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Neurological Decompression Sickness In U-2 Pilots: A Case Series 2002-2009

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Background



- ***U-2S Mission***

- High altitude (+60,000 ft) reconnaissance
- USAF's sole remaining *manned* high altitude platform



- ✧ ***Very High-Stress Physiological Profile***

- ✧ High risk of DCS without preventative measures

- ✧ ***Standard DCS Prevention Measures***

- ✧ Full pressure suit, 1-hour resting pre-breath, 100% O₂

- ✧ ***Historical DCS Incidence in U-2 Program (Prior to 1998)***

- ✧ Many *unreported* cases of joint/skin DCS
- ✧ No *recorded* cases of CNS-related DCS
- ✧ No *recorded* cases of permanent neurological damage

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CNS Neurological DCS ***(2002-2009)***



- ✧ **45 recorded DCS incidents of ALL types (37 pilots)**
- ✧ **16 confirmed cases neurological DCS (14 pilots)**
 - ✧ **Three (3) neurological + pulmonary DCS [2 at OL2]**
 - ✧ **Five (5) life and/or aircraft threatening [4 at OL2]**
- ✧ **4 possible cases of neurological DCS (4 pilots)**
- ✧ **Observations:**
 - ✧ **Majority were men (one woman)**
 - ✧ **No correlation to age, body habitus, or GelDex use**
 - ✧ **No PFO detected among 6 pilots tested**
 - ✧ **One pilot with MRI lesions among 9 tested**

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CNS Neurological DCS Cases (1991-2001)



- ✧ **22 recorded DCS incidents of ALL types**
- ✧ **Two (2) confirmed chokes cases**
- ✧ **Three (3) confirmed neurological DCS cases**
- ✧ **Two possible cases of neuro DCS (1991, 2000)**
- ✧ **Five subjects*, all men**
- ✧ **Incomplete data on body habitus, age, & tests**

* Cases don't add up to 5 because some subjects had multiple incidences and/or experienced multiple symptoms (i.e., chokes+neuro)

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Unusual Symptoms for Aviation-Related DCS



❖ Late Onset of Neurological Symptoms

- ❖ 3 cases: sudden onset severe symptoms >4hrs in-flight***
- ❖ 7 cases: delayed recognition of symptoms after landing***

❖ Recurrent Symptoms After Indicated Treatment

- ❖ Temporal association with commercial airline flights***
- ❖ 2 cases flew home approximately 72hrs after treatment***



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Unusual Symptoms for Aviation-Related DCS (con't.)



- ✧ ***Symptoms Persist Despite Indicated Treatment***
 - ✧ Subtle neuropsychological symptoms persist for years
 - ✧ One case of PTSD (one additional case possible)
- ✧ ***Permanent Neurological Sequelae in 1 Case***
 - ✧ Correlating lesions on MRI
 - ✧ Severe case – clinical equivalent of ischemic stroke
- ✧ ***Common in Diving-Related DCS, but Not Aviation***



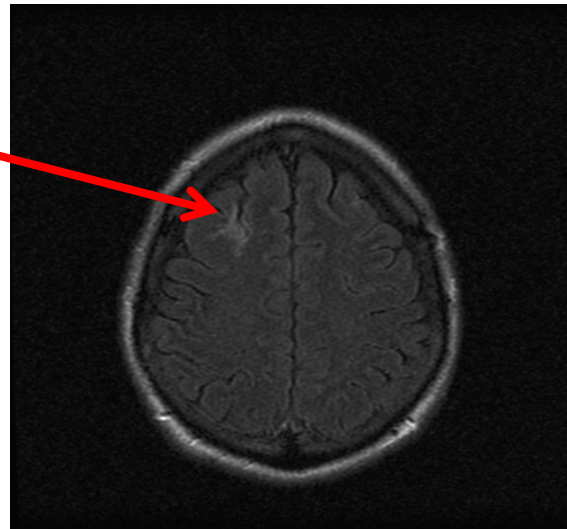
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Most Severe U-2 Neurological DCS Case



- ✧ **Several prior (undisclosed) incidents of DCS**
- ✧ **1-hour resting pre-breath, otherwise healthy male**
- ✧ **Cabin altitude 28,000 ft (8,534 m)**
- ✧ **Gradual onset of symptoms after 2.5 hrs flight**
 - ✧ **Joint pain progressing to fatigue, confusion, visual disturbances, difficulty breathing, chest pain, shock**



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U2 Pilot with Neurological DCS



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Most Severe U-2 Neurological DCS Case



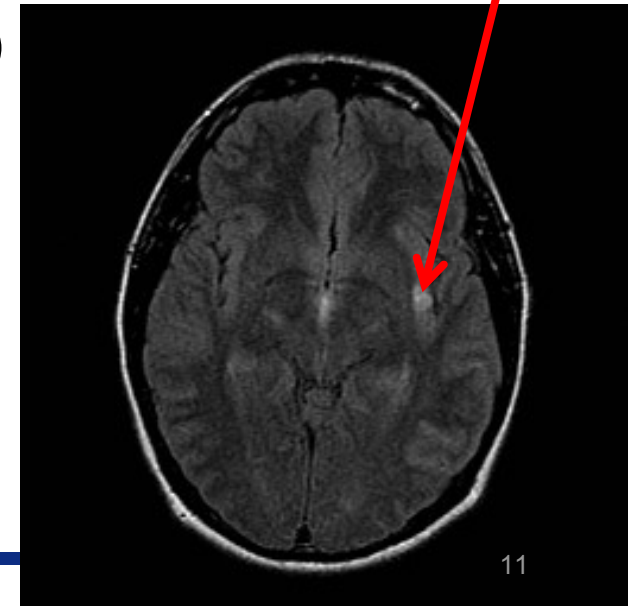
- ✧ **Pilot required coaching for flying, periods of unconsciousness, nearly crashed on landing**
- ✧ **Most severe symptoms resolved with HBOT**
- ✧ **Brain lesions on MRI improved after HBOT**
- ✧ **Permanent symptoms, corresponding MRI lesions**
 - ✧ **Headaches, fatigue, personality changes, memory deficits, vision problems**
- ✧ **Permanently disqualified from flying**



