ONLY TIME WILL TELL: CLOCK DRAWING AS AN EARLY INDICATOR OF NEUROLOGICAL DYSFUNCTION

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Time will reveal everything. It is a babbler, and speaks even when not asked.
—Euripides

ABSTRACT

The neurological exam is distinct from the rest of the physical exam in that it contains both quantitative and qualitative elements. Quantitatively, the neurological examination is designed to assess cranial nerve function, motor function, sensory function, coordination, and gait. Qualitatively, it attempts to gauge the mental status of an individual. As with most qualitative assessments, it is difficult to accurately measure an individual's mental status in the nonneuropsychologic setting of the hospital. Clinicians, including neurologists, frequently use semi-quantitative methods such as the line bisection test, the 3/3 recall test, and tests of reading and writing to estimate a patient's mental status but often overlook the highly useful clock-drawing test. While most neurologists are familiar with the clock drawing test, very few understand its finer subtleties. In the following paragraphs, I describe the proper use of the clock-drawing test and then, drawing on my own experiences with patients, demonstrate how the clock-drawing test can provide early evidence of specific derangements of neurological function.

VARIATIONS ON A THEME

Verbal Command. Though it sounds fairly simple and straightforward, the clock-drawing test is actually quite intricate and has several variations. It may be administered as a verbal command or as a copy command. In the verbal command variation, the patient is given a blank sheet of paper and asked first to draw a clock and then to indicate a specific time. To successfully complete this task, the patient must first draw the contour of the clock, then place the numbers 1 through 12 inside, and finally indicate the correct time by drawing in the hands of the clock. Some clinicians prefer to provide the patient with a pre-drawn circle arguing that the patient's ability to fill in the numbers may be adversely affected if the contour is poorly drawn.[1] Regardless of which variant—the free drawn or pre-drawn clock—is used, the verbal command clock-drawing test simultaneously assesses a patient's language function (verbal comprehension); memory functions (recall of a visual engram, short-term storage, and recall of time setting instructions); and executive function. The verbal command variation of the clock-drawing test is highly sensitive for temporal lobe dysfunction (due to its heavy involvement in both memory and language processes) and frontal lobe dysfunction (due to its mediation of executive planning).

Copy Command. In the copy command clock-drawing test, the patient is given a fully drawn clock with a certain time pre-marked and is asked to replicate the drawing as exactly as possible. The successful completion of the copy command requires less use of language and memory functions but requires greater reliance on visuospatial and perceptual processes. A modified version of the copy command clock-drawing test simply asks the patient to read aloud the indicated time on a clock drawn by the examiner (hereafter referred to as the clock-reading test). The copy command clock-drawing and clock-reading tests are good for assessing parietal lobe lesions such as those that may result in hemineglect.

From the above descriptions of the verbal command and copy command clock-drawing tests, it is clear why it is important to perform both tests for every patient. A patient with a temporal lobe lesion may copy a pre-drawn clock adequately, whereas his clock drawn to verbal command may show poor number spacing and incorrect time setting. Conversely, a patient with a parietal lobe lesion may draw an adequate clock to verbal command, while her clock drawing with the copy command may reveal clear signs of neglect.

Time-Setting Instructions. Another variable in the clock-drawing test is the time setting. The most common setting chosen by clinicians is "3 o'clock."[2] While this setting is adequate to assess comprehension and motor execution, it does not uncover any left neglect the patient may have because it does not require the left half of the clock to be used at all. Neurologists commonly use the setting of "20 after 8." This setting requires the use of both halves of the clock and forces the patient to recode the command "20" to the number "4" on the clock. This is a sensitive measure of intact higher cognitive functioning. However, though preferable to the "3 o'clock" setting, "20 after 8" is not the ideal time setting. The setting of choice is "10 after 11."[3] It is similar to the "20 after 8" setting in that it forces the patient to attend to both halves of the clock and requires the recoding of the command "10" to the number "2" on the clock. However, it has the added advantage of uncovering any *stimulus-bound errors* that the patient may make. That is to say, the presence of the number "10" on the clock may trap some patients and prevent the recoding of the command "10" into the number "2." Instead of drawing the minute hand towards the number "2" on the clock to indicate "10 af-

ter," patients prone to stimulus-bound errors will fixate and draw the minute hand toward the number "10" on the clock. Since the number "20" does not appear anywhere on the normal clock, there is no possibility for a stimulus-bound error with the "20 after 8" setting—the patient *must* recode the "20."

Now that we have reviewed the practical aspects of administering the clock-drawing test, I shall discuss clocks drawn by several patients of mine and show how their clock drawings reveal their pathology. In fact, many of these clocks were drawn before any imaging studies were performed and in most cases predict the lesion to be in the brain location indicated by the imaging study.

