A.L.), Rochester, MN; Neuropathology Laboratory (D.W.D., M. Murray) and Departments of Psychiatry and Psychology (D.K.), University of North Carolina at Chapel Hill; Department of Neurology (W.K.), University of Washington, Seattle; Lou Ruvo Center for Brain Health (J.B.L.), Neurologic Institute, Cleveland Clinic, OH; Thomas Jefferson University (C.L.), Philadelphia, PA; Department of Medicine (M. Maselli), Sunnybrook Health Sciences Centre, University of Toronto, Canada; Division of Neuroscience (E.M.), National Institute on Aging, Baltimore, MD; Paracelsus-Elona-Klinik (B.M.), Kas sel, Germany; Department of Pathology (T.J.M.), Stanford University, CA, GE Healthcare (E. Moreno), Medical Affairs, London, UK; Department of Behavioral Neurology and Cognitive Neuroscience (E. Mori), Tohoku University Graduate School of Medicine, Sendai, Japan; Department of Psychiatry (J.T.O.), University of Cambridge, UK; Department of Neurology (S.O.), Kanto Central Hospital, Tokyo, Japan; Department of Neurology (R.B.P.), Montreal General Hospital, Canada; Axovant Sciences, Inc. (S.R.), New York, NY; Laboratory of Neurogenetics (A.S.), NIH, Bethesda, MD; Lewy Body Dementia Association (A. Taylor), Bilbao, GA; Neurology Department (J.B.T.), Houston Methodist Hospital, TX; Division of Neuroscience/Neuropathology (P.T.), Fondazione IRCCS, Istituto Neurologico Carlo Besta, Milan, Italy; VA Puget Sound Health Care System (D.T.T.), Seattle, WA; University College London–North Essex Partnership University NHS Foundation Trust (Z.W.), UK; Department of Neurology and Neuropsychology of Aging (M.Y.), Kanazawa University Graduate School of Medical Sciences; and Yokohama City University Medical Center (K. Kosaka), Japan.

AUTHOR CONTRIBUTIONS
Ian McKeith: design or conceptualization of the study, analysis or interpretation of the data, drafting or revising the manuscript. Bradley Boeve: design or conceptualization of the study, analysis or interpretation of the data, drafting or revising the manuscript. Dennis Dickson: design or conceptualization of the study, analysis or interpretation of the data, drafting or revising the manuscript. Daniel Weintraub: design or conceptualization of the study, analysis or interpretation of the data, drafting or revising the manuscript. John-Paul Taylor: design or conceptualization of the study, analysis or interpretation of the data, drafting or revising the manuscript. Dag Aarsland: design or conceptualization of the study, analysis or interpretation of the data, drafting or revising the manuscript. James Galvin: design or conceptualization of the study, analysis or interpretation of the data, drafting or revising the manuscript. Johannes Arntzen: design or conceptualization of the study, analysis or interpretation of the data, drafting or revising the manuscript. Ian McKeith: design or conceptualization of the study, analysis or interpretation of the data, drafting or revising the manuscript. K. Kosaka: design or conceptualization of the study, analysis or interpretation of the data, drafting or revising the manuscript. DH: design or conceptualization of the study, analysis or interpretation of the data, drafting or revising the manuscript.
