Chronic DCI cognitive dysfunction improved with hyperbaric oxygen: a case report

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Introduction

Altitude chamber exposures have been used for training, allowing aircrew to experience their hypoxia and pressure effect symptoms. Decompression illness (DCI) (decompression sickness and air gas embolism) is a known complication that can occur subsequent to the training. A 27-year-old female underwent altitude chamber training to an altitude of 25,000 feet on July 26, 2012. During the hypoxia demonstration, she experienced onset of tingling in her left leg/arm and right leg, headache, dizziness, and malaise. She started 100% oxygen without resolution, and then had difficulty responding to attendants. She could hear them, but could not speak back. Upon examination, she also had photophobia. She received a USN treatment table 6 (TT6) hyperbaric treatment and was given a tailing TT5 the next day due to right hip pain development and continued headache, dizziness, and perception of decreased mental capacity. Her symptoms improved except for a continued moderate headache, but with recurrence of intermittent paresthesia and decreased memory. The patient was evaluated by neurology, psychiatry, psychology, and aerospace medicine specialists for continued symptoms including decreased executive function and reaction times. She was referred 14 months after the incident.

Materials and Methods

As the patient deployed multiple times, she had a number of Automated Neuropsychological Assessments Metrics (ANAM) tests (http://www.vistalifesciences.com/anam-intro.html). Prior to the 59 hyperbaric oxygen exposures at 2.0 ata, another ANAM was administered to create a pre-treatment baseline (June 25, 2013). The patient was treated twice daily (7 AM and 1 PM). Serial ANAM tests were done after every 10 treatments (weekly) and compared to the pre-treatment baseline and her last pre-deployment (March 20, 2012) ANAM scores. These ANAM results are compared here including the one administered on October 21, 2013, and the final ANAM on November 5, 2013. The October 2013 ANAM was after 39 hyperbaric treatments and an 11-day break for personal reasons.

Results

The March 20, 2012, ANAM demonstrated average or above scores in all seven subtests, whereas the June 25, 2013, scores were clearly below except for the "matching to sample" test, which was below average (see the ANAM result charts below). The serial ANAM scores improved over the treatment course through the 39 hyperbaric oxygen treatments where the ANAM on October 10 (not shown) was near that of the final ANAM on November 5, 2013. The 10-day break ANAM on October 21, 2013, demonstrated a deterioration. The ANAM results plateaued the last 2 weeks with a score category of below average in "simple reaction time" and clearly below in another "simple reaction time" scale. The other five subtests were average or above (November 5, 2013).

Discussion

The symptoms from the altitude exposure favor air gas embolism with continued symptoms similar to traumatic brain injury. Upon evaluation there was no shunting across the intra-atrial septum and MRI studies failed to demonstrate any pathological lesions. However, the cognitive symptoms continued to worsen over time. Our study of the potential use of hyperbaric oxygen for traumatic brain injury suggested more likely benefit when symptoms were treated within 2 years of the precipitating event (1). We felt the residual DCI symptoms warranted treatment even though they were past the traditional time frame. The protocol developed was based on neurological decompression sickness treatment where hyperbaric oxygen therapy is continued until the symptoms resolve or plateau. In this case, we had an objective measure (ANAM) administered after every 10 treatments. The ANAM is designed for repeated measures testing (2), but training effect is a concern in such tests. Eonta (3) demonstrated improvement in repeated tests given back to back on the same day, but plateauing over the last 2 days (3- and 4-day studies). In this case report, it could be a factor, but likely small, as the 10-day break demonstrated a deterioration in scores followed by improvement and plateau and the interval was 1 week. In addition, interval tests had individual subtests that had positive and negative changes, but with overall improvement throughout the course of treatment. Placebo effect cannot be ruled out; however, the patient was in medical hold at her home base and not performing an active job. Would the patient improve without hyperbaric oxygen? Certainly, she may have. However, her four pre-deployment ANAM scores were all average or above and the significant deterioration post incident seen in the June 2013 pre-treatment scores could not have been much worse. As the ANAM consultant observed, the case demonstrated real changes beyond mere practice effect. How much hyperbaric oxygen therapy was increasing the slope of improvement is the question.