Clock Drawing in Acute Neurological Processes

Backwards In Time. Figure 1 shows a clock freely drawn to verbal command on hospital day 1 by G.M., a 60-year old hypertensive, diabetic, hypercholesterolemic woman with a history of right-hemispheric stroke in 1990 who presented with progressive left-sided weakness of nine days' duration. She started with the number "12" and then continued to number *clockwise* with "11," "10," "9," "8," etc. When asked if the clock looked normal to her, she replied that it did because the "6" was opposite from the "12" and the "3" was opposite from the "9." She was then asked to draw in the time setting "10:30"; as evident in the figure, she began to write "1030" outside of the clock in the top right corner of the page. When asked to indicate 10:30 *inside* the clock, she wrote "1030" inside the clock between the numbers "8" and "7" and then made some arrow-like marks pointing away from the "1030."

Figure 1 is clearly not normal. However, despite the mirror-image reversal of the clock, it is worth noticing that the patient has accurately included all of the necessary numbers. Additionally, she was able to comprehend the verbal command to draw a clock and call upon her visual engram of a clock to produce the resulting image. The left hemispheric language functions of verbal comprehension and number writing seem to be fairly intact and we would not expect her pathology to involve the left hemisphere. Similarly, her memory functions also appeared intact throughout the clock-drawing test; hence we would not suspect any temporal lobe involvement.

The reversed-clock phenomenon seen in Figure 1 has been proposed by Kumral and Evyapan to be a right-hemispheric syndrome.[1] In an observational study of 700 stroke patients, Kumral and Evyapan found six patients who showed reversed clock drawing, all six of whom had suffered strokes in the right hemisphere. If we accept Kumral and Evyapan's proposal as true, then from the clock drawn in Figure 1, it could have been inferred that G.M. had suffered a right-hemispheric stroke (a presumption supported by the onset of progressive left-sided hemiparesis). Further, the poor executive planning demonstrated by G.M. in indicating the time setting of "10:30" would suggest some frontal dysfunction as well. A verbal command clock-drawing test administered on hospital day 4 (Fig. 2) is highly suggestive of right frontal lobe dysfunction. According to Freedman et al., the clock drawing most characteristic of right frontal lobe lesions is a normally numbered clock in which the numbers on the left half of the clock are pulled inward away from the clock contour.[2] This is exactly what is seen in Figure 2.

The clock-drawing test in Figure 1 was administered to G.M. at 10 a.m. on hospital day 1. A preadmission CT scan of the brain performed at 10 p.m. on hospital day 0 when the patient presented to the emergency room showed no obvious signs of a new stroke. A repeat CT scan performed at 8 p.m. on hospital day 1 (ten hours *after* the initial clock-drawing test) clearly showed signs of a massive new stroke in the right parietal region with frontal involvement due to mass effect. Thus, a clock-drawing test administered twelve hours after the initial CT scan detected right cerebral dysfunction that was not fully evident on the initial CT scan.

Clock Drawing versus Line Bisection. A finding of note in G.M. is that her stroke was still evolving after she presented to the emergency department. In the emergency depart-

Figure 1. Clock drawn by G.M. to verbal command on hospital day 1. Note the mirror image reversal of the numbering scheme and the unsuccessful attempt to indicate a time setting of 10:30.

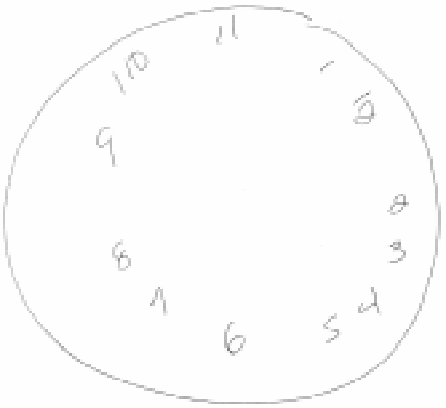

Figure 2. Clock drawn by G.M. to verbal command on hospital day 4. Note the pulling away of the numbers on the left side of the clock from the contour.

ment, physical exam was remarkable only for mild left-sided weakness. However, over the ensuing twelve hours, the left sided weakness progressed to dense hemiplegia and the patient developed left space visual neglect, left homonymous hemianopia, and a right gaze preference. Though the homonymous hemianopia and right gaze could not be tested formally with the clock-drawing test, progression of the left space neglect was closely followed with serial clock-reading tests and line-bisection tests. In this patient, the clock-reading test actually proved to be a more sensitive indicator of the left neglect than the ever-popular line bisection test. On hospital day 1, the line bisection test was clearly indicative of left-space hemineglect (Fig. 3). However, on hospital days 2 and 3, the line bisection test suggested that the left hemi-neglect had resolved whereas the clock-reading test revealed that the neglect in fact still persisted (Fig. 4).