analysis or interpretation of the data, drafting or revising the manuscript. Dominic flytche: analysis or interpretation of the data. Hirofuee Fujishi: design or conceptualization of the study, analysis or interpretation of the data. Douglas Galasko: analysis or interpretation of the data, drafting or revising the manuscript. Jennifer Goldman: design or conceptualization of the study, analysis or interpretation of the data, drafting or revising the manuscript. Stephen N. Gomperts: analysis or interpretation of the data, drafting or revising the manuscript. Neil R. Graff-Radford: design or conceptualization of the study, analysis or interpretation of the data, drafting or revising the manuscript. Lawrence S. Honig: analysis or interpretation of the data, drafting or revising the manuscript. Alex Iranzo: analysis or interpretation of the data, drafting or revising the manuscript. Kajal Kantarci: design or conceptualization of the study, analysis or interpretation of the data, drafting or revising the manuscript. Daniel Kaufer: analysis or interpretation of the data, drafting or revising the manuscript. Walter Kukul: design or conceptualization of the study, analysis or interpretation of the data, drafting or revising the manuscript. Simo Lewis: analysis or interpretation of the data, drafting or revising the manuscript. Carol Lippa: design or conceptualization of the study, analysis or interpretation of the data, drafting or revising the manuscript. Angela Lunde: design or conceptualization of the study, analysis or interpretation of the data, drafting or revising the manuscript. Angela de Mascolo: analysis or interpretation of the data, drafting or revising the manuscript. Pamela McLean: analysis or interpretation of the data, drafting or revising the manuscript. Brit Mollenhauer: analysis or interpretation of the data, drafting or revising the manuscript. Thomas Montine: analysis or interpretation of the data. Emilie Moreno: analysis or interpretation of the data, drafting or revising the manuscript. Etsuro Mori: analysis or interpretation of the data. Melissa Murray: analysis or interpretation of the data, drafting or revising the manuscript. John O’Brien: design or conceptualization of the study, analysis or interpretation of the data, drafting or revising the manuscript. Satoshi Orito: analysis or interpretation of the data. Ron Postuma: design or conceptualization of the study, analysis or interpretation of the data, drafting or revising the manuscript. Shanak Ramesawamy: analysis or interpretation of the data, drafting or revising the manuscript. Owen Ross: design or conceptualization of the study, analysis or interpretation of the data, drafting or revising the manuscript. David Salmon: design or conceptualization of the study, analysis or interpretation of the data, drafting or revising the manuscript. Andrew Singleton: design or conceptualization of the study, analysis or interpretation of the data. Angela Taylor: analysis or interpretation of the data, drafting or revising the manuscript. Christian Tost: analysis or interpretation of the data, drafting or revising the manuscript. Alan Thomas: analysis or interpretation of the data, drafting or revising the manuscript. Priyanka Toshchov: analysis or interpretation of the data, drafting or revising the manuscript. Jim Toole: analysis or interpretation of the data, drafting or revising the manuscript. John Trojanowski: analysis or interpretation of the data, drafting or revising the manuscript. Debby Tsuang: design or conceptualization of the study, analysis or interpretation of the data. Zuzana Walker: design or conceptualization of the study, analysis or interpretation of the data, drafting or revising the manuscript. Masahiro Yamada: analysis or interpretation of the data, drafting or revising the manuscript. Kenji Kosaka: analysis or interpretation of the data.

ACKNOWLEDGMENT

The authors thank Dr. Val Lowe, Mayo Clinic, Rochester, for FP-CIT SPECT and FDG-PET images (figures 1 and 4); and Dr. Kenichi Nakajima, Department of Nuclear Medicine, Kanazawa University, for MIBG myocardial scintigraphy images (figure 2).

