

Callosal Disconnection Syndromes

There are three structures that interconnect the cerebral hemispheres: The *anterior commissure*, a structure that interconnects the olfactory system and parts of the limbic system; the *hippocampal or posterior commissure*, that interconnects parts of the limbic system; and the *corpus callosum*, a large structure that mediates interconnection between a large number of cortical processing areas in each hemisphere. Although the corpus callosum is a single anatomical structure, it actually represents the discrete interconnection of a number of specific cortical centers.

Knowledge concerning the neuropsychology of interhemispheric disconnection is primarily derived from studies of patients who have callosal resection as a treatment for intractable seizure disorder. The hemispheres were surgically disconnected in order to stop the seizures from progressing to include the entire brain. Partial resections were also performed for seizure disorder and many patients receive partial resections of the corpus callosum as part of surgical treatment of tumors in this location. Cases of partial resection have also contributed to knowledge about cerebral disconnection.

Symptoms of Callosal Disconnection:

The most remarkable finding is the presence of intact everyday cognition and behavior to the point where the patient appears completely intact and unchanged when observed by family and friends. If the patient has no other brain illness, then cognitive functions are usually within the normal range. The symptoms of disconnection only emerge when specific tests are administered.

Stimuli presented to the left side of the visual space and objects held only in the left hand, and hence, only perceived by the right hemisphere, are not named. Presumably the language centers in the left hemisphere have no knowledge of the stimulus and the patient is unable to use language to describe them. Information presented to the left hemisphere is named and described in normal fashion.

Single words separately presented to each ear are reported normally. If two different words are presented to each ear at the same time (i.e., dichotically), the patient has a strong right ear advantage. This presumably occurs because the ipsilateral pathway from the left ear to the left hemisphere language center is suppressed by the stronger, more dominant information conveyed by the contralateral pathway from the right ear.

Early after surgery, the patient shows a marked apraxia of the left hand to verbal command. This occurs because the right hemisphere, which controls the left hand, has poor language comprehension. This symptom recovers to a considerable degree, indicating that the left hemisphere gains ipsilateral control of the left hand and/or the right hemisphere acquires basic language skill. Specific postures made by one hand of view cannot be copied by the other hand. Also, one hand cannot retrieve objects held by the opposite hand. These symptoms suggest that somesthetic sensory information is not exchanged by the hemispheres.

Studies of callosal disconnection have revealed that the right hemisphere has a significant lexicon of single words. Consequently, the left hand is able to name some objects or find objects by touch when given the name.

- Intermanual Conflict and the “Alien Hand”

With callosal disconnection, the actions of each side of the body are independently controlled by the contralateral hemisphere. Since there is no communication across the hemispheres that can mediate coordinated action, the patient’s hands often act as if they were independently motivated. This is most apparent when the left hand behaves inconsistently with what the patient says he is doing. Sometimes patients will notice the aberrant actions of the left hand and comment on the behavior as if the hand did not belong to them. This presumably represents the language center in the left hemisphere commenting on the dissociated actions of the left hand. One example often cited is that of a patient who was buttoning his shirt with one hand while the other hand followed behind unbuttoning it. Another patient was in the habit of slapping the left hand when it would behave errantly. Patients report that the hand is out of their control and hence “alien”.

- Verbal Anosmia

Patients with callosal disconnection are unable to name smells presented only to the right nostril. Smell sensation in the right nostril is intact since the patient can use the left hand to find an object corresponding to the smell.

- Double Hemianopsia

Patients with callosal disconnection cannot indicate the onset of a visual stimulus in the left or right visual field with the contralateral hand. For example, when a visual stimulus appears in the right field, the patient can indicate the onset of the stimulus with the right hand but not with the left hand. This is because visual information from the right field is perceived by the left hemisphere. Since this hemisphere controls the right hand, the patient can respond. Since the corpus callosum is severed, visual information from the right visual field is never perceived by the right hemisphere. This hemisphere controls the left hand and it cannot respond to the stimulus. The opposite pattern holds for the response of the right and left hands to stimuli presented to the left visual field.

- Processing of Verbal Information

Patients with callosal disconnection will have a complete right ear advantage for verbal information. Verbal information is very poorly perceived by the left ear. Dichotic presentations of verbal content result in an almost complete preference for the verbal stimuli presented in the right ear.

- Unilateral Apraxia of the Left Hand

Here the patient cannot perform an action with the left hand to verbal command that is easily performed by the right hand. The patient may be able to perform the action spontaneously (i.e., when not specifically to verbal command) or when given an object to hold that is used in the action.

- Unilateral Agraphia of the Left Hand

Patients with callosal disconnection have an inability to write with the left hand; the right hand writes fluently. In addition, the left hand is able to carry out other coordinated movements. It is apparent that the language centers controlling writing in the left hemisphere can no longer coordinate the left hand to produce language-related productions.

- Unilateral Anomia

Patients cannot name objects placed in the left hand when blindfolded. They can easily name objects placed in the right hand. Tactile information about an object placed in the left hand never reaches the language centers in the left hemisphere and the object cannot be named.

- Unilateral Constructional Apraxia

Callosal Disconnection results in poor performance by the right hand on tasks that require spatial processing. These include copying geometric forms and construction tasks. Spatial processing centers in the right hemisphere do not have access to the right hand and cannot guide its actions. This disability also extends to solving arithmetic problems on paper. If the problem requires the proper lay out of the numbers on paper then the patient may have difficulty solving it.

Assessment:

The evaluation of cerebral disconnection utilizes a number of specific, experimental procedures described above. It is very difficult for the typical clinical neuropsychology laboratory to adequately assess this syndrome because the necessary equipment is not available. For example, very few centers have tachistoscopes (i.e., specialized equipment used to present visual stimuli separately to each half of the visual fields).

Some of the assessment procedures involving the disconnection of actions of the hands in response to sensory stimulation are tested with simple procedures. For example, unilateral apraxia can be examined by requesting the patient to perform some simple act with the left hand while the eyes are closed. The examiner may also position the right hand in some way and ask the subject to reproduce the position with the left hand while the eyes are closed. In a similar fashion, the examiner may test unilateral anomia and unilateral construction apraxia.