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ORIGINAL ARTICLE

Retrospective Study

Spectra of intracranial diseases in Chinese military pilots (cadets) unqualified for transfer to pilot modified high performance aircraft

Yao Zhao, Di Gao, Yan-Bing Liu, Jing-Jing Xue, Xiang Lu, Jing-Jing Dong, Yan Zhang, Jia Zeng

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Abstract

BACKGROUND

With very high mortality and disability rates, cerebrovascular diseases and intracranial tumors severely threaten the health and fighting strength of flying personnel, requiring great concern and intensive screening in clinic, early warning in an early and accurate manner and early intervention of diseases possibly resulting in inflight incapacitation are key emphases of aeromedical support in clinic.

AIM

To probe into the spectra of intracranial diseases, flight factors and medical imaging characteristics of military pilots (cadets) in the physical examination for transfer to pilot modified high performance aircraft, thus rendering theoretical references for clinical aeromedical support of pilots.

METHODS

A total of 554 military pilots (cadets) undergoing physical examination for transfer to pilot modified high performance aircraft from December 2020 to April 2024 in a military medical center were enrolled in this study. Then, a retrospective study was carried out on intracranial disease spectra and head magnetic resonance imaging (MRI) data of 36 pilots (cadets) who were unqualified for transfer to pilot modified high performance aircraft. Besides, a descriptive statistical analysis was conducted on the clinical data, age, fighter type and head MRI data of such pilots (cadets).

RESULTS

Abnormal head images were found in 36 out of 554 pilots (cadets) participating in the physical examination for transfer to pilot modified high performance aircraft, including arachnoid cyst in 17 (3.1%) military pilots (cadets), suspected very small

aneurysm in 11 (2.0%), cavernous hemangioma in 4 (0.7%), vascular malformation in 2 (0.4%), and pituitary tumor in 3 (0.5%, one of which developed cavernous hemangioma simultaneously). Among the 17 pilots (cadets) with arachnoid cyst, 4 were identified as unqualified for transfer to pilot modified high performance aircraft because the marginal brain tissues were compressed by the cyst > 6 cm in length and diameter. The 11 pilots (cadets) with suspected very small aneurysms identified by 3.0T MRI consisted of 6 diagnosed with conus arteriosus by digital subtraction angiography and qualified for transfer to pilot modified high performance aircraft, and 5 identified as very small intracranial aneurysms with diameter < 3 mm and unqualified for transfer to pilot modified high performance aircraft. No symptoms and signs were observed in the 4 military pilots (cadets) with cavernous hemangioma, and the results of MRI revealed bleeding. The 1 of the 4 had the lesion located in pons and developed Rathke cyst in pituitary gland at the same time, and unqualified for transfer to pilot modified high performance aircraft. The 2 of the 4 were unqualified for flying, and 2 transferred to air combat service division. The 2 pilots (cadets) with vascular malformation were identified as unqualified for transfer to pilot modified high performance aircraft. Among the 3 pilots (cadets) with pituitary tumor, one pilot cadet was identified as unqualified for flying since the tumor compressed the optic chiasma, one had cavernous hemangioma in pons in the meantime and transferred to air combat service division, and one was diagnosed with nonfunctional microadenoma and qualified for transfer to pilot modified high performance aircraft.

CONCLUSION

High-resolution head MRI examination is of great significance for screening and detecting cerebrovascular diseases and intracranial tumors in military flying personnel, and attention should be paid to its clinical application to physical examination for transfer to pilot modified high performance aircraft.

Key Words: Aircrew; Cranial magnetic resonance imaging; Cerebrovascular diseases; Intracranial tumors; Aeromedical appraisal

Core Tip: Cerebrovascular diseases and intracranial tumors may lead to intracranial hemorrhage, epilepsy, headache, neurological impairment and other risk factors for inflight incapacitation. High-resolution head magnetic resonance imaging examination is of great significance for screening and detecting cerebrovascular diseases and intracranial tumors in military flying personnel, and its clinical application to physical examination for transfer to pilot modified high performance aircraft should be attached with great importance. It is essential to detect and to intervene and treat cerebrovascular diseases and intracranial tumors as early as possible, thus reducing the grounding rate and maintaining flight safety.

