

Warm up

Of UFOs and other thoughts

P McCrory

I was recently whiling away a few joyful hours in transit in yet another anonymous airport on the way to another conference. After contemplating why in American airports it is physically impossible to get any sort of food that is capable of sustaining a healthy life, I felt the need to search for something to read. At a news stand, I found a copy of the *Worst Case Survival Handbook* (by Joshua Piven and David Borgenicht, Hardie Grant Books) to re-read. I was of course immediately taken by the instructions on how to foil an alien abduction. Some of you may think this is somewhat farfetched however I draw your attention to a recent survey that suggested 4 million Americans have been the victims of such events. Forearmed with that knowledge and with one eye looking for flying saucers, I was entranced.

The first reassuring suggestion in such situations was not to panic. I seem to recall the *Hitchhiker's Guide To The Galaxy* offers similar advice, and more importantly had it printed on its cover. Once calm, then attempt to control your thoughts. The extra terrestrial biological entity (or EBE to those in the know) may have the ability to read your mind. Mental pictures of anal probes should be avoided specifically. Once calm and clear, then resist verbally by firmly telling the EBE to leave you alone. Physical resistance should only be used as a last resort!

Although some of the chapters are more in a medical line (for example, how to treat a severed limb) and many useful phrases are helpfully included ("*hello, I have been seriously wounded*" and my favorite "*you will never make me talk*") I was struck by the absence of a sports medicine

specific section. Perhaps we could have "how to have a urine drug test at the Olympics" or "what to do when the audiovisuals break down just before your conference presentation" or even "how to survive a sports medicine clinical exam". I can see a new book coming from those authors designed to fill this gap in our medical armamentarium.

Speaking of drug testing, I see that a recent poll in the Sunday Observer (21 April 2002) suggested that more than half of Britons aged between 18 and 24 have taken illegal drugs. In a time when decriminalisation of many "soft" drugs is being seriously considered, we have the hypocritical situation where our professional athletes are being increasingly tested for the same agents. Clearly many of these are not performance enhancing rather their effects are just the opposite!

How then do we balance our desire for "level playing field" where athletes are free of ergogenic agents? Given that we cannot even test for the newer anabolic hormonal derivatives, the enthusiasm by which athletes are tested for non-ergogenic social drugs seems somewhat surprising. A little common sense would be helpful.

Beam me up, Scottie!

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Boxing

Cavum septi pellucidi—a reason to ban boxers?

P McCrory

There is no evidence that a cavum septum pellucidum correlates with neuropsychological or clinical abnormality

Boxing has been a human activity since antiquity. In ancient Rome, it was banned because of the high injury rate when boxers used leather hand wraps with sharp metal spikes called sphaera. The safety of boxers became an issue in Great Britain in the early 18th century, when the use of biting, gouging, kicking, and other brutal techniques was outlawed. In 1743, the Broughton rules were introduced to limit some of these techniques, and these were subsequently replaced by the London Prize Ring rules in 1839. In 1867, the Marquis of Queensbury rules introduced the use of boxing gloves, three minute rounds, and the 10 second knockout in an attempt to make boxing

safer.¹ These measures did not eliminate either the acute or chronic neurological effects of boxing. Numerous accounts in both the medical literature and lay press have extensively documented the boxing deaths occurring in the ring since that time.²

In 1928, Martland first described the syndrome of dementia pugilistica or chronic traumatic encephalopathy in boxers.³ Before this time, it was known in lay boxing circles that a few professional boxers developed the so called "punch drunk" or "slug nutty" state. Other medical authors of the era further elucidated the clinical features of this condition.^{4,5} Since that time the association of chronic brain injury in boxers

has been the subject of numerous studies.^{1,6-13}

A commonly reported association of chronic brain injury in boxing is the presence on neuroimaging or post mortem studies of a cavum septum pellucidum. Some authors have suggested that a cavum represents an incidental anatomical variant of no clinical significance,¹⁴ whereas others have speculated that the higher incidence of cavum septum pellucidum in some studies represents an intrinsic predisposition to boxing in such people presumably on the basis of an abnormality in their limbic system.¹⁵ This paper sets out to examine the evidence for the significance of this anatomical variant in boxers.