Summary

This altitude training DCI case resulting in chronic cognitive dysfunction is the first case to our knowledge that has been treated after the normal timeframe. The availability of pre-incident cognitive function testing allowed us to objectively measure improvement during the hyperbaric oxygen therapy series. Such testing can be done, especially when a baseline is available. This has potential impact for similar cognitive neurological cases in diving and altitude as well as other bubble-related etiologies, including surgical-induced air gas emboli and blast injury (4).

References

1. Wolf EG, Profenna LC, Brower GL. Cognitive function in a traumatic brain injury randomized clinical trial. Undersea Hyperbaric Med 2013; 40:548.
2. C-Shop. ANAM4 TBI: User Manual. Norman, OK: Center for the Study of Human Operator Performance, University of Oklahoma; 2007.
3. Eonta SE, Carr W, McArdle JJ, Kain JM, Tate C, Wesensten NJ, et al. Automated Neuropsychological Assessment Metrics: repeated assessment with two military samples. Aviat Space Environ Med 2011; 82(1):34-9.
4. Kocsis JD, Tessler A. Pathology of blast-related brain injury. J Rehabil Res Dev 2009; 46(6): 667-72.

ANAM 20 Mar 2012

HISTORY

Injury cause(s):	Resulting in:	Symptoms Right after Injury: none recorded.
None recorded.	None recorded.	Symptoms Now While Resting: none recorded.
		Symptoms Now after Exertion: none recorded.

PROVIDER OBSERVATIONS
MACE:
Interval between current and previous injury:

PERFORMANCE AT A GLANCE

Comparison Group: Military: All Services Females Age 26-30

Comparison to BASELINE	SCALE (DOMAIN)		AVERAGE OR ABOVE	BELOW AVERAGE	CLEARLY BELOW
?	Simple Reaction Time	(REACTION TIME)	■		
?	Simple Reaction Time (R)	(REACTION TIME)	■		
?	Procedural Reaction Time	(PROCESSING SPEED	■		
?	Code Substitution - Learning	(LEARNING)	■		
?	Code Substitution - Delayed	(DELAYED MEMORY)	■		
?	Mathematical Processing	(WORKING MEMORY)	■		
?	Matching to Sample	(SPATIAL MEMORY)	■		

SLEEP (1-7)
Score: 2 - Able to concentrate, but not quite at peak.

MOOD (0-100)
81 HAPPINESS
69 VIGOR
08 FATIGUE
00 RESTLESSNESS
00 ANXIETY
00 DEPRESSION
00 ANGER

REFERENCE
Category lower limits for Below Average (9th percentile, 80.5 standard score) and Clearly Below Average (2nd percentile, 70 standard score) are based on Hannay, H. J., & Lezak, M. D. (2004). The neuropsychological examination: Interpretation. In M. D. Lezak, D. B. Howieson, & D. W. Loring (Eds.), *Neuropsychological Assessment* (pp. 133-156). New York: Oxford University Press.

ANAM 25 Jun 2013

HISTORY

Injury cause(s):	Resulting in:	Symptoms Right after Injury: none recorded.
None recorded.	None recorded.	Symptoms Now While Resting: none recorded.
		Symptoms Now after Exertion: none recorded.

PROVIDER OBSERVATIONS
MACE:
Interval between current and previous injury:

PERFORMANCE AT A GLANCE

Comparison Group: Military: All Services Females Age 26-30

Comparison to BASELINE	SCALE (DOMAIN)		AVERAGE OR ABOVE	BELOW AVERAGE	CLEARLY BELOW
?	Simple Reaction Time	(REACTION TIME)			■
?	Simple Reaction Time (R)	(REACTION TIME)			■
?	Procedural Reaction Time	(PROCESSING SPEED			■
?	Code Substitution - Learning	(LEARNING)			■
?	Code Substitution - Delayed	(DELAYED MEMORY)			■
?	Mathematical Processing	(WORKING MEMORY)			■
?	Matching to Sample	(SPATIAL MEMORY)		■	

SLEEP (1-7)
Score: 2 - Able to concentrate, but not quite at peak.

