

Aeromedical Evaluation for an F-16 Candidate with Incomplete Paraplegia

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- BACKGROUND:** A candidate with paraplegia contacted the Institute of Aviation Medicine, Oslo, requesting a medical examination and medical certification for flying back seat on an F-16 Fighting Falcon. Thorough aeromedical examinations, including specialist evaluations, were initiated for the final decision to be made.
- CASE REPORT:** Almost 13 yr earlier the candidate had acquired spinal cord damage at neurological level L1 after falling 4 m (13 ft) from out of a window. The CT scans showed luxation of the 12th thoracic vertebra with fracture and dislocation of the 1st lumbar vertebra. He went for surgery, where fixation of the 12th thoracic vertebra to the 1st lumbar vertebra was performed. He developed syringomyelia 1 yr postoperatively and was re-operated on twice in the following years. He was now in a wheelchair, but engaged himself in several sport activities such as sledge-hockey and sit-skiing, participating in several Paralympics.
- DISCUSSION:** With respect to the general principles of aviation medicine, several considerations had to be taken into account before a medical certification could be given. The risks associated with an F-16 flight in relationship to the candidate's general health and the fixation of his spinal cord had to be evaluated. Also, his ability to perform required tasks during the flight and in case of an emergency was an important issue discussed. Finally, the candidate's medical and physical condition should not present a considerable risk to flight safety. After extensive specialist consultations and in-depth discussions, the candidate was given medical certification to fly back seat in a F-16.
- KEYWORDS:** paraplegia, syringomyelia, F16, back seat, medical certification.

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In spring 2010, a team from National Norwegian Broadcasting (NRK) contacted the Institute of Aviation Medicine, Oslo, and presented the concept of a new television series. The aim of the series was to follow a set of people on their journey to fulfill their highest wish in life. One of the participants had an incomplete paraplegia after a falling accident in 1997 and his dream was to fly back seat on an F-16 Fighting Falcon. The Royal Norwegian Air Force approved the request for a back seat flight given that the flight could be conducted with an acceptable risk for both the passenger and the operation. Searching the literature, no similar case of such an examination ending with medical certification has been reported.

CASE REPORT

The candidate was a man of the age of 46. In January 1997, he had acquired spinal cord damage at neurological level L1 (ASIA grade B) after falling 4 m (13 ft) from out of a window,

landing on his back.¹ Upon arrival at the emergency ward, the neurological examination revealed lower limb paralyses, with only some muscle contraction for knee-adduction, and absence of joint reflexes. There was no sensibility in the fifth lumbar and first sacral dermatomes. Treatment with corticosteroids was immediately initiated. Radiographs and CT-scans of the vertebral column revealed luxation of the 12th thoracic vertebra with fracture and dislocation of the 1st lumbar vertebra. Immediate surgery with reposition of the thoracic

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vertebra together with spondylodesis between the thoracic and the lumbar vertebra was performed.

Postoperative physical rehabilitation was soon initiated. However, in the following months, the candidate developed increasing paresthesias and numbness in his upper limbs. MRI scan (**Fig. 1** and **Fig. 2**) showed syringomyelia from the first cervical vertebra down to the lumbar column. He went for surgery in 1999, with improvement of his symptoms (Figs. 1 and 2). Because of increasing complaints of pain and sensibility changes in his upper limbs, he was re-operated on a year later due to blockage of the shunt and progression of the syringomyelia.^{4,10,15}

Although in a wheelchair after the accident, with normal motor function only in his upper body, the candidate had engaged himself in sport activities such as sledge-hockey, “sit-skiing,” scuba diving, and go-cart. He participated in four Paralympics, from Nagano in 1998 to Vancouver in 2010, taking both gold and silver medals. Additionally, he had been a parachute jumper prior to the accident.

The candidate was referred to the Institute of Aviation Medicine for a thorough medical examination and assessment. A complete medical history was obtained and a full examination, including neurological examination, was performed. Except for his spinal condition and paraplegia, he had no previous or present serious illnesses. Besides his neuropathic pains, his other complaints were headaches and tinnitus. He was using medications only for the neuropathic pain. The general examination revealed a congenital thoracic kyphosis and wasting of large

muscle groups in the lower limbs, but was otherwise normal. His upper body was athletic and muscular. His hemodynamic parameters were normal and there was no history of acute hypotensive episodes, as may be found in some patients with spinal cord injury.⁶

During neurological examination he showed great strength in his upper body and upper limbs. Near normal strength in the lower limbs was only found in the proximal muscle group, those performing hip-adduction. Spasticity was found upon examining the lower limbs. Examinations of the visual and auditory system were normal, as were blood tests and urine sample, together with electrocardiogram and lung function testing. As expected, based on his diving experience, he successfully completed a hypobaric chamber flight to 8000 ft (2438 m), at an ascent rate of 20,000 ft · min⁻¹ (6096 m · min⁻¹) and a descent rate of 4000 ft · min⁻¹ (1219 m · min⁻¹) in order to check for middle ear, sinus, and dental barotrauma, and to familiarize him with the pressure, diluter demand oxygen mask, and regulator used in the F-16. He was also trained in equalizing the pressure when using the oxygen mask.