STUDY FUNDING

The DBL Consortium meeting was organized by the Mayo School of Continuous Professional Development (MSCPD) and supported by Acadia Pharmaceuticals, Alzheimer’s Association, Autism savants, Banner Health, GE Healthcare, the Lewy Body Dementia Association, the Lewy Body Society, Lundbeck, the National Institute on Aging, the National Institute on Neurologic Disease and Stroke, and an NIH grant (R15 NS095618). Kathy Faqua, Julie Reed, and colleagues at the MSCPD provided administrative support to the consortium meeting in Fort Lauderdale. I.G.M., D.B., J.P.T., J.A., and A.T. receive support from the UK NHIR Biomedical Research Centre awarded to the Newcastle upon Tyne Hospitals NHS Foundation Trust and Newcastle University. Travel grant support was provided by the Alzheimer’s Research UK AUUK NE Network Centre. B.F.B., D.W.D., K.K., and T.J.F. are supported by the NIH (P50-AG016574) and the Mangurian Foundation for Lewy Body Research. G.H. is a senior principal research fellowship holder from the National Health and Medical Research Council of Australia (1079673). D.A. is a Royal Society Wolfson Research Merit Award Holder and also the Wellcome Trust and the Alzheimer’s Society for their support. C.G.B. thanks the Maudsley BRC for Mental Health and BRU dementia for supporting his involvement in the work. A.C.-P. receives research support from the NIH (ROI NS082265, UO1 NS082134, P50 NS053488), the Burroughs Wellcome Fund, the Alzheimer’s Association/Michael J. Fox Foundation/Weston Biomarkers Across Neurodegenerative Disease initiative, and the Pechenik Montague Award Fund. D.Y. acknowledges support from NHRI Programme Grants for Applied Research (RP-PG-0610-10100 SHAPED). O.E.-A. acknowledges support for OE laboratory from the Michael J. Fox Foundation for Parkinson’s Research (New York). S.N.G. receives support from R21 NS 095243 and the National Parkinson’s Foundation. O.A.R. is supported through the Mayo Clinic A Morris K. Udall Parkinson’s Disease Research Center of Excellence (NINDS P50 NS072187), NINDS R01 NS078086, the Michael J. Fox Foundation for Parkinson’s Research, the Mayo Alzheimer Disease Center at the University of Minnesota, the Mayo Clinic Alzheimer’s Disease Research Program, and The Little Family Foundation. A.S.’s work is supported by the Intramural Program of the National Institute on Aging, Department of Health and Human Services. D.T. acknowledges the work of Cyrus Zabetian, MD, and Ignacio Mata, PhD, from VA Puget Sound Health Care System. J.Q.T. and V.M.Y.’s contributions were supported in part by a P50 NS053488 Morris K. Udall Parkinson’s Disease Research Center of Excellence grant from NINDS. P.T. acknowledges support from the Italian Ministry of Health “Ricerca Corrente.” M.Y. acknowledges support from the Japan Foundation for Neuroscience and Mental Health.

DISCLOSURE

I. McKeith receives support from the UK NHIR Biomedical Research Centre awarded to the Newcastle upon Tyne Hospitals NHS Foundation Trust and Newcastle University. He has consulted for Avanex Sciences, Takeda, Eisai, and GE Healthcare. B. Boeve has served as an investigator for clinical trials sponsored by GE Healthcare, FORUM Pharmaceuticals, C2N Diagnostics, and Avanex Sciences. He receives royalties from the publication of “Behavioral Neurology of Dementia” (Cambridge Medicine, 2009). He serves on the Scientific Advisory Board of the Tau Consortium. He receives research support from the NIH and the Mangurian Foundation. D. Dickson receives research support from the NIH (P50-AG016574, P50 NS072187, P01-AG089394) and CurePSP Foundation for PSP/CBD and Related Disorders. Dr. Dickson is an editorial board member of Acta Neuropathologica, Annals of Neurology, Brain, Brain Pathology, and Neuropathology, and he is editor-in-chief of American Journal of Neurodegenerative Disease and International Journal of Clinical and Experimental Pathology. G. Halliday consults for the National Health and Medical Research Council of Australia (NHMRC); received travel funds from AHC, International Society of Neurochemistry, International DLB Conference, AAN, International MSA Conference, NHMRC National Institute for Dementia Research, 2nd Chinese Brain Banking Meeting, and Japanese Neuroscience Society; is on the editorial boards of Acta Neuropathologica, J Neural Transm, J Parkinsonism Dus, Transl Neurodegen, and Neuropatol