MOOD (0-100)
44 HAPPINESS
47 VIGOR
56 FATIGUE
39 RESTLESSNESS
56 ANXIETY
56 DEPRESSION
33 ANGER

REFERENCE
Category lower limits for Below Average (9th percentile, 80.5 standard score) and Clearly Below Average (2nd percentile, 70 standard score) are based on Hannay, H. J., & Lezak, M. D. (2004). The neuropsychological examination: Interpretation. In M. D. Lezak, D. B. Howieson, & D. W. Loring (Eds.), *Neuropsychological Assessment* (pp. 133-156). New York: Oxford University Press.

ANAM 21 Oct 2013

HISTORY

Injury cause(s):	Resulting in:	Symptoms Right after Injury: none recorded.
None recorded.	None recorded.	Symptoms Now While Resting: none recorded.
		Symptoms Now after Exertion: none recorded.

PROVIDER OBSERVATIONS
MACE:
Interval between current and previous injury:

PERFORMANCE AT A GLANCE

Comparison Group: Military: All Services Females Age 26-30

Comparison to BASELINE	SCALE (DOMAIN)		AVERAGE OR ABOVE	BELOW AVERAGE	CLEARLY BELOW
-2.83	Simple Reaction Time	(REACTION TIME)		■	
-2.34	Simple Reaction Time (R)	(REACTION TIME)		■	
-2.7	Procedural Reaction Time	(PROCESSING SPEED		■	
0.99	Code Substitution - Learning	(LEARNING)	■		
0.32	Code Substitution - Delayed	(DELAYED MEMORY)	■		
-0.62	Mathematical Processing	(WORKING MEMORY)	■		
-0.63	Matching to Sample	(SPATIAL MEMORY)	■		

SLEEP (1-7)
Score: 3 - Relaxed and awake, but not fully alert.

MOOD (0-100)
58 HAPPINESS
47 VIGOR
42 FATIGUE
22 RESTLESSNESS
31 ANXIETY
25 DEPRESSION
08 ANGER

REFERENCE
Category lower limits for Below Average (9th percentile, 80.5 standard score) and Clearly Below Average (2nd percentile, 70 standard score) are based on Hannay, H. J., & Lezak, M. D. (2004). The neuropsychological examination: Interpretation. In M. D. Lezak, D. B. Howieson, & D. W. Loring (Eds.), *Neuropsychological Assessment* (pp. 133-156). New York: Oxford University Press.

ANAM 5 Nov 2013

HISTORY

Injury cause(s):	Resulting in:	Symptoms Right after Injury: none recorded.
None recorded.	None recorded.	Symptoms Now While Resting: none recorded.
		Symptoms Now after Exertion: none recorded.

PROVIDER OBSERVATIONS
MACE:
Interval between current and previous injury:

PERFORMANCE AT A GLANCE

Comparison Group: Military: All Services Females Age 26-30

Comparison to BASELINE	SCALE (DOMAIN)		AVERAGE OR ABOVE	BELOW AVERAGE	CLEARLY BELOW
-1.85	Simple Reaction Time	(REACTION TIME)		■	
-4	Simple Reaction Time (R)	(REACTION TIME)			■
-1.47	Procedural Reaction Time	(PROCESSING SPEED		■	
-0.06	Code Substitution - Learning	(LEARNING)	■		
0.42	Code Substitution - Delayed	(DELAYED MEMORY)	■		
0.01	Mathematical Processing	(WORKING MEMORY)	■		
-1.07	Matching to Sample	(SPATIAL MEMORY)	■		

SLEEP (1-7)
Score: 1 - Feeling very alert, wide awake, and energetic.

MOOD (0-100)
56 HAPPINESS
67 VIGOR
19 FATIGUE
14 RESTLESSNESS
36 ANXIETY
08 DEPRESSION
06 ANGER

REFERENCE
Category lower limits for Below Average (9th percentile, 80.5 standard score) and Clearly Below Average (2nd percentile, 70 standard score) are based on Hannay, H. J., & Lezak, M. D. (2004). The neuropsychological examination: Interpretation. In M. D. Lezak, D. B. Howieson, & D. W. Loring (Eds.), *Neuropsychological Assessment* (pp. 133-156). New York: Oxford University Press.