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Review of the Efficacy of Methods in the Early Detection of Vascular Dementia

Daniella G. Maciel, B.A. and Charles J. Golden, Ph.D.

Abstract

Various assessments are used to detect cognitive decline throughout the stages of vascular dementia (VaD); however, the literature lacks a review of assessment efficacy. Early signs of VaD may include a decline in executive functioning, processing speed, attention, visuospatial abilities, and memory retrieval deficits. This review examines peer-reviewed publications addressing the validity and efficacy of widely accepted (and some lesser-known) neuropsychological assessments used to detect cognitive dysfunction in VaD. in addition to some common related medical assessments. Articles reviewed here include selected case-control studies and a case. The Cambridge Cognitive Examination (CAMCOG) and the Montreal Cognitive Assessment (MoCA) surpassed the Mini-Mental Status Examination (MMSE) in the efficacy of early diagnosis. The MMSE and Mattis Dementia Rating Scale (DRS) had good power in diagnostic differentiation. The Clinical Dementia Rating (CDR) effectively detected the early transitional stage prior to the onset of clinical dementia. At the same time, Addenbrooke's Cognitive Examination-III (ACE-III) and the Wechsler Memory Scales (WMS-III) exhibited high diagnostic accuracy and differentiation power, indicating strong efficacy in early detection. Tests like the Clock Drawing Test (CDT), Olfactory Function Test (OFT), and Pocket Smell Test (PST) are valuable complements to other assessments. Results indicated support for the use of multiple assessments to increase diagnostic confidence. Effective methods to detect VaD early may assist in early treatment intervention, and additional exploration of this topic is indicated.

Introduction

Major and mild neurocognitive disorders are denoted by moderate to substantial decline in one or more cognitive domains as defined by the fifth edition of the *Diagnostic and Statistical Manual for Mental Disorders* (American Psychiatric Association [APA], 2013). In vascular neurocognitive disorder, the cognitive deficits are attributable to cerebrovascular events and are often in motor and sensory function domains, complex attention and aspects of executive functioning, and processing speed. However, vascular neurocognitive disorder can be difficult to assess early because cerebrovascular events (large vessel strokes, microvascular disease, and aneurysm) may not be immediately apparent in neuroimaging.

Several additional factors play a role in making vascular dementia difficult to detect early on. One reason is the task of differentiating a diagnosis of VaD from other neurocognitive disorders or medical conditions. For instance, the onset of motor symptoms such as impaired coordination and balance for VaD may occur at an earlier age post-stroke than Alzheimer's disease (AD;

Alzheimer's Association, n.d.). In addition, the time from initial presentation of symptoms to a formal diagnosis for early-onset dementia is considerably longer than late-onset dementia (4.4 years and 2.8 years, respectively; van Vliet et al., 2013). This may be because caregivers and physicians attribute early symptoms to non-dementia causes, such as psychological, psychiatric, or medical comorbidities, or medication use. Of note, the recognition of mixed dementia (such as VaD comorbid with AD) has become increasingly common (Bowler, 2007). This also highlights the need for clinicians to utilize assessments that can facilitate diagnostic differentiation in early efforts to detect vascular dementia.

Early detection of vascular dementia may be facilitated by a noticeable decline in cognitive and physical functioning that occurs in a stepwise fashion after a cerebrovascular event, which may be confirmed by neuroimaging, as opposed to the gradual progression in AD, Parkinson's dementia, and Lewy Body dementia (APA, 2013). In addition to the presence of cerebrovascular events, vascular neurocognitive disorder is usually differentiated from other neurocognitive disorders by early motor and mood changes (commonly including apathy), focal deficits, and better episodic memory retrieval and recognition abilities (Chan et al., 2008; Alzheimer's Association, n.d.; Traykov et al., 2005). VaD is also influenced less by hereditary factors and more by vascular risk factors than other neurocognitive disorders such as young-onset AD or Frontotemporal dementia (FTD; Alzheimer's Society, n.d.). A physician may distinguish features of probable VaD from other dementias due to more noticeable difficulties with processing information, maintaining attention, and executive functioning that interferes with making decisions and planning or organizing tasks (Kumral & Özgören, 2017). Distinct behavioral changes, memory and language deficits, and movement symptoms such as shuffling gait and rigid posture vary more and are less prominent in cases of VaD compared to cases of FTD, AD, and Lewy Body dementia, respectively (Alzheimer's Society, n.d.; Alzheimer’s Association, n.d.).

Additionally, it is essential to establish the differences between subsets of neurocognitive impairments and disorders. The DSM-5 coined the novel term major neurocognitive disorder (NCD), previously known as dementia (APA, 2013). Dementia is a group of symptoms that can be diagnosed when at least one cognitive ability (concentration, learning, memory, language, executive function, perceptual-motor function, or social cognition) is disturbed severely enough to interfere with independence. What differentiates major from mild neurocognitive disorder is whether an individual exhibits profound cognitive impairment or modest cognitive impairment, leading to a loss of independence or maintenance of independent functioning but may require compensatory strategies, respectively (APA, 2013). In the literature, the term mild cognitive impairment (MCI) has often been used interchangeably with mild NCD. However, MCI research was conducted in geriatric populations instead of all age groups, as used in mild NCD (Stokin et al., 2015). Cognitive impairment that exceeds what is expected of everyday functioning for an individual's age and level of education but does not meet dementia criteria may indicate that the individual's cognitive decline meets the criteria for MCI (Stokin et al., 2015). It is also important to note that individuals with MCI are typically classified as a group at high risk for dementia which suggests that assessing for MCI could aid in identifying an early stage of disease progression (Stokin et al., 2015).

Research that clarifies assessment discrepancies for diagnostic use in clinical settings is lackluster, which calls for further analysis. Furthermore, early detection of vascular dementia allows for the expeditious implementation of treatment in the form of medication, therapeutic interventions in compensatory strategies, and accommodations for patients to prevent further cognitive decline. Therefore, this review aims to compare early vascular neurocognitive disorder

detection methods and to reach a broad understanding of what assessments aid clinicians in making the most accurate diagnosis.

Methodology

The best approach to fulfilling the objective of this review was to seek out scholarly articles that combined quantitative and qualitative research findings on the efficacies of various neuropsychological assessments. The existing data gathered for this exploratory and methodological review was collected through the EBSCO and the ScienceDirect database. All scholarly articles were collected from peer-reviewed journals. The research findings gathered primarily derived from meta-analysis, systematic reviews, case studies, case-control studies, and cohort studies involving older adult study participants aged 55 and above. Articles reviewed were dated from 1998 to the most recent research published in 2020. Research articles that included outdated tests and assessments that do not apply to present-day use by clinicians were excluded. Search criteria were based on the following keywords: “vascular dementia”; “vascular neurocognitive disorder”; “early detection or early diagnosis or early identification”; “early cognitive decline or early cognitive impairment”; "assessment or neuropsychological assessment"; and "efficacy." These keywords were searched in various combinations to broaden search yield.

Articles that focused solely on late-stage vascular dementia, non-vascular dementia types, surgically treatable medical conditions, and organic mental disorders were also excluded to prevent discussion beyond the scope of this review. Lastly, neuropsychological assessments that were administered in combination with or integrated with other neuropsychological assessments to diagnose vascular neurocognitive disorder were excluded not to overlap discussion on efficacy.

Although most research studies included in this review were completed within the United States, research was not limited to American populations. Some studies from other countries were translated into English and included in this review to expand the literature on assessment efficacy, consistency, and validity when applied to different populations. Upon limiting the research articles to diagnostic criteria from DSM-III-R, DSM-IV, and DSM-5, a total of 14 articles were selected for review to gather information on the efficacy of 10 neuropsychological assessments, and a total of six articles were briefly reviewed to supplement discussion on commonly used medical assessments.

