Selective acalculia with sparing of the subtraction process in a patient with left parietotemporal hemorrhage

Hecaen et al. classified acalculia, the inability to calculate, into three types: alexia and agraphia for numbers and digits, acalculia resulting from spatial defects, and anarithea or acalculia caused by the inability to perform arithmetic operations. Recent models have suggested the presence of two mechanisms in calculation: a number-processing function and a calculation function. Acalculia usually presents in combination with other defects, especially aphasia, or as part of Gerstmann's syndrome; it may, however, also develop as an isolated deficit involving disturbances of all four basic arithmetic operations (addition, subtraction, multiplication, and division).

We describe a patient who developed anarithea for addition, multiplication, and division, with sparing of subtraction, 5 months after a left parietotemporal-lobe hematoma.

Case report. A 62-year-old, right-handed male engineer was admitted because of sudden onset of severe headache and speech disturbances. On admission, his blood pressure was 190/110. There was a mild right hemiparesis with a right central facial palsy, pathologic reflexes, and a right lower quadrantanopia. The patient had global aphasia. Brain CT showed an intracerebral hemorrhage in the left parietotemporal region with surrounding edema (figure 1).

During the next few weeks, his comprehension significantly improved. The patient was able to obey simple verbal commands, and his speech became more fluent. Repetition ability remained severely impaired. He was unable to write, but reacted correctly to written commands—he could choose the right answer to simple written questions and could differentiate between colors. His calculation ability could not be examined.

Over the next 3 months, his speech continued to improve, and only mild anomia without difficulties in comprehension or repetition remained. Although spontaneous speech was intelligible, in a sentence of an average of 10 words, one (usually semantic type) was paraphasic. Writing was normal for copying, spontaneity, and dictation. Reading was normal. Selective acalculia sparing subtraction was noted for the first time.

At 5 months following the hemorrhage, neuropsychologic assessment demonstrated only an impairment in calculation. Results on the Webster Adult Intelligence Scale—Revised (WAIS-R), Boston Diagnostic Aphasia

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References

Examination (BDAE), the Trail Making Test, and Williams Delayed Recall Test were within normal limits. On the WAIS-R, IQ was 104; responses for the arithmetic subsection were very poor (weighted score, 1), and of those that were correct, most involved subtraction. Results for the Wisconsin Card Sorting Test were 6 of 6. Repeat brain CT revealed a hypodense area in the left temporal lobe, including the area in the superior and midtemporal gyri (figure 2).

Methods. Arithmetic performance. The following operations were tested:
- Digital and alphabetic notation by having the patient transcode large numbers from one system to another and from Arabic to Roman numerals.
- Comprehension of multidigit numbers by having the patient identify the largest among five numbers.
- Comprehension of mathematical signs. The patient was asked to identify each sign and define its function.
- Knowledge of the four basic symbols by asking the patient to indicate those that were correct in 10 direct and 10 verbal explanation trials.
- Ability to perform diverse arithmetic operations by having the patient count forward and backward.
- Calculation ability on oral and written examinations.

Results. The patient copied, wrote on command, and translated written numbers to numeric form correctly. He also correlated paired numbers without mistakes. Comprehension of multidigit numbers was normal. Mathematical symbols were identified and defined correctly. Similarity tests of mathematical signs and symbols were normal, as was the similarity subtest of the WAIS-R. No difficulties were found for single (subtraction of three) or complex (subtraction of 17) operations when the patient counted backward. When counting forward, only the addition of one number (eg, 20 + 1) could be accomplished; more difficult operations were impossible. Results for calculation ability were as follows:

Addition. Both oral and written calculation were impaired. Of 20 trials adding two numbers from one to 10, only three were correct (1 + 2, 2 + 2, and 1 + 5). All 20 trials of complex number addition (numbers > 10) and all 10 trials of mixed number addition (one number < 10 with one number > 10) were incorrect, regardless of whether the larger number was the first or second given.

The patient’s ability to solve word problems requiring addition (for example, “How many boys were in the bus?”) was severely impaired. There were 20 simple number, 20 complex number, and 10 mixed number questions; only five (all simple operations) were answered correctly. After hesitation (more than 5 seconds), eight answers were incorrectly subtracted instead of added.

Multiplication and division. All 50 trials of multiplication and division in oral and written form were incorrect.

Subtraction. As for the addition trials, 20 simple number, 20 complex number, and 10 mixed number tests were used to test subtraction ability. All responses were given rapidly and correctly. Further examination using even more complex numbers (number > 100) yielded 100% correct responses as well. The same results were noted in the oral and written forms. Follow-up testing after 2 years showed no changes.

Discussion. Following a parietotemporal hematoma of the dominant hemisphere, our patient had isolated agraphia for addition, multiplication, and division, with a spared subtraction function. There was no impairment of other cogni-
tive or memory functions.

Isolated acalculia is most often associated with lesions of the parietotemporal region in the dominant hemisphere, as in our patient, but it may also occur in medial frontal cortical lesions and in subcortical infarcts involving the caudate nucleus, putamen, and internal capsule. McCloskey et al described traumatic brain-damaged subjects who had acalculia with impairment of all four arithmetic processes. There is only one previous report describing isolated acalculia with elaborate sparing of some processes.

Generally, the model of the calculation mechanisms distinguishes the number processing system from the calculation system. The first system includes the number comprehension and number production subsystems, with a specificity for Arabic and verbal numerals. The calculation system, a specific calculating cognitive process, includes the comprehension of operation symbols, the retrieval of arithmetic facts, and the execution of calculation procedures.

Preservation of subtraction ability in the present case raises the hypothesis that specific systems are responsible for simple (addition/subtraction) and complex (multiplication/division) arithmetic processes. It may also indicate separate coding for the simple processes (addition and subtraction), probably in the parietotemporal region.

Calculation is a complex procedure with several components, and cases of selective acalculia may help us understand the calculation processing system.

References