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INTRODUCTION

Early warning in an early and accurate manner and early intervention of diseases possibly resulting in inflight incapacitation are key emphases of aeromedical support in clinic[1]. With very high mortality and disability rates, cerebrovascular diseases and intracranial tumors severely threaten the health and fighting strength of military flying personnel[2,3], requiring great concern and intensive screening in clinic. During the December 2020 to April 2024, 554 military pilots (cadets) took part in the physical examination for transfer to pilot modified high performance aircraft in a military medical center. Abnormalities were found in 36 pilots (cadets) by 3.0T head magnetic resonance imaging (MRI) examination. The clinical data and appraisal conclusions of these pilots were retrospectively studied, and an analysis was implemented on their disease spectra and imaging characteristics, thus mastering the characteristics of craniocerebral diseases and medical appraisal requirements of military pilots (cadets). Besides, the reasons for their disqualification for transfer to pilot modified high performance aircraft were analyzed, offering theoretical reference for formulating reasonable evaluation standards and related policies for flight physical examination of military flying personnel.

MATERIALS AND METHODS

Case groups

The 554 military pilots (cadets) who were hospitalized in a military medical center for the physical examination for

Table 1 Fighter type and age distribution of 36 pilots (cadets) with abnormal head magnetic resonance imaging results

Fighter type (battle station)		*n*	Proportion	Age (years)	Median age (years)	Flying time (hours)
Pilot cadet	Primary trainer cadet	16	44.4	20-23	21.4 ± 1.0	17-200
	Advanced trainer cadet	8	22.2	24-25	24.5 ± 0.5	300-370
	Pilot cadet in basic education stage	6	16.7	19-22	20.3 ± 1.0	0
Fighter pilot		6	16.7	29-34	31.1 ± 1.7	1200-1600

transfer to pilot modified high performance aircraft from December 2020 to April 2024, and 36 pilots (cadets) had abnormal results of 3.0T head MRI examination were recruited in this study, followed by a retrospective analysis on their clinical data and appraisal conclusions.

Methods

Descriptive statistical analyses were carried out on the age, fighter type, flying time, type of diseases found in physical examination and appraisal conclusions of the 36 military pilots (cadets) with abnormal results of 3.0T head MRI examination. In addition, the disease proportion and systemic disease order were calculated. The 11 pilots (cadets) with cerebrovascular diseases unqualified for transfer to pilot modified high performance aircraft were identified and shunted.

RESULTS

All the 36 pilots (cadets) enrolled were male, aged 19-34 years old with a median age of 23.5 years ± 3.9 years old. The flying time was 0-1600 hours. The fighter type plus the number and age distribution is listed in Table 1.

Totally 6 diseases were detected in the 36 military pilots (cadets), which, in the order of detection rate, were arachnoid cyst in 17 pilots (cadets), suspected cerebral aneurysm in 11, cavernous hemangioma in 4, pituitary tumor in 3 (one of which was accompanied by cavernous vascular malformation) and vascular malformation in 2. Among the 11 cases of suspected cerebral aneurysm, 6 cases were diagnosed as conus arteriosus by digital subtraction angiography (DSA), and qualified for transfer to pilot modified high performance aircraft. The 11 pilots (cadets) were definitely diagnosed with cerebrovascular diseases, including 5 cases of cerebral aneurysm, 4 cases of cavernous hemangioma and 2 cases of vascular malformation, and unqualified for transfer to pilot modified high performance aircraft (Table 2).

According to head MRI images, the sella turcica was slightly enlarged, and a quasi-circular 14 cm long focus showing slightly short T1 and long T2 signals was found in the pituitary gland. This focus showed slightly hyperintense signal on diffusion-weighted image (DWI), iso-intense signal on T1-weighted image (T1WI), and hyperintense signal on T2-weighted image (T2WI) and T2 fluid attenuated inversion recovery (T2FLAIR). Such a focus had a clear boundary, without enhancement after enhancement. Besides, the pituitary stalk moved forward slightly under pressure. In addition, there was a 5 mm quasi-circular focus in pons, with clear boundary and showing hyperintense signal on MRI, hypo-intense signal on DWI and SWI, slightly hypo-intense signal on T1WI, and normal signal on T2WI and T2FLAIR, and this focus had moderate enhancement after enhancement. Imaging diagnosis: Abnormal enhanced focus was found in pons, possibly suggesting cavernous hemangioma. No enhanced cystic focus was found in the sella, possibly suggesting Rathke cyst (Figure 1).

DISCUSSION

Due to influences of flying height, flight load and other factors, fighter pilots have increased psychological and physiological stress response intensity, together with greatly fluctuated blood pressure and heart rate in combat and training flight. Moreover, acceleration change can also cause changes in intracranial pressure and blood supply to the brain of fighter pilots. In the case of cerebrovascular diseases and intracranial tumors, cerebral hemorrhage, seizures, neurological symptoms and the like may be induced in pilots, resulting in inflight incapacitation, which is a severe threat to flight safety[4-6]. Head MRI examination is not included in the existing pilot physical examination and annual physical examination. In this study, the pilots with intracranial diseases did not suffer neurological symptoms or focal neurological signs, and they were discovered only by head MRI screening in the physical examination for transition to fighters. Furthermore, the detection rate of occult asymptomatic cerebrovascular diseases and intracranial tumors was as high as 5.4%, requiring the vigilance of clinical aeromedical personnel.