Early Signs of Vascular Dementia

Vascular neurocognitive disorder is the second most common dementia behind Alzheimer's disease. In the U.K. alone, around 150,000 people are affected by vascular dementia, according to the Alzheimer’s Society (n.d.). Reduced blood flow to the brain leading to cell death can cause vascular dementia and be attributable to a "...single strategic infarct, multiple cortical or lacunar infarcts or a microvascular insult...” as described by Grossmann et al. (2006). Even with the advent of computerized tomography (CT) and magnetic resonance imagining (MRI), a diagnosis of vascular dementia cannot be implied or entirely determined without neuropsychological testing (Grossman et al., 2006). While the symptom presentation of a major or mild vascular neurocognitive disorder is mainly dependent on the specific location of brain lesions, typical clinical features of the disorder can become evident early on, including executive functioning and attention deficits as well as slowed motor performance and information processing (Kumral & Özgören, 2017). Some early signs of vascular dementia can include problems with concentration, planning, and decision-making difficulties, struggles with comprehension, language disruptions, visuospatial deficits, changes in mood or behavior including apathy, and while less common for

vascular neurocognitive disorder compared to Alzheimer's disease, problems with memory may also be present (Robinson et al., 2015). Although it may be an early presenting feature, something important to note is that memory has been excluded from DSM-5's criteria for dementia (APA, 2013).

As clinicians and health care providers find barriers to knowledge in distinguishing early signs of Alzheimer's disease from vascular dementia in diagnosis, a great need for effective assessments presents itself. Research conducted in a 2018 study aimed to clarify the link between Alzheimer's dementia and early vascular risk factors, which further suggests overlap with these two neurocognitive disorders (Williams et al., 2018). This study found that individuals exhibiting vascular risk factors, such as smoking, had lower accuracy scores on the cognitive domains measured within the Computerized Assessment of Memory and Cognitive Impairment (CAMGI), including attention, executive functioning, and even memory, which can be a feature of vascular dementia (although less prominent than in Alzheimer's disease).

Seventeen to 20 percent of all dementias among the older population are accounted for by vascular neurocognitive disorder (Venkat et al., 2015). A study conducted in 2007 by Plassman et al. utilized a nationally representative sample to find the prevalence of a variety of dementias in the U.S., and an estimated 594,000 cases of vascular neurocognitive disorder were found. While vascular neurocognitive disorder symptoms typically have an abrupt onset and showcase a stepwise decline in cognition, they can be classified into eight types based on varying etiology and clinical aspects. The prevalence of vascular dementia, along with the variety of clinical features associated with this disorder's impact on cognition, suggests the need for early detection through effective neuropsychological assessments to facilitate early intervention.

Assessments Utilized for the Early Detection of Vascular Dementia

Mini-Mental Status Examination. A popular assessment of cognitive functioning is the Mini-Mental Status Examination (MMSE). The universal use of the MMSE is primarily due to the screening's brief 30-point scale in measuring the presence and severity of cognitive impairment over time. There ismuch cognitive overlap between Alzheimer's disease (AD) and early features of vascular dementia (VaD), with scores of 23 or below indicating mild cognitive impairment for a possible diagnosis of dementia. However, there is not enough specificity with this initial screening measure. As noted in 1999 by Pasquier, the MMSE lacks timed elements that would aid in assessing processing speed, executive functioning, and mental slowing, common features of vascular neurocognitive disorder. Furthermore, de Koning et al. indicated in a 1998 study that the MMSE, while sufficient in diagnosing left-sided stroke patients, has an apparent diagnostic weakness when assessing patients with right-sided strokes for cognitive impairment. A meta-analysis conducted by Mitchell (2008) stated that the MMSE had "very limited value" in detecting mild cognitive impairment, which is vital in assessing early features of vascular dementia.

With these deficiencies noted, a qualitative analysis of the Pentagon task in the MMSE conducted in 2018 evaluated tests efficacy in diagnostic differentiation (Lo Buono et al., 2018). The study primarily focused on the different methods of qualitative scoring on the Pentagon Copying Test within the MMSE and the progression of visual constructive apraxia in VaD compared to AD. For two years, 50 patients with vascular dementia and 50 patients with Alzheimer's dementia were assessed using the MMSE at the basal visit and again after one year. Five criteria measured for the proper execution of pentagon copying included: number of corners, intersection, closing and opening of outline, pentagon rotation, and "closing in." Scores were evaluated for both AD and VaD groups by two neuropsychologists.

By utilizing intragroup analysis, significant differences were found in the total qualitative and MMSE scores from the basal (T0) to one-year visit (T1) for the VaD group. VaD patients showed diminished performance on the Pentagon Copying tasks, particularly in the number of angles, intersection/distance, closure/opening, and rotation scores, while for AD patients, only closure/opening and rotation scores were significantly different from T0 to T1. The number of angles and "closing-in" scores remained constant for AD patients at both times. An analysis of diagnostic accuracy, the MMSE had a more remarkable classification ability to differentiate AD from VaD. Correlation analysis was used to conclude that the total qualitative score was correlated with age in the group with VaD but not for the AD group, which further explained the differences. Ultimately, these features of cognitive decline worsened at a more rapid rate in VaD patients than in AD patients, which aided in diagnostic differentiation.

This study examined the Pentagon Copying task within the MMSE and expanded data on the qualitative differences in drawings for different dementia types. The research contributed to previous findings of visuoconstructive deficits prevalent in VaD as the Pentagon Copying task can reveal the perseverations, simplifications, and spatial distortions that typically appear in their drawings. In addition, evaluation of the significant differences in the pentagon drawings between VaD and AD groups showcased the relevance of this research in determining that the MMSE is a sensitive measure for assessing visuoconstructive abilities early on, which presents as a greater vulnerability for patients with VaD compared to AD.

Mattis Dementia Rating Scale. Pasquier's (1999) study indicated a preference for utilizing the Mattis Dementia Rating Scale (DRS) on impaired geriatric patients to detect the possible existence of brain pathology. This brief assessment, like the MMSE, tracks cognitive status over time but includes broader measures of cognitive functioning, including complex attention, conceptualization, memory, and construction, which can strengthen the test's efficacy in assessing vascular dementia.

While the DRS has high test-retest reliability according to Mattis (1976) and is sensitive to frontal and frontal-subcortical dysfunctions, which can aid in early detection of vascular dementia, a 1999 study conducted on an elderly population to evaluate its efficacy in diagnostic differentiation suggested less promising results (Donnelly & Grohmann, 1999). By evaluating and comparing 58 patients with probable VaD to 62 patients with probable AD, 57 patients with major depression, and 31 healthy controls using the DRS, Donnelly and Grohmann (1999) found that the DRS had strengths in distinguishing true dementia from late-onset depression. However, the only factor discriminating between vascular dementia and Alzheimer's disease was the performance on memory tasks, significantly weaker for participants who presented with AD. These findings suggest that while the DRS on its own may not be as sensitive for distinguishing VaD from AD, it could be a helpful tool to assist in the process of diagnostic differentiation (Donnelly & Grohman, 1999).

