Anterograde Amnesia after Methamphetamine Lab Exposure

Abstract
Anterograde Amnesia after Methamphetamine Lab Exposure Background: Some known toxic exposures can produce detrimental cognitive deficits. Yet, very few substances have been linked to the development of anterograde amnesia. Here, we report a novel case of a middle-age man who presented with a profound and apparently permanent anterograde amnesia following his exposure to a clandestine methamphetamine laboratory. Case Report: A 47 year-old, right-handed man presented in 2013 with a history of memory loss and seizures since 2001, when he was exposed during his work as a firefighter to the fumes of spilled material intended to synthesize methamphetamine in a clandestine laboratory. Following the exposure, he suffered a major and immediate impairment of multiple cognitive domains, with anterograde memory being most impaired. A formal neurobehavioral status examination NBSE showed a profound impairment in episodic/verbal memory and lesser impairment of executive function. The patient clinical course has to date been stable without further deterioration or improvement. Discussion: This case highlights a clear temporal relationship of methamphetamine laboratory exposure and the development of deficits in memory and executive dysfunction suggestive of involvement of both prefrontal-striatal circuits and medial temporal areas. This is in concordance with prior animal studies, and warrants further investigation in the future.

Keywords: Amnesia; Anterograde; Methamphetamine; Toxicology

Background
Medical knowledge of the anatomical and functional substrates of anterograde memory has largely been elucidated through unplanned loss-of-function cases. Classic examples include H.M, who underwent an excisional surgery of the temporal lobes [1], and R.B, who suffered a bilateral ischemic hippocampal injury. [2]. Both had a profound inability to encode new memories. In the last decade, it has been reported that toxic exposures can be another mechanism for the development of anterograde amnesia [3]. Here, we report a novel case of a 35 year-old man who developed an immediate and apparently permanent anterograde amnesia following his exposure to a methamphetamine laboratory.

Case Report
JS, a 35 year-old right-handed man who presented to our center in May 2013 with a history of memory loss and seizures since 2001, when he was exposed during his work as a firefighter to the fumes of spilled material intended to synthesize methamphetamine in a clandestine laboratory. Following the exposure, JS lost consciousness, although no trauma was involved. Following his hospitalization and recovery, he started experiencing stereotypical spells of "out-of-body experience" or stating that were followed at times by generalized shaking. He also developed angry outbursts and depressed mood. He suffered a major and immediate impairment of multiple cognitive domains following the injuries, with anterograde memory being most impaired; e.g. he could not remember dates or names for more than a few minutes. His remote memory remained intact and he was able to retain all of his acquired procedural skills and knowledge up to the time of the injury. Although there has been no improvement in his memory impairment since the time of the injury, he has learned to cope with his limitations. His family provides him with written notes, organizing his chores and tasks, such as shopping or household maintenance, on a daily basis; he is able to follow these instructions. He is able to drive with the help of a global positioning system (GPS) device.

An electroencephalogram at JS’ initial presentation showed frequent focal spikes of 20-40 microvolts originating from the right temporal region; a finding that correlated with the MRI appearance of bilateral flair intensity in hippocampal areas. Trials of valproic acid, phenytoin, and topiramate were undertaken and, later, discontinued due to side effects or inefficacy. At the time of his presentation to our clinic in 2013, he was managed solely on Lacosamide. His last seizure was in 2009.

A formal neurobehavioral status examination (NBSE) conducted in early 2015 showed a profound impairment in episodic/verbal memory and to a lesser extent in sustained and complex attention, executive functioning and verbal fluency (Table 1). Hold tasks (such as literacy) and fund of knowledge/
long term memory appeared to be relatively unaffected. He is almost entirely independent in the management of his activities, and shows no evidence of continuing or progressive functional decline. JS continues to be seen in follow-up in the neurology clinic, and his clinical course has to date been stable without further deterioration.

**Table 1:** The result of Neurobehavioral Status Exam (NBSE) of our case.

| Test Description                                                                 | Score | Interpretation             |
|----------------------------------------------------------------------------------|-------|-----------------------------|
| Blessed Information-Memory-Concentration test (BIMC) [4]. Screening test of general cognition. | 14    | Impaired Normal: 0-8       |
| Digit Span (DS) [5]. Forward DS assesses simple auditory attention; backward DS also incorporates working memory | Forward: 5, Backward: 4 | Borderline |
| Trailmaking Test Part A (Number Sequencing; sustained attention) [6].           | 129 sec | Severely impaired z = -12.16 |
| Trailmaking Test Part B (Alternating Number-Letter; complex attention with set-shifting) [6]. | Unable to complete | Severely impaired |
| Memory Impairment Screen MIS (list-learning episodic memory) [7].               | 0     | Severely impaired Normal: 5-8 |
| WMS-R Logical Memory (Story A) (paragraph recall episodic memory) [8].         | 25-Jan | Severely impaired z = -3.56 |
| Semantic Fluency (Animal Naming in 60 seconds) [9].                             | 7 Animals | Severely impaired z = -3.09 |
| Phonemic Fluency (F, A, S; 60 seconds per letter) [10].                         | F:5, A: 4, S: 7 Total FAS: 16 | Moderately impaired z = -2.25 |
| Rapid Estimate of Adult Literacy in Medicine (REALM) [11].                     | 66    | High-School Level Health literacy |
| Clinical Dementia Rating CDR [12].                                              | 1     | 0: No Impairment 0.5: Very Mild Impairment 1: Mild Impairment 2: Moderate Impairment 3: Severe Impairment |
Discussion

The anatomical core of the episodic memory system is the medial temporal lobe and hippocampus [13]. Clandestine methamphetamine labs are known to produce phosphine, iodine, hydrochloric acid, various solvents, methamphetamine and methamphetamine intermediates [14]. A descriptive study performed by the Washington State Poison Control Center reported the health outcomes of people exposed to clandestine methamphetamine labs most commonly to be headaches, respiratory/eye irritation, nausea, and vomiting [15]. Interestingly, a retrospective chart evaluation of 66 police officers exposed to clandestine methamphetamine labs reported memory loss in up to 77%, but without further description [16].