With the popularization of high-resolution nuclear magnetic resonance and the progress of imaging artificial intelligence technologies, the positive rate of intracranial diseases detected by head nuclear magnetic resonance examination is also increasing significantly[7]. The normal results in 1.5T nuclear magnetic resonance examination may be positive in 3.0T nuclear magnetic resonance examination. In the case of suspected cerebral aneurysms according to 3.0T head magnetic resonance angiography, it is suggested to implement cerebral vascular DSA to avoid false positive[8]. In this study, 6 out of the 11 military pilots with suspected cerebral aneurysms detected by MRI were diagnosed with conus arteriosus by DSA, and they were identified as qualified for transfer to pilot modified high performance aircraft since the

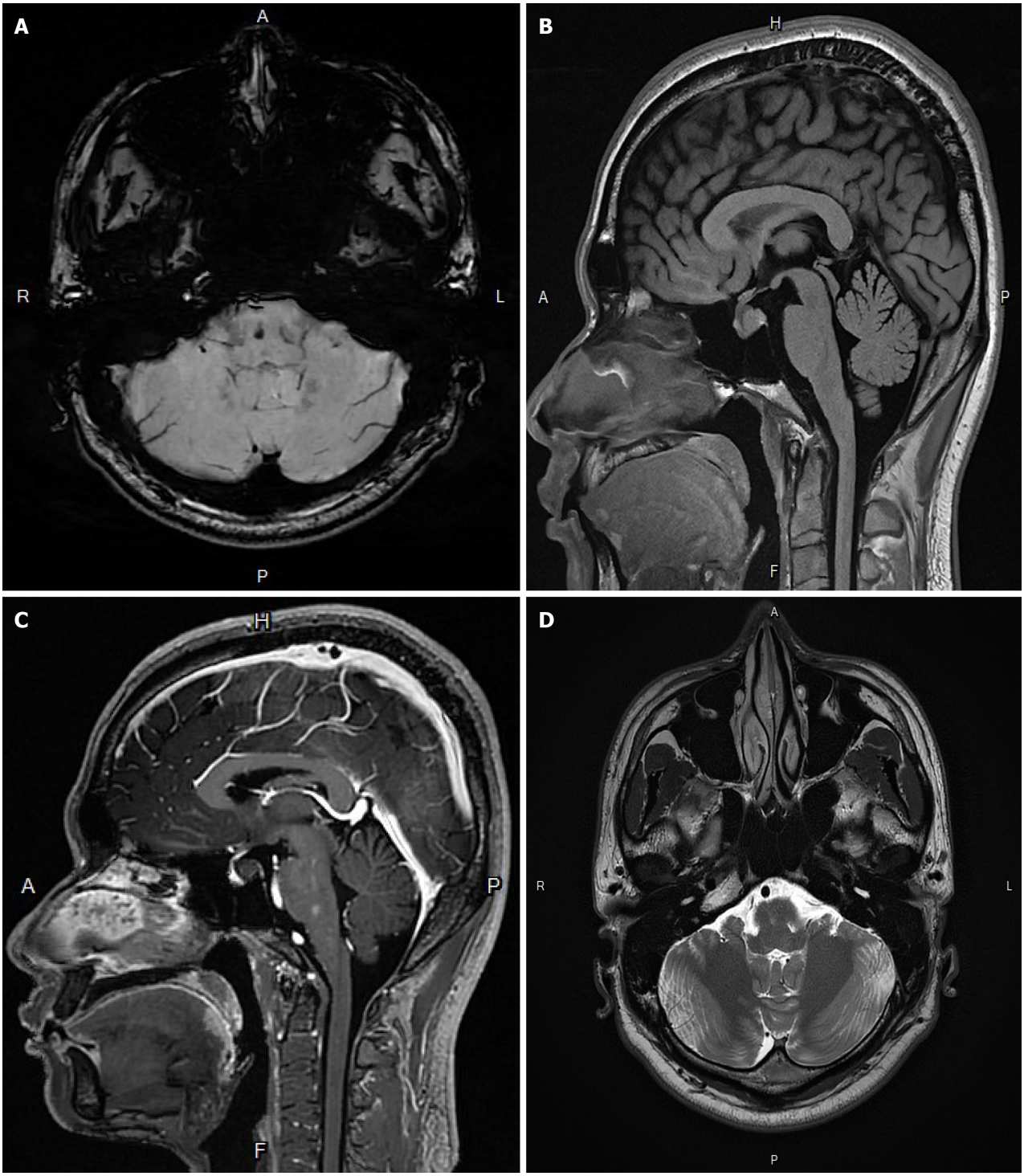

Figure 1 Head magnetic resonance imaging images. A: Magnetic resonance imaging of head; B: T1-weighted image (T1WI); C: T1WI after enhancement; D: T2-weighted image.