Lukatela and colleagues (2000) evaluated the differences in cognitive dysfunction for patients with AD and VaD as measured by the DRS. Specific areas of cognitive dysfunction are assessed within the DRS when used as a dementia screener, including attention, initiation/perseveration, conceptualization, construction, and memory. Patients with AD were predicted to perform worse on memory tasks within the DRS than VaD as memory impairment is a central feature of AD. Considering that declines in frontal executive functions (problem-solving, abstract thinking, and motor programming) are central features of VaD, Lukatela et al. (2000) hypothesized that tasks requiring frontal functioning and motor involvement (e.g., DRS-Constructive and DRS-Initiation/Perseveration scales) would be more severely impaired for VaD

patients compared to AD patients. Of the 245 patients sampled, the DRS assessment was conducted on 89 patients with a single stroke, 70 patients with multiple infarctions after at least one month of most recent cerebrovascular accident, and 86 patients with AD within one month of diagnosis. Using MRI, the location of each cortical infarction was assessed for each patient with single or multiple infarcts that comprised the VaD group. Patients with mixed dementia were excluded from the study to prevent overlapping etiologies, and 59 healthy controls were a part of the control group.

A between-group ANOVA revealed that all three groups performed significantly worse on the DRS than healthy controls, which indicates the usefulness of the DRS in differentiating patients with dementia from patients without dementia by using a cut-off score of 123 on the DRS. While VaD and AD patients performed similarly on the attention scale, the study utilized post hoc analyses to conclude that VaD and AD patients significantly differed in performance on the other tasks measured by the DRS, which indicates good diagnostic differentiation power. The DRS-Memory scale, in particular, was superior to the other scales in differentiating the AD from both VaD groups. By evaluating specific memory tasks, Lukatela et al. (2000) concluded that the multiple infarction group performed worse than the single stroke group, specifically for the sentence recall task. Performance on sentence recall and design recognition within this scale was the worst for patients with AD, confirming initial hypotheses and revealing a strength of the DRS-Memory scale in assessing specific types of memory impairments (Lukatela et al., 2000).

Moreover, on the DRS-Construction scale, AD patients performed significantly better than patients in both VaD groups, which implies this scale that assesses motor involvement can help differentiate dementia type. AD patients also performed worse on the DRS-Conceptualization scale, which could be explained by greater language and visuospatial abilities impairments than patients with multiple infarctions. Finally, depending on the subtype of VaD, the DRS-Initiation/Perseveration scale effectively differentiated qualitative deficits. While patients with multiple infarctions performed significantly worse on this scale than patients with AD, patients with a single stroke did not perform significantly differently from the AD group. This finding suggests that without a neuroimaging technique to confirm the VaD subtype, the DRS-Initiation/Perseveration scale may not be optimal for early differentiation.

However, Lukatela et al. (2000) discussed how the DRS could differentiate between cortical and subcortical dementia, especially in the context of more frequent subcortical lesions found in patients with multiple infarctions. Overall, findings indicate that the DRS, especially when utilized to assess for differences in memory deficits, can be a quality tool for clinicians to use for early detection and to reach a diagnosis of vascular dementia.

Cambridge Cognitive Examination. The Cambridge Examination for Mental Disorders of the Elderly (CAMDEX) is a standardized measure often utilized to assess and diagnose individuals with possible dementia. In addition, a brief neuropsychological battery to globally assess cognitive functioning is the Cambridge Cognitive Examination (CAMCOG) that composes a self-contained section of the CAMDEX. In a 1998 study conducted in the Netherlands, de Koning et al. assessed for and compared the diagnostic accuracy of the CAMCOG compared to the MMSE for dementia in patients 3 to 9 months post-stroke. Patients 55 years or older with a recent transient ischemic attack, ischemic stroke, or primary intracerebral hemorrhage were selected. The CAMCOG and the MMSE were administered to all 284 patients independent of the extensive diagnostic procedures used to confirm the diagnosis.

Three-quarters of the patients with dementia were diagnosed with possible or probable vascular dementia. Compared to patients without a diagnosis of dementia, on average, patients

with dementia scored 25 points less on the CAMCOG, which was significant. In screening for vascular neurocognitive disorder, de Koning et al. (1998) acknowledged the CAMCOG's original design that served to reliably differentiate between healthy functioning individuals from individuals with dementia and extended the field of research by assessing its diagnostic value specifically for post-stroke patients. In addition, the CAMCOG indicated strong validity as age, gender, and education did not influence the variability of test scores.

This supported the conclusion that the CAMCOG (when adjusting for stroke type and localization) was significantly more accurate than the MMSE in predicting early diagnosis after a recent stroke. This study revealed strong support for CAMCOG accuracy over and above the diagnostic power of the MMSE. Another advantage that the CAMCOG has over the MMSE is the screening measure's more comprehensive inclusive range of cognitive functions such as orientation, expressive and comprehensive language, memory, attention, calculation, praxis, abstraction, and perception that are not present on the MMSE and the range of possible scores is larger. Clinicians may find the CAMCOG to be a more helpful tool when assessing for various features that may be present and indicative of broader cognitive dysfunction.

Despite the clear strengths presented from this study, there were problems with the CAMCOG regarding the possible overestimation of dementia risk in patients with left hemispheric strokes. This study also indicated that test results from patients with severe aphasia, many of which were not excluded from this study, rendered the CAMCOG scores meaningless due to score interpretation difficulties in ascertaining whether the cognitive impairment was attributable to dementia or aphasia. These two distinct revelations suggest the potential risk for misdiagnosis when using this measure. This being acknowledged, aphasia is less likely to be exhibited as a feature of vascular neurocognitive disorder than Alzheimer's disease, which may signify a discerning factor.

Olfactory Function Test. A case study was conducted in 2020 regarding implementing a lesser-known assessment, the Olfactory Function Test (OFT), that is often used to diagnose Alzheimer's disease (Suh et al., 2020). The high prevalence of individuals with Alzheimer's disease exhibiting deficits in their ability to identify and distinguish odors was estimated to be 100 percent, while for vascular dementia patients, the prevalence was only about 15 percent (Duff et al., 2002). The OFT, which assesses olfactory threshold and odor discrimination and identification, was used on a 75-year-old male who presented with symptoms of anosmia. The patient exhibited no symptoms of dementia except for this abnormal olfactory dysfunction. Upon completion of the test, the patient was diagnosed with anosmia and referred to a neuropsychiatry clinic where the MMSE and Clinical Dementia Rating (CDR) was performed. While the MMSE indicated performance in the normal range, CDR scores, MRI findings, and clinical history lead to a diagnosis of vascular dementia.

The findings from this case study revealed the efficacy of the OFT in detecting early signs of vascular dementia in individuals without symptoms of cognitive decline. Not only did the evaluation of this assessment conclude with promising outcomes for early diagnosis, but the study revealed weaknesses in the MMSE. By evaluating the diagnostic outcome of the patient within this case, without the OFT and MRI scans to confirm vascular etiology, the study concluded that the MMSE on its own would have failed to detect any abnormalities in cognitive functioning and, therefore, to delay diagnosis and early preventative intervention.

However, it is essential to acknowledge the limitations of a case study which calls for further research to be conducted to assess the efficacy of the OFT in clinical trials with larger, representative populations.

Pocket Smell Test. Duff et al. (2002) made a point of acknowledging that vascular dementia patients had greater insight into olfactory deficits compared to Alzheimer's patients when using the Pocket Smell Test (PST), a screening measure like the OFT. The PST was initially utilized to distinguish between a diagnosis of Alzheimer's dementia and major depression among elderly patients with a classification accuracy as high as 97.5 percent, higher than MMSE accuracy ratings. Duff et al. (2002) used the PST in this study to discriminate vascular dementia, Alzheimer's dementia, and major depression (MD) in elderly patients to extend the previous literature. Within this study, three groups were diagnosed as having VaD, AD, or MD, with 20 patients 55 years and older in each group. By excluding patients with medical or psychiatric conditions that could affect olfactory functioning, findings could be confined to having dementia etiology. All patients were given the PST and the MMSE to compare assessment accuracy and usefulness in diagnosis.