To quickly summarize the findings for G.M., we can infer from the abnormal drawings on the verbal command clock-drawing tests that the patient had a lesion in the right hemisphere that involved the frontal lobe. We see from the abnormal responses on the clock-reading test that she also had involvement of the right parietal lobe. These suggestions gleaned from the clock tests were consistent with the neuroimaging-based diagnosis of a right parietal lobe stroke with right frontal lobe involvement. Additionally, the clock tests detected the persistence of a left neglect syndrome that may have been missed if only the line bisection test had been used.

Figure 3. Line-bisection test for G.M. on hospital day 1.

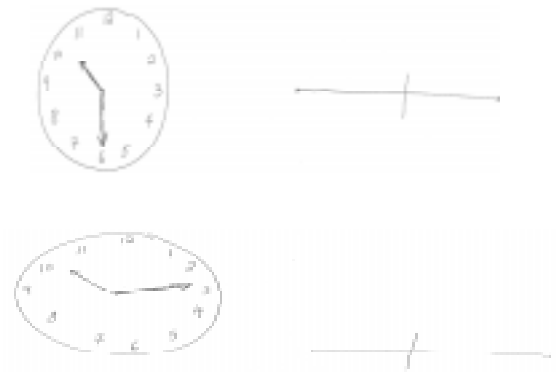

Figure 4. Clock-reading and line-bisection tests for G.M. on hospital days 2 and 3. Note that the line bisection fails to detect a left hemineglect that is still evident on the clock-reading test. In the top part of the figure, the patient was asked to read the time shown on the clock and said "seven o'clock." Patient reported that she saw the numbers 1, 2, 3, 4, 5, and 86 and one arrow when confronted about her reply. In the bottom part of the figure, the same patient was asked to tell the time shown and replied "three o'clock." When asked how many numbers she saw on the clock, she replied "2, 3, 4, 5, 6, and 1."

Clock Drawing in Chronic Neurological Decline

Localized Dysfunction. The clock-drawing test may also be used in the assessment of more insidious processes than acute stroke. Figure 5 reveals a clock drawn on hospital day 1 by T.R., a 35-year-old HIV-positive man (CD4 cell count=5) who presented with new onset focal motor seizures with secondary generalization. His clock freely drawn to verbal command is not strikingly abnormal, but the subtle findings are still informative. His clock drawing shows poor planning in that the numbers are irregularly spaced and quite noticeably pulled in from the contour. These abnormalities of executive planning suggest frontal pathology. Indeed, on CT scan the patient was found to have a large mass lesion in the left fronto-parietal region with extensive associated cytotoxic edema. Though it could be argued that HIV encephalopathy may be responsible for the abnormal clock images, this is not likely because the patient's clock drawings are characteristic of *localized* cognitive dysfunction.

Global Decline. The clock-drawing test may also be a good early indicator of *global* neurocognitive decline such as that seen with dementia. Patients with dementia tend to perform poorly on tests of clock drawing.[1] They show poor arrangement of numbers within the clock, and they are often limited to one-task processing. That is to say, they can concentrate only on writing the numbers in the proper order or on placing the numbers correctly in space. They cannot attend to both tasks simultaneously. If a patient with dementia concentrates on the numbering sequence, he is likely to draw a clock with poorly spaced numbers. If he attempts to space the num-

Figure 5. Clock drawing by T.R. to verbal command on hospital day 1. Note the large gaps in numbering and the pulling away of the numbers from the right side of the clock contour.

bers accurately, he may skip or repeat a number inadvertently.

Since patients with known dementia, as defined by a score below 123 on the Mattis Dementia Rating Scale, have characteristic clock drawings, it is feasible to suggest that patients who demonstrate similar clock drawings but are otherwise unimpaired may have early or mild dementia. L.M, a 75-year-old woman with a history of hypercholesterolemia and long-standing uncontrolled hypertension, was brought by ambulance to the ED with the chief complaint of sudden onset dysphasia and left thumb weakness. A verbal command clock-drawing test administered to L.M. on hospital day 11 showed very poor arrangement of numbers (Fig. 6a). A repeat verbal command clock-drawing test administered immediately after the first test still showed little improvement in number arrangement with practice (Fig. 6b). It would be interesting to find out how well L.M.'s scores on the Dementia Rating Scale correlate with her poor performance on the clock-drawing test.