DISCUSSION

To conclude if the candidate could fly or not, certain considerations according to general principles in aviation medicine had to be addressed.^{9,11,13} These were:

- If the environmental factors could worsen his medical condition;
- If the environmental factors could worsen his function and ability to perform the required tasks during normal operation and emergency; and
- If there were any considerable risks that his condition in any way could jeopardize flight safety.

Since this was a designated passenger flight, high G forces could be avoided. However, in case of an emergency situation, exposure to G forces might be unavoidable. For instance, firing the ejection seat would subject the candidate to 12–14 G in the vertical axis. The tolerance to +G_z forces became a major issue of discussion regarding possible damaging effects on the candidate’s spinal condition.

Medical specialists who had followed the candidate were consulted. In their initial evaluation, the neurosurgeons dissuaded the candidate from flying with reference to the secondary worsening of the syringomyelia after his first surgery, which came after an episode of coughing. A greater trauma as in case of an ejection might worsen the syringomyelia and give new neurological complications or sequelae. Due to

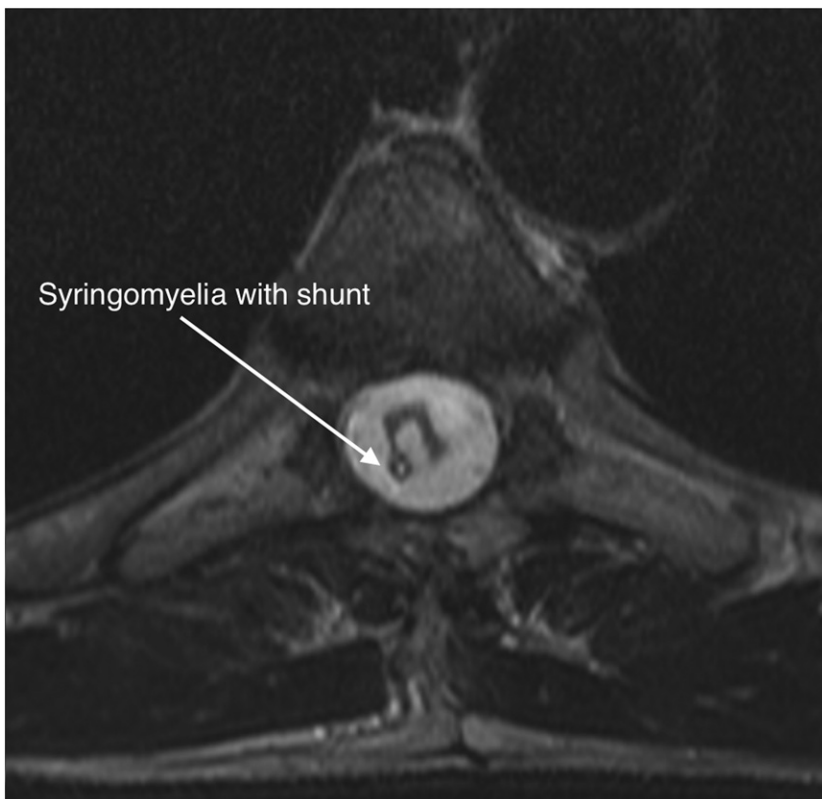


Fig. 1. Axial T2-weighted MRI image of the syringomyelia. The image shows the tip of the shunt within the syrinx.

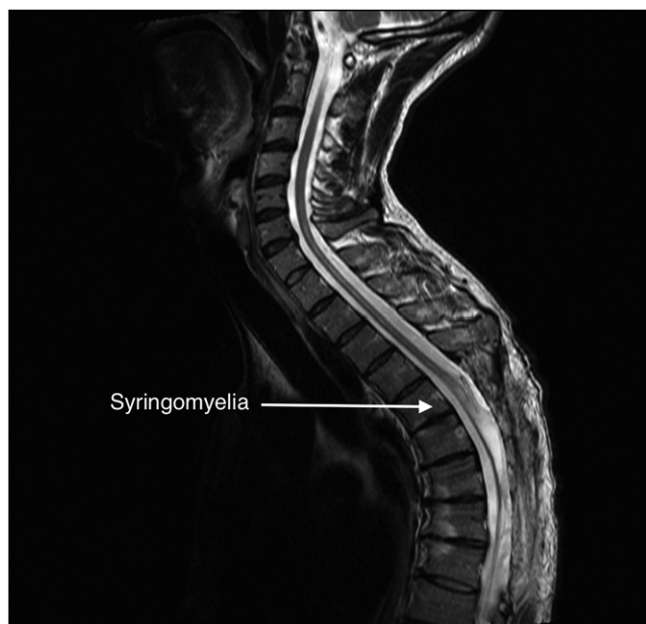


Fig. 2. Sagittal MRI image of the syringomyelia.