Duff et al. (2020) found that AD patients scored significantly lower on the PST compared to VaD patients (15 percent revealed deficits) and MD patients (0 percent revealed deficits), which concluded with the PST's successful discrimination between those three groups. It was found that 90 percent of VaD patients' subjective reports of olfactory dysfunction were consistent with objective testing results. Considering the patients' level of education correlated with MMSE scores for AD and VaD groups, a clinician using the PST may be able to make more straightforward interpretations.

Despite the discriminating power of the PST, vascular damage in the entorhinal cortex and olfactory bulb regions are not as expected compared to the deterioration of these brain regions in the early stages of Alzheimer's disease. It is important to note that the early symptoms of vascular dementia can vary depending on lesion site and scope, making olfactory dysfunction a possible consideration in the early assessment of vascular neurocognitive disorder in the future.

Clinical Dementia Rating Scale. To examine whether the early and late stages of vascular dementia and Alzheimer's dementia vary considerably in the phenotypic presentation was the primary aim of a 2008 study done by Chan et al. As a core method, the validated Clinical Dementia Rating Scale was used to assess dementia severity. A sample population of 343 patients with 103 VaD patients and 116 AD patients were given a global CDR score to stage the severity of dementia for each patient. Memory, orientation, judgment, problem-solving, community affairs, home and hobbies, and personal care were the six dimensions of severity assessed by the CDR. Most of the patients (83.6%) were of Chinese ethnicity.

Chan et al. (2008) concluded that the CDR has good discriminatory ability in mild dementia by extending the study's comparison of dementia from the moderate-severe CDR 2-3 stage to the very mild 0.5 CDR stage. For the VaD patients measured to be in 2-3 CDR stage, worse Geriatric Depression scale scores, and lower Barthel scores measuring self-care functions, gait apraxia, and Parkinsonism, were present. Clinicians using the CDR for patients with these features would find it helpful to confirm the stage of vascular dementia or to determine or modify the treatment plan.

Non-criterion related features, assessed separately from the CDR, including loss of insight, word finding-difficulty, and apathy, were found to be more common among VaD subjects in the early stages of dementia, with apathy present to a significant degree in the very mild 0.5 CDR stage revealing apparent phenotypic differences. Kasai et al. (2012) noted that a CDR of 0.5 is a transitional stage from a healthy, normally functioning individual to a diagnosis of dementia, which is critical to note for early detection. Chan et al. (2008) ultimately described the CDR as "bypass[ing] the limitations" of measuring the cognitive decline in the typical stages of dementia.

A previous study completed in 2007 examined the diagnostic value of the CDR and the measure's agreement analysis with gold-standard dementia diagnostic criteria, the Blessed

Dementia Rating Scale, and the DSM-III-R for detecting dementia severity (Chaves et al., 2007). The CDR was administered to 295 patients from Southern Brazil (121 with AD, 113 with VaD, and 61 with mild cognitive impairment) against 48 healthy elderly adult controls. In addition, the CDR was translated and culturally adapted for this sample population of lower education.

Through agreement analysis, Chaves et al. (2007) concluded support for the CDR's high reliability and interrater agreement, consistent with previous studies involving samples of English-speaking cohorts with higher education. This finding can speak to the usefulness of the CDR in assessing dementia severity in different populations. The CDR was found to have good diagnostic concordance with standard diagnostic criteria (86 percent sensitivity and 100 percent specificity) and a strong correlation with the MMSE. Additionally, the CDR classified questionable dementia at a higher rate than clinical criteria, implying a sensitive and specific measure. Both 2007 and 2008 findings can suggest that while the CDR is a valid and valuable measure for assessing the severity of dementia which is of great value for assessing early signs of cognitive decline, further neuropsychological test batteries may be needed to distinguish VaD from other neurocognitive disorders (Chan et al., 2008; Chaves et al., 2007)

Addenbrooke's Cognitive Examination III. The research on U.K. memory clinic patients aged 75-85 years examined the validity of a lesser-known assessment used for the early detection of dementia, the Addenbrooke's Cognitive Examination-III (ACE-III) (Jubb & Evans, 2015). While significantly correlated with its predecessor, the ACE-Revised (ACE-R), this study sought to identify optimal cut-off values for the ACE-III that would indicate an improvement from the ACE-R's previously established lower optimal cut-off point of 88 that had very low specificity.

The ACE-III is a brief diagnostic measure estimated to take an average of 20 minutes to administer and score the five cognitive domains assessed, including attention, memory, fluency, language, and visuospatial abilities. ACE-III was administered prior to the diagnosis of 59 subjects, and widely accepted diagnostic criteria were used to diagnose 12.5 percent of participants with vascular dementia within the dementia group.

When differentiating between dementia and no-dementia groups, the performance on all five cognitive domains and total ACE-III scores were significantly lower in the dementia group. By evaluating for an optimal alternative cut-off point, Jubb and Evans (2015) determined that a score of 81 out of a total score of 100 points revealed a much-improved specificity and likelihood ratio of dementia which differs from the ACE-R's previously mentioned cut-off score of 88. In addition to previous literature on this measure's efficacy, this study concluded that the ACE-III had high sensitivity and specificity for differentiating patients exhibiting symptoms of early-onset dementia from healthy controls. These results indicated that clinicians could use the ACE-III assessment as a tool with excellent diagnostic accuracy in detecting early dementia that optimized the previous diagnostic accuracy of the ACE-R.

Furthermore, Jubb and Evans (2015) researched the impact of years of education on ACE-III performance to explore any demographic discrepancies within the studied population. As most subjects had at least 11 years of education, an exploratory analysis concluded that the no-dementia group revealed higher total ACE-III scores for the high education group with more than 11 years of full-time education compared to the low education group. In contrast, the dementia group revealed similar prevalence scores between both education groups, with the low education group exhibiting very good diagnostic accuracy and the high education group exhibiting excellent diagnostic accuracy. The researchers took this finding into account to suggest that level of education would need to be considered in future clinical practice with the ACE-III to minimize risks for false positives among patients with lower education and false negatives among patients

with higher education.

The diagnostic efficacy of the ACE-III was evident. However, limitations were also apparent in this particular study, such as the age of participants being significantly higher than on clinical trials from previous literature that implemented the ACE-III, which could have impacted optimal cut-off scores. In addition, only 12.5 percent of subjects were diagnosed with vascular dementia. Although, in contrast, the rest of the subjects were diagnosed with AD or AD with cerebrovascular disease, future research on expanding the administration of the ACE-III to larger populations with a higher incidence of VaD would be impactful.

Ten Point Clock Test. A 2002 study evaluated the efficacy and sensitivity of the Ten Point Clock Test (CDT) indetecting and distinguishing early cognitive impairment in patients with frontotemporal dementia (FTD) from those with Alzheimer's dementia and vascular dementia in correlation with other neuropsychological tests (Moretti et al., 2002). While Clock Drawing Test (i.e., CDT) administrations can vary in what type of cognitive domains are assessed, this screening measure has typically been deemed cost-effective, brief, and reliable by previous literature (Royall et al., 1999). Thirty patients with VaD were given the CDT in which they were required to draw a clockface with the time reading 11:10 inside a previously traced circle.

By evaluating the performance of the patients with vascular dementia, the CDT was not found to have a significant correlation with MMSE results; the correlation was only significant for the AD and FTD patient groups. Instead, positive correlations were present between the CDT and tasks assessing proverb interpretation and phonological fluency within the VaD group.

Vascular dementia patients exhibited the worst performance on phonological fluency tasks, which differed significantly from the AD group performance. A surprising aspect of the research, as evidenced only by the VaD group, was a strong correlation between the CDT and language expression tasks. In examining the performance of VaD patients on phonological tasks and determining that it was not significantly different from the FTD group performance, indicating a possible barrier to differentiation, the CDT could instead be a more sensitive measure in successfully detecting cognitive impairment in mild dementia.