Methamphetamine is a known neurotoxin that imposes cellular damage through numerous mechanisms, including oxidative stress, excitotoxicity, hyperthermia, neuroinflammation, mitochondrial dysfunction, and endoplasmic reticulum stress [17]. Animal models of methamphetamine use have shown a marked neurodegeneration in the limbic system, including hippocampus, in association with the limbic-originated seizures [18]. The breakdown of the blood-brain-barrier and the activation of glial cells by the released neurotransmitters are some of the hypotheses that were proposed for the degeneration [19].

A deficient strategic (i.e., executive) control of verbal encoding and retrieval has been noted by previous studies done on human subjects with history of methamphetamine dependence, but this was proposed to be the sequela of methamphetamine-related prefronto-striatal circuit neurotoxicity rather than hippocampal involvement [20]. Yet, another small study on 12 subjects with methamphetamine dependence revealed that they matched their controls in all cognitive domains testing, except for verbal memory [21].

The results of these studies are consistent to a certain extent with JS, who manifested deficits in memory and executive dysfunction suggestive of involvement of both prefrontal-striatal circuits and medial temporal areas. Yet, our case also revealed evidence of striking—and apparently permanent—damage to anterograde memory, which was not seen in previous studies. Anterograde memory, which was not seen in previous studies.

References

1. Scoville WB, Milner B (1957) Loss of recent memory after bilateral hippocampal lesions. J Neurol Neurosurg Psychiatry 20(1): 11-21.
2. Zola-Morgan S, Squire LR, Amaral DG (1986) Human amnesia and the medial temporal region: enduring memory impairment following a bilateral lesion limited to field CA1 of the hippocampus. J Neurosci 6(10): 2950-2967.
3. Park HY, Lee PH, Shin DH, Kim GW (2006) Anterograde amnesia with hippocampal lesions following glufosinate intoxication. Neurology 67(5): 914-915.
4. Blessed G, Tomlinson BE, Roth M (1968) The association between quantitative measures of dementia and of senile changes in the cerebral gray matter of elderly subjects. Br J Psychiatry 114(512): 797-811.
5. Wechsler D (1981) Wechsler adult intelligence scale-revised (WAIS-R). Psychological Corporation, New York, USA.
6. Reitan R (1958) Validity of the trail making test as an indicator of organic brain damage. J Comp Physiol Psychol 8(3): 271-276.
7. Buschke H, Kuslansky G, Katz M, Stewart WF, Slivinski MJ, et al. (1999) Screening for dementia with the memory impairment screen. Neurology 52(2): 231-237.
8. Wechsler D (1987) Wechsler memory scale-revised. The Psychological Corporation, San Antonio, Texas, USA.
9. Munsch AU, Bondi MW, Butters N, Salmon DP, Katzman R, et al. (1992) Comparisons of verbal fluency tasks in the detection of dementia of the Alzheimer type. Arch Neurol 49(12): 1253-1258.
10. Benton AL, Hamsher K (1989) Multilingual aphasia examination. AJA Assoc, Iowa City, USA.
11. Davis TC, Long SW, Jackson RH, Mayeaux EJ, George RB, et al. (1993) Rapid Estimate of Adult Literacy in Medicine: a shortened screening instrument. Fam Med 25(6): 391-395.
12. Morris JC (1993) Clinical Dementia Rating: Current version and scoring rules. Neurology 43(11): 2412-2414.
13. Aggleton JP, Saunders RC (1997) The relationships between temporal lobe and diencephalic structures implicated in anterograde amnesia. Memory 5(1-2): 49-71.
14. Martyny JW, Arbuckle SL, McCanmon CS, Esswein EJ, Erb N, et al. (2007) Chemical concentrations and contamination associated with clandestine methamphetamine laboratories. J Chem Health Safety 14(4): 40-52.
15. Trasher DL, Von Derau K, Burgess J (2009) Health effects from reported exposure to methamphetamine labs: a poison center-based study. J Med Toxicol 5(4): 200-204.
16. Witter RZ, Martyny JW, Mueller K, Gottschall B, Newman LS (2007) Symptoms experienced by law enforcement personnel during methamphetamine lab investigations. J Occup Environ Hyg 4(12): 895-902.
17. Davidson C, Gow AJ, Lee TH, Ellinwood EH (2001) Methamphetamine neurotoxicity: necrotic and apoptotic mechanisms and relevance to human abuse and treatment. Brain Research Reviews 36(1): 1-22.
18. Bowyer JF, Peterson SL, Rountree RL, Tor-Agbiyde J, Wang GJ (1998) Neuronal degeneration in rat forebrain resulting from D-amphetamine-induced convulsions is dependent on seizure severity and age. Brain Res 809(1): 77-90.
19. Bowyer JF, Ali S (2006) High doses of methamphetamine that cause disruption of the blood-brain barrier in limbic regions produce extensive neuronal degeneration in mouse hippocampus. Synapse 60(7): 521-532.
20. Woods SP, Rippeth JD, Conover E, Gongvatana A, Gonzalez R, et al. (2005) Deficient strategic control of verbal encoding and retrieval in individuals with methamphetamine dependence. Neuropsychology 19(1): 35-43.
21. Rapeli P, Kivisaari R, Kühkönen S, Puukari V, Autti T, et al. (2005) Do individuals with former amphetamine dependence have cognitive deficits? Nord J Psychiatry 59(4): 293-297.