Appl Neurobiol; receives royalties from Academic Press, Elsevier, and Oxford University Press; receives research grant funding from NHMRC (1088307, 1077467, and 1079679), the Michael J. Fox Foundation, Shaka-it-up Australia, Parkinson’s NSW, and University of Newcastle upon Tyne (infrastructure and equipment); and holds stock in Cochlear Ltd. V. Vonsattel is supported in part by a P50 NS053488 and the Mayo Clinic Alzheimer’s Disease Center at the University of Minnesota. D.J. Kawashima is supported in part by a P50 NS053488 and the Mayo Clinic Alzheimer’s Disease Center at the University of Minnesota. G. Kish is supported in part by a P50 NS053488 and the Mayo Clinic Alzheimer’s Disease Center at the University of Minnesota. B. Mollenhauer is supported in part by a P50 NS053488 and the Mayo Clinic Alzheimer’s Disease Center at the University of Minnesota. K.K. receives research grant funding from the Alzheimer’s Association; the Alzheimer’s Association/Michael J. Fox Foundation/Weston Biomarkers Across Neurodegenerative Disease initiative; and the Pechenik Montague Award Fund. D.Y. acknowledges support from NHRI Programme Grants for Applied Research (RP-PG-0610-10100 SHAPED). O.E.-A. acknowledges support for OE laboratory from the Michael J. Fox Foundation for Parkinson’s Research (New York). S.N.G. receives support from R21 NS 095243 and the National Parkinson’s Foundation. O.A.R. is supported through the Mayo Clinic A Morris K. Udall Parkinson’s Disease Research Center of Excellence (NINDS P50 NS072187), NINDS R01 NS078086, the Michael J. Fox Foundation for Parkinson’s Research, the Mayo Alzheimer Disease Center at the University of Minnesota, the Mayo Clinic Alzheimer’s Disease Research Program, and The Little Family Foundation. A.S.’s work is supported by the Intramural Program of the National Institute on Aging, Department of Health and Human Services. D.T. acknowledges the work of Cyrus Zabetian, MD, and Ignacio Mata, PhD, from VA Puget Sound Health Care System. J.Q.T. and V.M.Y.’s contributions were supported in part by a P50 NS053488 Morris K. Udall Parkinson’s Disease Research Center of Excellence grant from NINDS. P.T. acknowledges support from the Italian Ministry of Health “Ricerca Corrente.” M.Y. acknowledges support from the Japan Foundation for Neuroscience and Mental Health.
and the International Parkinson and Movement Disorder Society; hon-
oraria from AbbVie, Acadia, Biogen, Biotie, Clintrex LLC, Janssen,
Merck, Novartis, Pfizer, Teva Pharmaceuticals, UCB, and the CHDI
Foundation; license fee payments from the University of Pennsylvania
for the QUPI and QUPI-RS; royalties from Wolters Kluwer; and
and fees for legal consultation for a lawsuit related to antipsychotic
prescribing in a patient with Parkinson disease. D. Aarsland has received
research support and/or honoraria from Astra-Zeneca, H. Lundbeck,
Novartis Pharmaceuticals, and GE Health, and serves as a paid consultant
for H. Lundbeck and Axovant. J. Galvin receives research support from
Biogen, Axovant, NIH, Association for Frontotemporal Degeneration,
and Florida Department of Health, and is a consultant for Biogen and
Eisai. J. Arrows reports no disclosures relevant to the manuscript. C.
Ballard has received honoraria and grant funding from Acadia Pharma-
ceuticals, which manufactures pimavanserin. Other financial disclosures
in the last 2 years include the following: contract grant funding from
Lundbeck, Takeda, and Axovant pharmaceutical companies and honor-
aria from Lundbeck, Lilly, Otsuka, and Orion pharmaceutical compa-
nies. A. Bayton reports no disclosures relevant to the manuscript.
T. Beach is a consultant to GE Healthcare and Avid Radiopharmaceut-
icals, performs contracted research for Avid Radiopharmaceuticals and
Novadea Biopharmaceuticals, and receives research funding from NIH
grant (R30AG019610), the Arizona Department of Health and Human
Services, and the Michael J. Fox Foundation for Parkinson’s Research.
F. Blanc has received speaker’s honoraria and travel expenses from Roche,
Biogen Idec, Novartis, and Merck Serono. N. Bohlen receives research
support from the NIH, Department of Veterans Affairs, and the Michael
J. Fox Foundation. L. Bonanni reports no disclosures relevant to the
manuscript. J. Bras was supported by a fellowship from the Alzheimer’s
Society and funding from the Lewy Body Society and Parkinson’s UK.