Although the CDT is a widely accepted parametric test, Moretti et al. (2002) were clear to make a note that it "could not be used in isolation" when making a clinical diagnosis. Despite this explicit limitation, this observation is ultimately applicable to most other assessments used to identify dementia as well. Furthermore, the average scores for the CDT across the three groups ranged from 2.96 for AD, 4 for FTD, and 4.23 for VaD, which suggests that the Ten-Point Clock Test has strong potential to aid in the differential diagnosis of VaD, FTD, or AD and to detect symptoms of dementia in the early stages.

Another clinical study conducted a few years later examined the efficacy of the CDT only involving patients with subcortical vascular dementia (Moretti et al., 2005). Moretti and colleagues discussed how the CDT is often classified as a useful screening measure for mild Alzheimer's dementia. Since vascular dementia patients often have superior verbal long-term memory and more significant impairment in frontal executive functioning compared to Alzheimer's patients, this study identified and addressed significant gaps in the literature by examining the CDT's strength in assessing executive function specifically for vascular dementia patients. Researchers predicted that the CDT would be a reliable and effective tool to assess a VaD patient's frontal executive functioning abilities and visuospatial reasoning involved with space perception. Impairments in these cognitive abilities likely result from frontal-subcortical loop disconnections through cerebrovascular events.

By following a sample of 144 vascular dementia patients for 24 months, Moretti et al.

(2005) assessed how other neuropsychological and functional tests such as the MMSE, Proverbs Test, knowledge-of-self-evaluation, word fluency tests, and visuospatial tests correlated with scores on the CDT. All test batteries listed were administered at baseline, at 12 months, and finally at 24 months to determine any changes in performance over time.

Interestingly, vascular dementia patients will typically mix left and right hemispheres when drawing numbers on the clock and have more trouble reading time correctly than AD patients. Furthermore, strong correlations between CDT scores and visuospatial perception, semantic and phonological abilities specific to frontal executive function, as well as left and right-space recognition, were found to support the study's hypothesis. This implies that the deficits in space perception exhibited among patients with VaD differ mainly from patients with AD and can be detected by the CDT, indicating a potential strength the CDT has in assisting clinicians with diagnostic differentiation.

Montreal Cognitive Assessment. In the context of the MMSE falling short of its suitability to detect very mild cognitive impairment prior to the onset of dementia, a 2012 study examined the efficacy of the Montreal Cognitive Assessment (MoCA) in various components (Kasai et al., 2012). Like the MMSE, the MoCA is an easy-to-administer assessment that is relatively brief and estimated to take around 20 minutes to administer. Executive functioning/visuospatial, naming, memory, abstraction, delayed recall, attention, language, and orientation compose the eight subscales assessed in the MoCA. Kasai and colleagues evaluated the MoCA's strength in screening 184 patients above 75 years of age with a CDR of 0.5 for mild cognitive impairment in efforts to expand the previous literature. In addition, by dividing the group of 184 patients into very mild subcortical vascular dementia (vmSVD) and other types of dementia, the researchers could pinpoint the characteristics of people with vmSVD.

By comparing the MoCA to the MMSE, the MoCA was found to have greater specificity, positive and negative predictive value but lower sensitivity. Based on MoCA scores, CDR effects on visuospatial/executive functioning, attention, and delayed recall subscales were statistically significant, suggesting strength in detecting impairments in these cognitive tasks. However, Kasai et al. (2012) concluded MMSE scores detected mild cognitive impairment well, and the MoCA was not a superior assessment in this regard. These findings were inconsistent with later research that concluded the MMSE continued to fall short of detecting mild cognitive impairment and the MoCA better met the criteria suited for early screening tests, particularly for subjects aged 60 and above (Ciesielska et al., 2016).

Kasai et al.'s (2012) study also examined the association between MoCA scores and the presence of infarction along with the MoCA's ability to detect very mild subcortical vascular dementia characteristics in patients. No significant infarction effects were found to be associated with the MoCA or the MMSE, which suggests similar efficacy in detecting the cognitive impact of potential infarction presence. Although only twelve out of 392 participants had large cortical infarctions, these individuals had significantly lower MoCA scores than subjects without infarctions. Considering these large cortical infarcts were revealed by MRI scans in different cortical sites depending on the participant, these findings indicate a potential area for further research into how specific brain lesions affected MoCA subscale scores.

Furthermore, this study supports the aim of this review by showcasing that significantly lower total MoCA scores were found for the 37 participants with vmSVD, compared to 147 subjects with other types of dementia who also shared a 0.5 CDR score, and 164 healthy controls. Nevertheless, the efficacy of the MoCA is comparable to the MMSE in detecting patients with vmSVD characteristics, revealing a potential solid alternative for clinicians to administer

compared to the latter widely used assessment.

Additionally, with the problematic ceiling effect of the MMSE, the MoCA was found more sensitive in picking up vascular cognitive impairment, according to two studies published in 2012 by Pendlebury et al. The MoCA attention subscale, in particular, contains working memory and attention tasks. Consistent with the commonly reported cognitive deficitsof vmSVD patients, Kasai et al. (2012) examined large strokes within the hypersensitive thalamic-cortical network to conclude that they were related to deficits in attention and short-term memory. This finding displays the ability of the MoCA attention subscale to detect these early dementia characteristics and the MoCA's usefulness as a good screening test.

Despite its frequency of occurrence, declines in cognitive functioning can go undetected post-cerebrovascular accident. This intensifies the need for extensive and efficacious screening measures and improvements in assessments like the MoCA. An up-to-date study completed in 2020 by Zaidi et al. examined the MoCA's clinical utility in detecting cognitive impairment among a group of 161 individuals at three months post-stroke. This study implemented a unique 3-category approach in which subjects were classified as having a high, low, or indeterminate probability of cognitive impairment. According to MoCA scores, 48 percent of subjects were classified in the indeterminate group, and to improve group classification, a processing speed subscale was added. This particular subscale addition to the MoCA only slightly extended administration procedure yet significantly increased confidence in classification outcome that was worth noting for this review to aid clinicians in the early detection of vascular dementia.

Wechsler Memory Scale-3rd Edition. While the North American version of the Wechsler Memory Scale-3rd Edition (WMS-III) has been validated by previous studies, a study done in Portugal aimed to evaluate the utility of the Portuguese version of the WMS-III among the elderly population suffering from dementia (Gonçalves et al., 2017). Moreover, the study analyzed the assessment's capacity to detect and differentiate between AD and subcortical vascular dementia (SVD) among patients exhibiting early-stage dementia. While it is known that memory impairments are not commonly pronounced cognitive features of vascular dementia, especially in early cases, impairments in executive functioning can reflect greater problems with memory retrieval.

Cerebrovascular events causing regional damage to the lateral frontal cortex can affect working memory and long-term episodic memory retrieval and encoding (Fletcher & Henson, 2001). These neurological research findings suggest the importance of assessing for memory impairment in patients showcasing possible signs of early vascular dementia.

Of the ninety-two subjects comprising this study's clinical sample, 16 patients with probable VaD, 36 patients with probable AD, and 40 healthy controls were included. All study participants ranged from 65 to 91 years of age. Patients with severe depressive symptomatology were excluded to avoid confusing memory impairment as a by-product of mental disorder instead of cerebrovascular etiology. The WMS-III was administered after group assignments to assess specific memory components of patients and not to make a diagnosis. To make a diagnosis, extensive clinical, cognitive, and medical evaluation, including CT or MRI scans, were used.