the relative instability of the candidate's spine after the surgery, there was also an increased risk of additional spinal cord injury elsewhere.¹⁶

The consultant physician in rehabilitation medicine, who had followed and treated the candidate since the accident, had a different opinion. He considered the general health of the candidate as good and emphasized that the candidate had been active in contact sports for many years and sustained several hits toward his spine without any complications. He argued that the presence of a cystoarachnoidal shunt would prevent a worsening of the syringomyelia. The consultant physician also concluded that the candidate's spine would tolerate an ejection without major risk of trauma to the spine since it was fixed with four screws, resulting in a firm spine. In addition, standard radiographs of the spine showed no sign of osteoporosis or osteopenia. He also emphasized the fact that the candidate was given permit to freely mobilize right after the primary surgery, without the necessity of using a three-point corset.

Based on the evaluation from the consultant physician in rehabilitation medicine, the neurosurgeons were consulted again. They had now examined the MRI scans taken in 2009, almost 9 yr after the last surgery. The scans did not show any worsening of the syringomyelia. The syrinx communicated with the subarachnoidal space. Even though the neurosurgeons initially had been of the opinion that there was a risk of injury to the spine and the syrinx in case of an ejection, they acknowledged that the functioning open syrinx decreased the probability of such worsening of the syrinx. Also, the fixation of the 12th thoracic vertebra to the 1st lumbar vertebra gave the spine almost the same strength as before the accident.

Further discussion regarded the candidate's tolerance to high sustained G force, as a normal training flight in the F-16 may involve forces of up to +9 G_z. The tensing of muscles in the lower limbs to prevent pooling of blood would not be effective,

the fitting of G trousers might prove to be difficult due to the muscle wasting, and the protective effect of the G-suit might be reduced as well.¹⁴ The candidate would be using the standard RNoAF F-16 full coverage anti-G suit. This suit provides better protection than the old five-bladder G-suit, and tight fitting may not be as critical compared to the five-bladder suit. Although the musculoskeletal strain brought on by G forces was considered substantial, his athletic career provided some reassurance that it would not be the major issue.^{3,5,12} However, for the duration of the flight, it was recommended that +5 G_z should be the maximum G force level, with special attention given to any reactions during the first application of more than +3 G_z.

In case of an emergency, an ejection would subject the candidate to a short duration G of +12–14 G_z for less than 0.5 s when firing the ACES II ejection seat. Due to paralysis in his lower limbs and lack of active leg restraint in the ACES II seat, there would be an increased risk of his legs being caught by the windblast, resulting in serious injuries (flail injuries) during seat deceleration in a high-speed ejection.^{7,17} Slowing the aircraft to the lowest practical airspeed before an ejection is on the pilot's checklist if time permits. The pilot knew that airspeed reduction before an ejection would be of great importance for this passenger.

The flight was to take place from an air base on the west coast of Norway, where wind speed is often high. Landing the ACES II round canopy parachute at a high horizontal speed increases the risk of landing injuries. However, his former experience with parachute steering was considered an advantage. As four-line release and steering is mainly achieved by the arms, his paraplegia would not prevent him from steering to an optimal landing site and landing in the best direction relative to the wind. An operational restriction of maximum 20 kn wind during the flight was therefore given and landing on water was considered the safest with respect to landing injuries. Having water/sea in close proximity while flying was therefore recommended.

In case of evacuation, the candidate could only do this by using his arms. Since he was an athlete with very good strength in his upper body, it was considered that he would be able to exit the aircraft, but take a longer time evacuating the area than a person without physical limitations.

In July 2010, the candidate was finally medically certified to fly in the F-16 as a back seat passenger; however, with some residual medical risk being identified. To mitigate this risk, the following operational restrictions were recommended:

- Maximum G force level of +5 G_z;
- Operations over or close to open water in case of ejection and evacuation; and
- Maximum wind speed of 20 kn.

Also, the candidate should spend minimal time in the cockpit while on the ground. Additionally, increased firefighters on standby should be arranged on the ground. Following our recommendation, he went flying in August 2010. The flight was successful; the candidate enjoyed the entire flight without

experiencing any complications, neither physical nor psychological. Takeoff and landing were uneventful. The candidate particularly enjoyed flying with the G force level up to +5 G_z. Most of the flying was performed above water. There were no problems fitting the suit and the equipment. He reported the day to be exciting and fun, and feeling calm and secure. The candidate reported feeling good about the number of people involved that particular day to make his dream come true. To our knowledge, the candidate is the first person with paraplegia reported to have flown in the F-16. A similar risk management process may be used in other situations where unique opportunities for experience in the aviation environment are sought.^{2,8}

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