P. Brandt has received commercial support as a consultant from Renovo
Neural, Inc., Roche, Teva/Lundbeck, and AbbVie. He has received com-
mercial support for grants/research from Renovo and Teva/Lundbeck.
Dr. Brandt has ownership interests in Acusort AB and Parkcell AB.
D. Burn and A. Chen-Plotkin report no disclosures relevant to the man-
uscript. J. Duda serves on the Editorial Board for npj Parkinson’s Disease
and has received research support from the US Department of Veterans
Affairs, NIH, and the Michael J. Fox Foundation for Parkinson’s Research. O. El-Agnaf reports no disclosures relevant to the manuscript.
H. Feldman receives research funding from the NIH, the Canadian
Institutes of Health Research, the Weston Foundation, UC Cures for
Alzheimer’s Disease, and Heart and Stroke Foundation of Canada. He
has served as coinvestigator on clinical trials sponsored by TauRx, Hoff-
man LaRoche, and Lilly. He currently serves on the scientific advisory
boards for the Tau Consortium, Tau Rx, and the Alzheimer Society of
Canada Research Policy. He has performed service agreements for UCB/UCBDC with Genentech Banner Health, Eisai, Arena, and Merck.
He receives royalties for the publication of An Atlas of Alzheimer’s Disease
T. Ferman, D. ffytche, and H. Hirose report no disclosures relevant to the
manuscript. D. Galasko is funded by NIH grant AG051313, the Michael
J. Fox Foundation, and the California Institute for Regenerative
Medicine. He has received funding from tV Pharmaceuticals and Eli
Lilly, Inc., for consultation, from Eli Lilly and Prothera for service on the
Data Safety Boards, and payment from Biomed Central as Editor for
Alzheimer’s Research and Therapy. J. Goldman has received grant/research
support from the NIH, Michael J. Fox Foundation, Rush University,
Parkinson Disease Foundation, Acadia, and Biotie (site PI), consulting
fees from Acadia, Biogen, Pfizer, and Teva, and honoraria from the
International Parkinson and Movement Disorder Society, American
Academy of Neurology, MediDecus, and Pri-Med. S. Compart reports
no disclosures relevant to the manuscript. N. Graff-Radford is a mul-
ticenter study on Lewy body disease for Axovant and is taking part in
multicenter studies with Eli Lilly, Biogen, and TauRx. He has consulted
for Cytorx. L. Honig has performed consulting for Bristol-Myers Squibb,
Forum, Lilly, and Lundbeck pharmaceutical companies; has performed
clinical drug trials research funded by AbbVie, Axovant, Bristol-Myers
Squibb, C2N, Forum, Genentech, Lilly, Lundbeck, Merck, Pfizer,
Roche, TauRx, and tV pharmaceutical companies; receives compensa-
tion from editorial board activities of JAMA Neurology; and receives
research support from NIH. A. Iranza reports no disclosures relevant
to the manuscript. K. Kantarci serves on the Data Safety Monitoring
Board for Takeda Pharmaceuticals. She is funded by the NIH. D. Kaufer
served as a consultant to Janssen Research and Development and was
a member of the Scientific Advisory Board of the FTLD Disorders Registry.
He currently serves as a consultant to Axovant Sciences, Inc., as a member of
the Scientific Advisory Board of the FTLD Disorders Registry, is a member
of the Scientific Advisory Council of the Lewy Body Dementia Associ-
aton, and is a member of the Board of Directors of Alzheimer’s North
Carolina. He receives research support from NIH, TauRx Therapeutics,
Navidea Biopharmaceuticals, Axovant Sciences, Neurim Pharmaceuticals,
and AbbVie. W. Frisoni is a member of the Scientific Advisory Board of NIH grant U101
AG016796 “National Alzheimer’s Coordinating Center” and has no
other relevant disclosures. He is a Senior Associate Editor for Alzheimer’s
and Dementia and is also on the editorial board of Alzheimer’s Disease and
Associated Disorders (nonnumerated positions). V. Lee may accrue rev-
ue in the future on patents submitted by the University of Pennsylvania
wherein she is coinventor and she received revenue from the sale of
Avid to El Lilly as coinventor on imaging-related patents submitted by
the University of Pennsylvania. She receives research support from the
NIH, GSK, Janssen, Biogen, and several nonprofits. J. Leverenz has
served as a consultant for Axovant, GE Healthcare, Navidea Biopharma-
cuticals, and Takeda and is funded by grants from the Alzheimer’s Drug
Discovery Fund, Genzyme/Sanoﬁ, Jane and Lee Seidman Fund, Lewy
Body Dementia Association, Michael J. Fox Foundation, and NIH
(BR1AG051495, R50NS062684, U01NS106610). S. Lewin, C. Lippa, and
A. Lande report no disclosures relevant to the manuscript. M. Ma-
sella has no disclosures relating to this work. Outside of this work, Dr.