The subtests within the WMS-III measure accumulated scores on immediate recall, delayed recall and recognition, attention, and working memory, along with primary indices and auditory processing composites in summary. Due to frontal white matter and basal ganglia damage, impaired immediate and working memory and recognition deficits were hypothesized to be greater for the SVD subjects compared to AD subjects, considering more cognitive resources would likely need to be allocated for attention. However, patients with AD were hypothesized to have more

significant impairments in delayed memory and overall memory than SVD patients.

By examining specific memory task performance, Gonçalves et al. (2017) revealed that performance on the indices was better for SVD patients than AD patients concluding the WMS-III's strength in facilitating differentiation. However, in terms of average scores on the working memory index, AD subjects exhibited more robust performance than VaD subjects, inconsistent with predictions. Findings also indicated that the working memory index had the least diagnostic accuracy, which implies the need for further investigation and possible index revision for clinician use. Confirming their hypothesis, AD patients performed worse on delayed memory indices, and SVD patients were found to have problems with information retrieval. The indices that distinguished SVD patients from controls best included the visual immediate, immediate memory, and working memory indexes. Approximately 81 percent of patients with SVD were accurately identified and distinguished from healthy participants using the letter-number sequencing subtest cut-off score, which supported the subtest's strength in specificity and discrimination power. Overall, most indices within the WMS-III are well-equipped to detect all cases of AD and SVD, making the WMS-III a good measure for clinicians to use.

An evident limitation of the study that could have impacted WMS-III scores was that the AD, SVD, and healthy control groups differed in education, with the SVD participants being the least educated. It is possible that due to lower levels of education among the SVD group, performance on the vocabulary subtest that reflects crystallized intelligence was lower than in the AD group. It could have also been due to possible infarctions in the left hemisphere of the brain among the SVD patients, but the study could not gather enough evidence to clarify an explanation for this. Although this study made efforts to control for potential confounding effects of education level by producing a subsequent analysis that included education as a covariate, it would be ideal for future studies to correct these discrepancies.

Despite limitations, the WMS-III has an obvious advantage as an assessment since it incorporates measures that aid in executive functioning analysis, further reiterating limitations of the MMSE that is not sensitive enough to detect SVD. The auditory recognition delayed index was the most decisive measure for differentiating SVD patients from AD patients. WMS-III results can confirm that individuals with SVD typically have inadequate retrieval abilities but the adequate capacity to store and encode information which further assists clinicians in dementia differentiation in the early stages. Findings from this research provide sufficient support for the Portuguese version of the WMS-III as a valid measure presenting good internal consistency with the North American version.

Brief Review of Common Medical Assessments for Vascular Dementia Diagnosis

According to the DSM-5, a probable vascular neurocognitive disorder diagnosis considers neuroimaging evidence, clinical history, and genetic evidence of cerebrovascular disease (APA, 2013). MRI and CT scans help to confirm a diagnosis of vascular dementia by ruling out causes of cognitive impairment that can be treatable by surgical means such as subdural hematoma, tumor, or fluid build-up inside the brain (van Straaten et al., 2004). To effectively discuss these medical techniques that share a goal of differentiation and accurate diagnosis of VaD, it would be beneficial to note the clear distinctions between the efficacy of CT and MRI scans.

Magnetic resonance imaging. MRI scans serve the purpose of gathering information on blood vessel damage and can show shrinkage of cerebral tissue in specific regions of the brain (van Straaten et al., 2004). A typical coronal T1-weighted MRI scan protocol would take vertical slices of the brain from the back towards the front of the brain to find evidence of atrophy, cortical

infarctions, andlacunes.

Fluid-Attenuated Inversion Recovery (FLAIR). This particular type of MRI sequence method is not to be used in isolation, considering some thalamic areas and regions below the tentorium containing lesions may go undetected. To detect intracerebral hemorrhages and calcifications that could be affecting cognition, another type of MRI sequence called axial T2 gradient-echo images might be used.

While CT scans are preferable to MRI scans to rule out disorders that are treatable by surgery, MRI has strength in revealing more detailed information on vascular lesions, including lesions that are more difficult to detect using CT scans. Specifically, CT scans have difficulty finding lesions in areas of the temporal lobe. Furthermore, MRI scans are helpful to distinguish between the different causes and types of VaD, such as 'pure' or 'mixed' dementia. Finally, MRI scans have another advantage: by having the power to scan the brain in several anatomical planes, atrophy and other specific pathology types can be found, which is essential for medical professionals to confirm a vascular dementia diagnosis.

Computerized tomography. CT scans of the brain are used by physicians to identify cerebral structures that block x-ray beams through data that is gathered and interpreted by computer-based tomographic reconstruction (Pasi et al., 2011). Although in less fine detail than provided by MRI scans, structural abnormalities such as lesions or abnormal tissue growths consistent with cancer can be identified. Noncontrast CT images could also help to support a clinical diagnosis of dementia.

A 2014 analysis by Bermingham found that CT scans have moderate to high accuracy in discriminating VaD from other types of dementia. By reviewing patient histories from146 cases who met criteria for dementia by DSM-IV standards, the utilization of CT scans allowed for the revision of 12 percent of the diagnosis to include or exclude vascular components, Alzheimer's disease, or structural lesion as the cause for cognitive decline (Condefer et al., 2004). Although this finding impacted only around 2 percent of the cases, changes in diagnosis due to CT analysis led to changes in treatment decisions for those particular patients, which emphasizes the importance of catching diagnostic discrepancies early on. In addition, the study disputed claims of MRI scans having a clear superiority over CT scans in detecting dementia with vascular components, indicating there was a lack of evidence to support this.

Positron emission tomography. In contrast to both MRI and CT scans, Positron emission tomography (PET) scans utilize radioactive substances that help track regions exhibiting evident reductions in glucose metabolism to identify areas of atrophy within the brain (Bermingham, 2014).Significant increases in glucose uptake or abnormalities in glucose metabolism can indicate neoplasms, or abnormal tissue growths, in the brain that could help to explain cognitive decline from vascular components. However, Health Quality Ontario (Bermingham, 2014) reported that despite how PET scans can be used as "stand-alone devices", in 2013 in Canada, PET scans were only approved to screen for lung and colorectal cancers, indicating a considerable limitation in this study.

Based on a recent study conducted in 2020, individuals with cardiovascular risk factors demonstrate lowered glucose uptake and altered global brain metabolism compared to healthy controls (Borja et al., 2020). Considering PET scans can track patterns of F-fluorodeoxyglucose (FDG) uptake in the brain, this tracer was noted as an excellent molecular biomarker to detect functional alterations in cognition that are consistent with features of vascular dementia. Using PET scans, differences in metabolic activity and the consequences of atherosclerosis in the brain can be assessed in patients with dementia and declining mental functioning compared to healthy

individuals.

It is essential to acknowledge that the most significant risk factor for stroke and a potential contributing factor to the development of small vessel disease is atherosclerosis (Bos et al., 2015). While CT and MRI scans can identify large plaques within the brain that can impact cognitive function, Borja et al. (2020) emphasized that these plaques are typically present only during the late stages of the disease. Therefore, PET scans may be a powerful tool to diagnose early atherosclerosis and detect brain inflammation leading to stroke and vascular dementia before irreversible damage and cognitive loss.

Electroencephalogram. Vascular dementia and other declines in mental functioning can be associated with changes in electrical activity in the brain, as discussed by Al-Qazzaz, Ali, Ahmad, Chellappan, Islam, and Escudero (2014). Neurophysiological biomarkers such as electroencephalograms (EEG) can detect these neural changes. EEG rapidly tracks information processing within the brain and provides precise localization that further aids in the clinical interpretation of dementia presence and severity. Additionally, EEG has a high temporal resolution, an advantage over the other neuroimaging techniques mentioned. In contrast, lower spatial resolution is characteristic of EEG, which presents a disadvantage.