Conclusion

From the three patients discussed in this paper, I hope it has become evident to the reader that the clock-drawing test, if employed properly, can provide much insight into a patient's pathology. Not only can the clock-drawing test allow the examiner to detect the presence of a lesion, but it can also provide helpful localizing clues as to where in the brain the lesion may be. While advanced imaging studies such as CT scans and MRIs can certainly provide much of the same information with greater sensitivity, they may not always be available or indicated. Though a mainstay of most urban medical centers, MRI suites (and to a lesser extent, CT scanners) remain very much a luxury at many smaller hospitals. Even at large institutions, it can prove *exceedingly* difficult to get a CT scan or MRI during late hours and on weekends. Additionally, in the present healthcare atmosphere, as the metastatic veil of managed care infiltrates deeper into the body of medicine, clinicians will need to rely more heavily on their history-taking and physical examination skills and less heavily on expensive modern technology. Under most HMOs, "just in case" is no longer a valid indication to get a CT scan or MRI—the clinician must have just cause. For the physician who suspects neurological dysfunction based on her clinical acumen alone, a properly administered clock-drawing test can provide the quantitative proof needed to justify a subsequent CT scan or MRI. Thus, it behooves every neurologist, and perhaps every clinician, to administer a clock-drawing exam at the initial presentation of every patient. Additionally, since they require neither expensive equipment nor highly trained personnel, routine clock-drawing tests may prove to be a cost-effective means of charting the onset and progression of dementia in elderly patients. The test can be administered on a yearly basis and saved as part of the patient's official medical record for comparison with baseline and future versions.

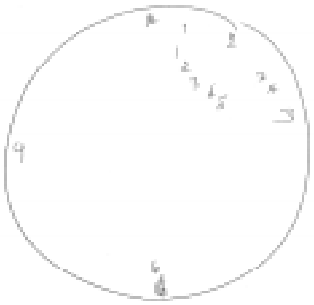

Figure 6a. Clock drawn by L.M. to verbal command on hospital day 11 (first attempt). Note the poor planning and number arrangement.

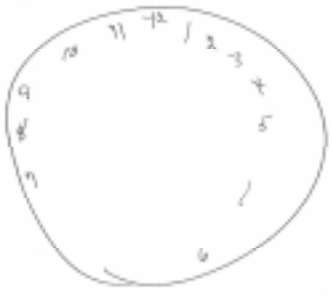

Figure 6b. Repeat clock drawn to verbal command by L.M. on hospital 11. The poor planning and number arrangement persists.

Parting thought. Now that I have reached the end of my discourse, I shall leave the reader with a question: how does one interpret an abnormal clock drawing in a patient with an otherwise normal neurological exam and normal brain imaging studies? Figure 7 shows a clock drawn by A.N, a 52-year-old woman admitted for episodic vertigo, nausea, and vomiting of six days' duration. A CT scan of the head was normal and the patient's vertigo was deemed peripheral in origin. She also had a normal neurological exam except for impaired clock drawing and impaired cube drawing. In the clock-drawing test given on hospital day 1 (Fig. 7), A.N. missed several numbers and perseverated on the number "3." On a clock-drawing test repeated the next day (Fig. 8), she labeled the right side of the clock correctly but then repeated the numbers from 1 to 5 on the left side to produce a symmetric clock. Since she had no other abnormalities on exam or on CT scan, it is difficult to understand why her clocks are as they are. Though the possibilities of factitious disorder or malingering should be mentioned, they need not be entertained as very likely diagnoses since the rest of the patient's exam was normal. Can it be that the clock-drawing test is so sensitive that it has detected a subtle cognitive abnormality that is not yet evident by any other means of testing?

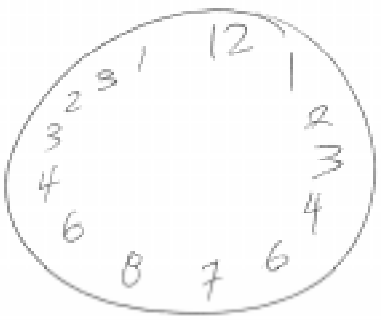

Figure 7. Author-rendered replica of clock by A.N. to verbal command on hospital day one. Note the omission of the number 5 and perseveration on the number 3.

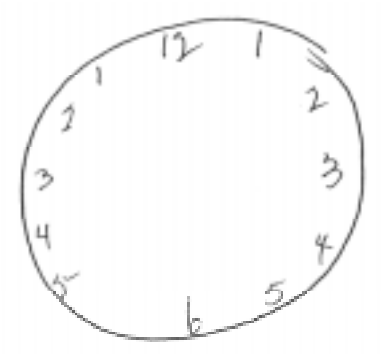

Figure 8. Clock drawn by A.N. to verbal command on hospital day 2. Note the symmetric arrangment of numbers on the two sides of the clock.

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