Medical Xpress

Deficits in brain's reward system observed in ADHD patients

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A brain-imaging study conducted at the U.S. Department of Energy's (DOE) Brookhaven National Laboratory provides the first definitive evidence that patients suffering from attention deficit hyperactivity disorder (ADHD) have lower-than-normal levels of certain proteins essential for experiencing reward and motivation.

"These deficits in the brain's reward system may help explain clinical symptoms of ADHD, including inattention and reduced motivation, as well as the propensity for complications such as drug abuse and obesity among ADHD patients," said lead author Nora Volkow, Director of the National Institute on Drug Abuse and a long-time collaborator on neuroimaging research at Brookhaven Lab.

The study, published in the September 9, 2009, issue of the Journal of the American Medical Association, also has important implications for treatment. "Finding ways to address the underlying reward-system deficit could improve the direct clinical outcome of ADHD, and potentially reduce the likelihood of other negative consequences of this condition," said study co-author Gene-Jack Wang, chair of Brookhaven's medical department.

Prior to this study, it was not clear whether people with ADHD had abnormalities in the brain's dopamine-mediated motivation/reward system. Previous studies were relatively small and may have been complicated by the fact that some ADHD patients had undergone treatments, or had a history of drug abuse or other conditions that can

affect the dopamine system.

To strengthen the statistics and control for these factors, the current study looked at 53 adult ADHD patients who had never received treatment and 44 healthy control subjects — all of whom had been carefully screened to eliminate potentially confounding variables.

The scientists used positron emission tomography (PET) to measure two markers of the dopamine system — dopamine receptors, to which the chemical messenger binds to propagate the "reward" signal, and dopamine transporters, which take up and recycle excess dopamine after the signal is sent.

Lying in a PET scanner, each patient was injected with a minute amount of a "radiotracer" compound — a chemical labeled with a radioactive form of carbon and designed to bind specifically to one of the targets. Different tracers were used for each target, and patients were scanned for each at separate times. By detecting the signal from the radiotracers, the PET machine can measure the receptor and transporter locations and concentrations in various parts of the brain.

The results clearly showed that, relative to the healthy control subjects, the ADHD patients had lower levels of dopamine receptors and transporters in the accumbens and midbrain — two key regions of the brain directly involved in processing motivation and reward. In addition, the measurements of dopamine markers correlated with measures of behavior and clinical observations of ADHD symptoms, such as reduced levels of attention as measured by standard psychological tests.

"Our findings imply that these deficits in the dopamine reward pathway play a role in the symptoms of inattention in ADHD and could underlie these patients' abnormal responses to reward," Volkow said.

"This pathway plays a key role in reinforcement, motivation, and in learning how to associate various stimuli with rewards," she continued. "Its involvement in ADHD supports the use of interventions to enhance the appeal and relevance of school and work tasks to improve performance.

"Our results also support the continued use of stimulant medications — the most common pharmacological treatment for ADHD — which have been shown to increase attention to cognitive tasks by elevating brain dopamine," she said.

The findings may also help explain why ADHD patients are more likely than control subjects to develop drug-abuse disorders and conditions such as obesity.

Said Wang: "Other studies from our group suggest that patients who abuse drugs or overeat may be unconsciously attempting to compensate for a deficient reward system by boosting their dopamine levels. Understanding how deficits in the dopamine system contribute to ADHD and finding ways to improve the functioning of the reward system could help mitigate these troubling consequences in the ADHD patient population."

Source: DOE/Brookhaven National Laboratory