Most Recent U-2 Neurological DCS Case



- ✧ No prior history of DCS
- ✧ 1-hour resting pre-breath, otherwise healthy male
- ✧ Cabin altitude 29,000 ft (8,839 m), 9.2hr flight
- ✧ Gradual onset of symptoms 5 hrs after landing
 - ✧ Bitemporal headache, partially resolved with NSAID
 - ✧ Overnight, headache recurred with worsening fatigue, dizziness, unsteady Romberg, blurred vision
 - ✧ Symptoms resolved with HBOT (USN TT-6)
- ✧ Symptoms recurred 48hrs later
 - ✧ Resolved with HBOT (USN TT-6 x2, TT-5)
- ✧ MRI lesion 05 Mar 10
 - ✧ Asymptomatic, normal neurological exam
- ✧ Should he fly again?





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Possible Causes



- ✧ ***Pilots More Willing to Report***
 - ✧ **Classification barriers removed**
 - ✧ **No more “two strikes” penalty**
 - ✧ **Operational culture changed after 2006 incident**
- ✧ ***Normal Statistical Variation?***
 - ✧ **True incidence unknown, relatively small numbers**
- ✧ ***Increased Operations Tempo***
 - ✧ **Frequency & duration of flights unprecedented**
 - ✧ **Workload falling on fewer pilots (reduced manning)**

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Mission Duration & Frequency



	Previous Generation U-2 Pilots (1980's – 1997)	Today's U-2 Pilots (1998 – Present)	Percent Change
Number of Pilots Available	49	37	24% fewer pilots
Average Annual Hours per Pilot	207	353	70% more hours
Average Annual Sorties per Pilot	42	92	122% more sorties
Time to Achieve "1,000-Hour" Status	7-10 years	3-5 years	They're ALL "1,000-Hour" pilots now!

Bottom Line:
Increased duration & frequency of hypobaric exposure

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Other Causes Ruled Out by Investigation



- ✧ **No correlation with aircraft tail number**
- ✧ **No mechanical failures in aircraft or life support systems**
- ✧ **No changes in equipment or integration/launch procedures**
- ✧ **No aircraft/LOX systems, LOX supply contamination**
- ✧ **No unique environmental contamination sources**
- ✧ **No correlation with amphetamine (GelDex 'go-pill') use**
- ✧ **No correlation with anthropomorphic variables or pre-existing medical conditions**
- ✧ **No evidence of malingering**



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Possible Risk Mitigation Measures



- ✧ **Address Known Major Risk Factors for DCS:**
 - ✧ **Pre-breath, altitude, activity & exposure time at altitude**
- ✧ **Exercise Enhanced Pre-Breath**
 - ✧ **Risk reduction is population-based**
- ✧ **Reduce Time of Exposure (Sortie Length)**
- ✧ **Reduce Mission Operating Altitude**
- ✧ **Fly with Pressure Suit Partially Inflated at All Times**
- ✧ **Increase Rest Cycle Between Missions, Deployments**
- ✧ **Educate – Lower Threshold for Treatment Needed**
- ✧ **Return flights home with supplemental oxygen**



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Clinical Outcomes



Symptoms Similar to Traumatic Brain Injury (TBI)

- ✦ **Normal imaging studies & neurological exam**
- ✦ **Persistent subtle symptoms, often overlooked initially**
- ✦ **Fatigue, headaches, irritability, sleep disturbances, difficulty focusing, memory problems**
- ✦ **Risk of concurrent PTSD**
- ✦ **Permanent deficits in most severely injured patient**
- ✦ **Suggests common final pathway of injury**
- ✦ **Window of increased susceptibility for re-injury?**

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Conclusions



- ✧ ***Increased Number of Neuro DCS Incidents Among U-2 Pilots***
 - ✧ Coincident with persistent, increased tempo of operations
- ✧ ***Unusual Symptoms for Aviation-Related DCS***
 - ✧ Onset of neurological DCS after >4 hours at altitude
 - ✧ Recurrence of symptoms after indicated treatment
 - ✧ Subtle, but persistent neuropsychological symptoms
 - ✧ Permanent injuries in some
 - ✧ Suggests common final pathway for brain injury
- ✧ ***Implications for Aeromedical Management***
 - ✧ Should neuro DCS patients be managed as head injuries?
- ✧ ***Implications for Treatment***
 - ✧ Immediate HBOT for ***ANY SUSPECTED*** neuro DCS
 - ✧ Operational patients at risk for concurrent PTSD
 - ✧ Could TBI treatments benefit neuro DCS patients (and vice versa)?



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