EEG signals can detect various brain waves that aid in the early diagnosis and differentiation of vascular dementia from other disorders like AD (Al-Qazzaz, Ali, Ahmad, Chellappan, Islam, & Escudero, 2014). Delta waves, for example, commonly occur in serious organic brain diseases; as delta waves increase in density, glucose metabolism within the brain decreases, and vice versa. This represents an inverse relationship frequently demonstrated in cerebrovascular diseases and as an outcome of dementia. Theta waves measured by EEGs are typically present during activities that require mental effort, attention, and information processing. Therefore, increases in theta wave power can indicate cognitive impairment associated with dementia. Alpha waves, composed of various subunits, help physicians determine dementia severity. Al-Qazzaz, Ali, Ahmad, Chellappan, Islam, and Escudero (2014) determined that EEG signal analysis detects hidden brain abnormalities by providing quantitative data over “mere visual inspection," which is useful when confirming an early diagnosis.

Wang et al. (2019) combined EEG measures and machine learning methods to differentiate patients with early vascular dementia from healthy controls. Patterns of brain connectivity and spontaneous and evoked brain activity typically operate abnormally in patients with vascular dementia. To improve the efficacy of EEG signal analysis in identifying pathological changes within the brain, the authors suggested combining machine learning methods such as linear discriminant analysis, back-propagation neural networks, and support vector machines. Support vector machines accurately identified early vascular dementia patients with 80 percent accuracy in capturing brain abnormalities consistent with cognitive impairments. Overall, findings revealed that compelling descriptions of cognitive changes in vascular dementia patients were successfully evaluated from connectivity patterns derived from EEG signal analysis.

Patients exhibiting signs of vascular dementia and other symptoms of cognitive impairment or decline are often eligible to undergo neuroimaging scans. Notably, Borja et al. (2020) observed that relying solely on specific cognitive symptoms to determine a patient’s need for a brain scan could hinder the discovery of other potentially treatable conditions. Imaging modalities such as the ones mentioned above play a significant role in not only differentiating dementia types but also detecting cognitive abnormalities consistent with vascular etiology early on.

Discussion

The purpose of this paper was to review the literature examining the use of neuropsychological assessments in detecting early vascular dementia. Survivors of stroke (up to 21 percent) may be affected by vascular dementia three months post-stroke onset, which makes monitoring for early symptoms of cognitive decline crucial (Al-Qazzaz, Ali, Ahmad, & Islam, 2014). Several assessments reviewed in this paper emphasized detecting mild cognitive impairment. Depending on the vascular dementia subtype, mild cognitive impairment may precede a diagnosis, particularly the subcortical microvascular disease subtype (Meyer et al., 2002). Therefore, it is important to consider practical assessments that gauge mild cognitive impairment to optimize the effectiveness of a screening measure in detecting early symptoms of vascular dementia, considering that nearly 50 percent of individuals with MCI develop dementia later (Igoumenou & Ebmeier, 2012). Assessments discussed in this paper that evaluate MCI included the MMSE, CAMCOG, and the MoCA.

The MMSE was found to lack sufficient value in diagnosing mild cognitive impairment, like the CAMCOG's usefulness in this assessment area (Engelhardt et al., 2011; Mitchell, 2009). However, in assessing patients with possible vascular dementia, the MMSE was a valuable instrument for diagnostic differentiation (Lo Buono et al., 2018).The Pentagon Copying test within the MMSE is an effective tool to measure visuoconstructive decline, a strong indicator of VaD. Administering the MMSE's Pentagon Copying test over a period can reveal necessary information to a clinician about the rate at which visuoconstructive apraxia worsens faster for VaD patients compared to a patient with AD.

The MoCA was not found to be superior to the MMSE in detecting mild cognitive impairment for patients over 75 years of age, but a separate study found that the MoCA was better suited for MCI screening among patients aged 60 and above, which suggests that the use of the MoCA is ultimately up to clinician discretion (Ciesielska et al., 2016; Kasai et al., 2012). Further research is needed to evaluate the impact of patient age on early diagnosis of vascular dementia when utilizing these assessments. The MoCA and the MMSE were found to be adequately helpful measures in detecting very mild subcortical vascular dementia and cognitive decline because of infarction presence (Kasai et al., 2012). Pendlebury, Mariz, et al. (2012) supported the MoCA's superior sensitivity for spotting vascular cognitive impairment over and above the MMSE. In particular, the MoCA's attention subscale was demonstrated to be an asset to the test's overall diagnostic efficacy, and adding a processing speed subscale could also aid clinicians in assessing for cognitive deficits that could be affecting executive functioning (Zaidi et al., 2020). When assessing for working memory, concentration, and attention in a patient with possible VaD, the MoCA would be a helpful instrument in this regard (Kasai et al., 2012).

While the commonly administered MMSE has clear advantages in administration procedure and strengths in diagnostic differentiation, this review concludes with various assessments exhibiting similar and even superior efficacy. The usefulness of the CAMCOG surpassed the MMSE in accurately diagnosing early vascular dementia post-stroke. In addition, the CAMCOG assesses for a broader range of cognitive abilities than the MMSE, suggesting that the CAMCOG's greater accuracy in detecting for VaD may be attributable to this.

However, the CAMCOG demonstrated reduced usefulness in diagnosing dementia after left-hemispheric strokes, while the MMSE was indicated as a valid method for diagnosing left-sided strokes (de Koning et al., 1998). Administering both assessments in the instances that neuroimaging is not available, while not ideal, may compensate for what the other assessment lacks. It is also important to note that the CAMCOG is not valid for distinguishing patients with

severe aphasia from patients with dementia. For this review, upon excluding patients with severe aphasia, clinicians may find it beneficial to consider the CAMCOG over the MMSE when determining early vascular dementia, specifically for post-right-hemispheric cortical infarction.

The Mattis Dementia Rating Scale, like the CAMCOG, assesses for a broader range of cognitive areas of functioning, which adds to its diagnostic accuracy. The DRS was a helpful measure in diagnosing dementia and distinguishing VaD from AD, specifically when using the DRS-Memory Scale, according to Lukatela et al. (2000). Additional support for the usefulness of this assessment in analyzing frontal executive functioning and motor involvement was provided by DRS-Constructive and DRS-Initiation/Perseveration scales. The DRS was useful in detecting qualitative differences in deficits between patients with evidence of multiple infarctions, single stroke, or AD. However, the attention scale was not as effective indifferentiation. While not the central issue of this review, diagnostic differentiation played a prominent role in confirming an early diagnosis considering this can alter treatment approaches. Therefore, clinicians should consider the DRS when assessing memory and frontal lobe functioning in post-stroke patients with possible dementia.

A case study and a separate clinical trial study discussed the diagnostic efficacy of two similar tests that assessed for olfactory functioning: the Olfactory Function Test and the Pocket Smell Test. Although these tests may not be preferable as a stand-alone diagnostic assessment, the olfactory decline may be of clinical benefit to assess by administering the OFT or the PST to patients with possible VaD. The OFT was found to be a useful instrument in detecting anosmia in older adult patients who report early olfactory deficits without symptoms of early vascular dementia that may have gone undetected by MMSE (Suh et al., 2020). More robust support for the diagnostic differentiation power of the PST was found in comparison to the MMSE (Duff et al., 2002). While anosmia is not a commonly reported feature of VaD, evaluating a patient presenting with good insight regarding their decline in the ability to smell could call for an assessment of this type to aid in the early diagnosis of VaD. In cases where an elderly patient may present with a wide variety of symptoms that may or may not indicate AD, the PST is a practical assessment in differentiating dementia presence and type from AD.