conus arteriosus does not affect the function[9]. The other 5 cases were diagnosed as cerebral aneurysms (very small aneurysms less than 3 mm) by DSA. After evaluation by experts of cerebrovascular surgery inside and outside the military, the bleeding risk was less than 0.1%. Considering the surgical risk and clinical benefit, follow-up and strengthened monitoring were adopted for these 5 pilots (cadets). Among them, 3 pilot cadets were recommended to transfer to pilot transport plane and helicopter, and 2 fighter pilots were recommended to pilot two-seat high performance aircraft or advanced trainers. These 5 pilots (cadets) with cerebral aneurysms underwent strict monitoring of the changes in heart rate and blood pressure, as well as annual head MRI examination. Cavernous hemangioma is a high-risk factor for epilepsy, focal neurological dysfunction, cerebral hemorrhage and headache, seriously affecting flight safety[10]. In this study, therefore, 4 pilots (cadets) diagnosed with cavernous hemangioma were all identified as transfer to pilot modified high performance aircraft, among which 3 (75%) were grounded.

Table 2 Distribution of diseases and appraisal conclusions in 36 pilots (cadets) with abnormal head magnetic resonance imaging results, *n* (%)

Disease	*n*	Proportion	Detection rate	Fighter pilot	Advanced trainer cadet	Primary trainer cadet	Pilot cadet in basic education stage	Qualified for transfer to pilot modified high performance aircraft	Unqualified for transfer to pilot modified high performance aircraft	Qualified for flying	Transfer to pilot fighter	Transfer to pilot transport plane	Transfer to pilot helicopter	Transfer to air combat service division
Arachnoid cyst	17	47.2	3.1	1	4	9	3	7	10 (58.8)	4	7	6	0	0
Cerebral conus arteriosus	6	16.7	1.1	2	1	3	0	6	0 (0)	0	6	0	0	0
Cerebral aneurysm	5	13.9	0.9	2	2	1	0	0	5 (100)	0	2 (two-seat)	2	1	
Cavernous hemangioma	4	11.1	0.7	0	2	1	1	0	4 (100)	3	0	0	0	1
Pituitary tumor	3	8.3	0.5	1	1	0	1	1	2 (66.7)	1	1	0	0	1
Vascular malformation	2	5.6	0.4	0	0	2	0	0	2 (100)	0	0	0	2	2

In China, the prevailing criteria for flying personnel appraisal are central nervous system diseases and their sequelae, as well as disqualification for flying. In aeromedical appraisal, risk factors endangering flight safety such as epilepsy, intracranial hemorrhage, and focal neurological dysfunction should be evaluated, and then a comprehensive and accurate evaluation should be made in combination with the fighter type and flight experience of military flying personnel. Due to greatly fluctuated heart rate and blood pressure of fighter pilots in an air combat flight, intracranial pressure and intracranial blood supply can be changed by a high-load flight, easily leading to cerebrovascular disease/hemorrhage and other risk factors for inflight incapacitation[11-13]. Therefore, it is suggested to make strict requirements for the selection of pilot cadets and the pilots of single-seat high performance aircraft with disqualification for flying. Flying personnel with no symptoms and a low probability of hemorrhage are allowed to pilot multi-seat high performance aircraft with a small load, relevant head nuclear magnetic resonance examinations should be implemented frequently during follow-up, and risk factors (such as blood pressure, blood lipid, smoking and drinking) and flight intensity should also be controlled.

CONCLUSION

Cerebrovascular diseases and intracranial tumors may lead to intracranial hemorrhage, epilepsy, headache, neurological impairment and other risk factors for inflight incapacitation. High-resolution head MRI examination is of great significance for screening and detecting cerebrovascular diseases and intracranial tumors in flying personnel, and its clinical application to physical examination for transfer to pilot modified high performance aircraft should be attached with great importance. It is essential to detect and to intervene and treat cerebrovascular diseases and intracranial tumors as early as possible, thus reducing the grounding rate and maintaining flight safety.

FOOTNOTES

Author contributions: Zhao Y, Gao D and Liu YB contributed equally to this work, developed the methodology, collected data, analyzed and interpreted data, written manuscript; Xue JJ, Lu X and Dong JJ collected and analyzed the clinical data; Xue JJ, Gao D and Zhang Y wrote the manuscript; Zeng J revised the manuscript and designed the research; all of the authors read and approved the final version of the manuscript to be published.

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