"A commonly reported association of chronic brain injury in boxing is the presence on neuroimaging of a cavum septum pellucidum"

ANATOMY

The existence of cavum septi pellucidi has been known at least since the 15th century and the cavum vergae since the

Table 1 Incidence of cavum septi pellucidi (CSP) in various studies

Type of evidence	CSP incidence (%)	Reference
Neuropathology	3	24
	20	20
	60	25
Neuroradiology	0.7	47
	1	49
	6	48
	9	52
	9	53
	10	38
	14	46
	17	37
	22	42
	37	36

19th century.^{16–18} In the modern era, the association of a cavum septum pellucidum and boxers was first incidentally noted by Spillane.¹⁹

The septum pellucidum rostrally forms the medial wall of the bodies of the lateral ventricles. The posterior margin is the fornix and the rostral and superior limits are formed by the corpus callosum. The septum consists of two leaves of glial tissue with both white and grey matter components, connected by the medial forebrain bundle to the hippocampus and through the fornix to the limbic system. In coronal section, the two leaves are usually fused or contiguous in adults. If they remain separated, then the closed space between them anteriorly is known as a cavum septum pellucidum, and posteriorly to the fornix as a cavum vergae. Such cava will communicate with the ventricular system only when their leaves are ruptured or fenestrated and it is therefore inappropriate to use the term “fifth” and “sixth” ventricles for these structures. In addition, the cava have a different embryonic development from the ventricular system and are not lined by ependymal cells. The role of the septum is not completely established, but it may take part in limbic functions such as arousal and rage mechanisms. In lower animals, the septum serves as an intermediate station for olfactory impulses.²⁰

INCIDENCE OF CAVUM SEPTI PELLUCIDI

The two leaves of the septum are separated in utero up to the 36 week stage of gestation.^{21, 22} As the fetus approaches term, the persistence of the cavum decreases, so that only about one third of term infants maintain the fetal state.²¹

There is no clear information on the persistence of the cavum septum pellucidum in the general population at any time after the neonatal period.^{22, 23} Corsellis *et*

*al*²⁴ reported an incidence of 3% in 500 adult brains from a psychiatric hospital population; however, Schwidde,²⁰ in an unselected series of 1032 autopsies, found a cavum septum pellucidum in 20%, and Van Wageningen and Aird²⁵ reported an incidence of 60% in their study of 30 adults. Imaging studies (discussed below) variously report cavum septum pellucidum incidence ranging between 0.7% and 37% (table 1).

NEUROPATHOLOGICAL STUDIES

Relatively few detailed studies of neuropathological changes in ex-boxers have been performed.^{24, 26, 27} There have been a number of individual case reports with varying amounts of clinical and pathological information provided.^{28–31} In only one of these case reports was a cavum septum pellucidum noted.³¹ Payne studied six boxers, all of which had a cavum septum (with fenestrations noted in three).²⁶ He assumed that the septal abnormalities were a secondary consequence of the enlarging ventricles.

The largest of the studies, by Corsellis *et al*,²⁴ examined 15 ex-boxers (12 professional) whose brains had been collected in a pathology department brain bank and their boxing and social history sought retrospectively. These boxers had fought in the period 1900–1940; eight were national or world champions in their weight division. One of the striking features was their extraordinarily high exposure to boxing. The number of bouts fought ranged from 400 to 700+, with many also fighting in fairground boxing booths (up to 30–40 fights per day over a number of years).

In this study, Corsellis *et al* detailed a number of neuropathological features that have become the sine qua non of chronic traumatic encephalopathy. These included:

- (1) abnormalities of the septum pellucidum;
- (2) cerebellar and other scarring of the brain;

(3) substantia nigral degeneration;

(4) regional occurrence of neurofibrillary tangles (these have been subsequently shown to be ubiquitinated tangles that have tau immunoreactivity^{32, 33}).

With regard to the septal abnormalities, a cavum was noted in 12/13 brains (two brains having an intraventricular haemorrhage that made determination of primary septal abnormalities impossible). The maximum coronal width ranged from 1 to 8 mm (mean 5.2 mm). In 11/13 cases, the cavum showed pronounced fenestration, and in most only a “few thin tags” remained. The cavum in boxers was described as having a characteristic appearance with not only fenestration but with detachment of the fornix from the undersurface of the corpus callosum, with the two flattened fornical bodies splaying out horizontally over the dorsal surface of the thalamus. The body of the corpus callosum was often thinned as well.