Maselli served as an Associate Editor for Current Pain and Panreal Medicine;
served as an advisor to Biscove Medical Imaging CRO, UCB, and GE Healthcare; received honoraria and travel/accom-
modations/meeting expenses from Novartis and Teva; received royalties
from Henry Stewart Talks Ltd.; received peer-reviewed research grants
from Canadian Institutes of Health Research, Early Researcher Award,
Ministry of Economic Development and Innovation of Ontario, Ontario
Brain Institute, Sunnybrook AFP Innovation Fund, Alzheimer’s Drug
Discovery Foundation (ADDF), Brain Canada, Heart and Stroke
Foundation Centre for Stroke Recovery, Weston Brain Institute, and
Washington University; received investigator-initiated research support
from Teva; received contract research support from Axovant; and received
salary support from the Department of Medicine at Stanford Health
Sciences Centre and University of Toronto and from the Sunnybrook
Foundation. In addition, Dr. Maselli has a patent US 14/074,606 pend-
ing, a patent PCT/US15/023618 pending, a patent AR 2015010810 pending, and a patent TW 104110766 pending. E. Maultz and P.
McLean report no disclosures relevant to the manuscript. B. Mollenhauer
has received independent research grants from TEVA-Pharma, Dezin,
Boehringer-Ingelheim, and Merck. He currently serves as a paid consultant
from Bayer Schering Pharma AG, Roche, AbbVie, TEVA-Pharma, and
Biogen, and for presentations from GlassSmithKline, Otsuka Pharma,
and TEVA-Pharma, and travel costs from TEVA-Pharma. B.M. is a member
of the executive steering committee of the Parkinson Progression Marker
Initiative of the Michael J. Fox Foundation for Parkinson’s Research and
has received grants from the BMBF, EU, Deutsches Parkinson Vereini-
gung, Michael J. Fox Foundation for Parkinson’s Research, and Stifter-
verband für die deutsche Wissenschaft, and has scientific collaborations
with Roche, Bristol-Myers Squibb, Lilly Lilly, Covance, and Biogen.
T. Montine reports no disclosures relevant to the manuscript. E. Moreno
is a full employee of GE Healthcare and has been involved in the clinical
development of DaTSCAN for the diagnosis of DLB. E. Morl received
honoraria from serving on the scientific advisory board of Eisai, grants
and personal fees from Eisai, Daiichi Sankyo, Novartis, and FUJIFILM
Bi, and personal fees from Johnson & Johnson, Otsu, and Niland Medi-
Physics. M. Murray is funded by the Ed and Edith Moore Alzheimer’s
Disease Research Program (6AZ01) and Gerstner Family Career Devel-
opment Award. J. O’Brien has acted as a consultant for GE Healthcare,
Cytorx, TauRx, Axona, Piramal, and Lilly and has received grants from
Avid (Lilly). S. Orito received honoraria for sponsored lectures from
FUJIFILM Bi Pharma Co Ltd. R. Postuma received grants from the
Fondation de la Recherche en Santé du Canada, Personalized Medicine,
Institutes of Health Research, the Weston Foundation, as well as funding for consultancy

Neurology 89  July 4, 2017
98
REFERENCES


Neurology 89 July 4, 2017 99