In what the above-mentioned case study was lacking with the OFT to confirm a diagnosis, the Clinical Dementia Rating Scale helped detect features of early vascular dementia. The CDR can be a useful tool for clinicians to assess dementia severity with precision. Clinicians can assess for features of individuals within the very mild 0.5 CDR stage, a crucial transitional stage that is seemingly present before the onset of full-blown dementia (Chan et al., 2008; Kasai et al., 2012). The CDR seems to be the most useful for clinicians when classifying mild cognitive impairment and staging severity of dementia in the early stages and over time (Chaves et al., 2007). Depending on the clinical features present, the CDR could be used by clinicians to confirm the stage of dementia to further aid in developing or modifying a treatment plan (Chan et al., 2008).

Addenbrooke's Cognitive Examination-III was shown to have excellent diagnostic accuracy and significantly improved specificity from the previously outdated ACE-R assessment for dementia (Jubb & Evans, 2015). However, evidence for effectively differentiating vascular dementia cases was lacking, considering the group of subjects with VaD was the smallest out of the other dementia groups examined, which calls for further investigation and future expansion of sample size. Nevertheless, the ACE-III is a useful measure for clinicians to differentiate between early cases of dementia from healthy controls, especially for patients with higher levels of education.

The Ten Point Clock Test was found to have no significant correlation with the MMSE in

detecting for features of vascular dementia, but positive correlations with Proverb Interpretation and phonological fluency tasks (e.g., verbal expression tasks) indicating strength in detecting for mild dementia (Moretti et al., 2002). Although it has been previously advised not to use CDT as an isolated measure, strong support for the usefulness of the CDT as a clinical method to differentiate vascular dementia from Alzheimer's dementia was found. Ultimately, the CDT is helpful for clinicians to effectively assess patients for frontal executive functioning and visuospatial perception impairments, common among VaD patients (Moretti et al., 2005). The CDT can also strengthen clinical support for an early diagnosis of vascular neurocognitive disorder.

Contrary to belief, assessing for memory impairment could be of exceptional importance when determining an early case of vascular dementia. The Portuguese version of the Wechsler Memory Scale-III was found to have great diagnostic efficacy and differentiation power, presenting a valid, consistent measure with the North American version (Gonçalves et al., 2017). The working memory index within the WMS-III has the weakest diagnostic accuracy and, therefore, may be less useful for clinicians in detecting differences early on between VaD and AD patients. However, the auditory recognition delayed index is the strongest measure in diagnostic differentiation, which suggests this index may compensate for the other. While memory deficits are more pronounced in patients with AD, the WMS-III can be a useful measure when assessing the type of memory dysfunction attributable to dementia type. Clinicians could administer the WMS-III to assess for early problems with memory retrieval specific to vascular dementia in addition to executive functioning deficits.

This review concludes with a brief discussion of four commonly used medical assessments that can support or confirm an early diagnosis of vascular dementia: MRI, CT, PET,and EEG. In addition, as noted by Venkat et al. (2015), an effective and substantially supported cognitive evaluation should incorporate the results of various tests to rule out or confirm neurological and vascular etiologies.

However, CT scans can detect cerebral lesions as MRI scans in less detail and with greater difficulty assessing regions such as the temporal lobe (Pasi et al., 2011; van Straaten et al., 2004). MRI scans, in particular, were found to be quality methods of illustrating cerebral atrophy, infarctions, calcifications, and ischemia by analyzing blood vessel damage. Catching cortical lesions below the tentorium that may be causing dementia could be a limitation, depending on the type of MRI sequence. Both CT and MRI scans have strong discriminatory accuracy when distinguishing VaD from other dementias rendering both procedures practical depending on what medical professionals are explicitly inspecting for in the brain (Bermingham, 2014; van Straaten et al., 2004).

PET scans can monitor FDG uptake and metabolism alterations within the brain to signify evidence of atrophy and neoplasms similar to MRI and CT capabilities. PET scans may have an advantage over MRI and CT scans by detecting early evidence of atherosclerosis and brain inflammation prior to irreparable damage from stroke and subsequent vascular dementia. Strong support was found for using this medical imaging technique in medical settings to confirm an early diagnosis (Borja et al., 2020).

Depending on the type of brain wave analyzed, EEGs can effectively assess for cognitive impairment, dementia severity, and dementia type (Al-Qazzaz, Ali, Ahmad, Chellappan, Islam, & Escudero, 2014). In addition, the quantitative data provided by an EEG can help clinicians gather early evidence to support findings from one or more neuropsychological assessments. Incorporating EEGs with machine learning methods also substantially improved efficacy in

detecting early vascular dementia (Wang etal., 2019).

When patients receive a diagnosis from specialized medical staff in the context of presenting with a variety of pathological vascular symptoms without early neuropsychological testing, a delay in diagnosing for early vascular dementia can significantly impact patient outcomes (Suh et al., 2020). Implementing efficacious and comprehensive neuropsychological assessments as reviewed in this paper to detect early cognitive decline further bridges the importance of formulating a thorough cognitive and medical evaluation to determine a concrete diagnosis of early VaD.

Future Research

Future directions for research can stem from the limitations of this comprehensive review. Several complications arise when the process of detecting early vascular dementia is linked with efforts to research the predictive value of testing for very mild symptoms of cognitive impairment. This calls for intensive research into how stages in vascular dementia progress and what type of cognitive deficits typically occur early on. As seen from a unique case study and several other clinical trials, early presentation of vascular dementia can vary, making it extremely difficult to pinpoint which cognitive dysfunctions are attributable to vascular etiology.

An explicit limitation of this review is that updated literature is lacking for some of the assessments discussed. Sleutjes et al. (2020) examined the MMSE-2, which was formulated as a revision to improve the sensitivity and validity of the original MMSE, which presented various shortcomings in MCI and early VaD diagnosis discussed. Updated versions of the DRS, CAMCOG, MoCA, and WMS-III were also not reviewed: DRS-2, CAMCOG-R, MoCA Version 8.3, WMS-IV, respectively. Future research would be of considerable benefit to clinicians if efficacy findings for newer versions of neuropsychological assessments that have yet to be administered and validated for international use were incorporated into the literature.

Applying these current neuropsychological assessments to different cultural populations should be assessed and compared to aid in an accurate diagnosis. In Asian countries, particularly Japan and China, the prevalence of vascular dementia is higher compared to White populations (Chan et al., 2008). Vascular neurocognitive disorders account for nearly 30% of dementias in Asia compared to 15-20% in North America and Europe (Wolters & Ikram, 2019). In addition, the prevalence of VaD is higher among women than men for all age groups based on a prospective cohort study conducted in the Netherlands (Ruitenberg et al., 2001). For these reasons, future research needs to expand the literature on the efficacy and validity of translated and culturally adapted assessments.

Specifically, in the Jubb and Evans (2015) study, clinicians suggested considering the level of education when administering the MoCA as this factor could potentially impact scores if not controlled. However, more extensive literature on the impact of education level on neuropsychological assessment scores and the progression of vascular dementia is lacking.

Lastly, the efficacy of other lesser-known neuropsychological tests and medical assessments for vascular dementia not mentioned here should be researched in the future. Moreover, numerous diagnoses of early vascular dementia were established from the various assessments and neuroimaging studies reviewed. However, no updates on whether these diagnoses remained the same or changed over time have been researched. This would be educational and clinical value, considering new findings could reveal holes in the current literature or further support the predictive and long-term value of those assessment scores and brain imaging scans.

About the Authors

Daniella G. Maciel, B.A., is a student in the College of Psychology at Nova Southeastern University. Address all correspondence concerning this article to dm304atmynsu.nova.edu.

Charles J. Golden, Ph.D., ABPP, ABAP, is with the College of Psychology at Nova Southeastern University.

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