Corsellis *et al* also speculated on the mechanism of cavum formation. Payne²⁶ had suggested that passive ventricular enlargement stretches the leaves of the septum apart. Mawdsley and Ferguson³⁴ invoked the concept of repeated sudden rises in intraventricular pressure leading to rupture of the septal leaves. Corsellis *et al* felt that, because the dorsal attachment of the septum is relatively thin and fragile, repeated head blows strain the dorsal septal attachment because of the repeated movements of the corpus callosum on the tethered fornix. He felt that once this process has been initiated, then ventricular enlargement stretches the septum and the fenestrations enlarge.

RADIOLOGICAL STUDIES

Pneumoencephalographic evidence

The presence of a cavum septum pellucidum was first noted by Spillane¹⁹ who described five retired professional boxers who developed a chronic neurological problem in later life. He described in detail the clinical and pneumoencephalographic findings in these boxers and noted incidentally the presence of a cavum septum pellucidum in two of the boxers. Interestingly all of the boxers had a high exposure, with none having less than 200 bouts. One of the boxers had also gone on to fight in fairground boxing booths, having 30–40 fights per day for several years.

This work was expanded by Mawdsley and Ferguson³⁴ and Isherwood *et al*³⁵ who analysed pneumoencephalographic changes in 16 boxers. Of the 12 boxers with evidence of cortical atrophy, eight had a cavum septum pellucidum. Unfortunately little clinical information or boxing exposure was reported which would have enabled more detailed analysis. Finke *et al*³⁶ reported an incidence of

cavum septum pellucidum of up to 37% from pneumoencephalographic studies.

Computed tomography (CT) evidence

Harvey and Davis³⁷ described a young boxer with chronic traumatic encephalography having had only 100 fights (25 as a professional). CT scanning showed ventricular enlargement which was confirmed by pneumoencephalography. A cavum septum pellucidum was also noted. There have also been a number of case series of active and/or retired boxers with a variety of minor radiological findings reported.³⁸⁻⁴⁴ In the study by Ross *et al*³⁹ of 38 ex-boxers, 70% of the CT scans were normal. There was no correlation between the number of bouts or the number of knockouts with the radiological findings. It has also been questioned whether the abnormal CT scan findings noted in the older boxers were a manifestation of the normal ageing process rather than changes caused by boxing.¹⁴

A similar finding was noted in a study of amateur boxers⁴⁵ in which neuropsychological function before and after a fight showed no significant differences. CT scans were performed one week after the fight; however, the results were not discussed in the paper.

"Boxers with a cavum septum pellucidum were more likely to have cerebral atrophy"

The largest study of CT scans in boxers is that of Jordan *et al*,⁴⁶ who reported the findings in 388 active professional boxers. CT was normal in 93% and showed "borderline" atrophy in 6%. Boxers with a cavum septum pellucidum (14%) were more likely to have cerebral atrophy.

Bogdanoff *et al*⁴⁷ reported the presence of a cavum septum pellucidum as a manifestation of chronic traumatic encephalopathy; however, this study has severe methodological problems. In their study of 1914 consecutive patients, only five had been boxers. Three of these boxers had been referred for cerebral imaging for investigation of a chronic neurological condition.

A contrary finding was noted by MacPherson and Teasdale.⁴⁸ In 1000 consecutive patients seen at a neurosurgical trauma centre, they identified a cavum septum pellucidum in 5.5% of subjects. They concluded that the presence of an isolated cavum septum pellucidum almost certainly represents a persistent congenital anomaly of no clinical significance, and, apart from regular

observation, this finding alone should not affect a boxer's career.

Magnetic resonance imaging (MRI) evidence

One of the earliest studies using MRI in boxers was by Cabanis *et al*.⁴⁹ They examined 12 active and 40 retired boxers (13 amateur, 39 professional). A cavum septum pellucidum was noted in two boxers only. Cerebral atrophy was noted in eight, and the mammillary bodies and optic chiasm was described as small in 30. No correlative clinical data were presented, and, given that this was in the early days of MRI using a 0.15 T scanner with 9 mm slices, technical limitations are likely to limit any conclusions that may be drawn from their findings.

"No clear relation between boxing exposure and radiological findings was noted"

Levin *et al*⁵⁰ and Jordan and Zimmerman⁵¹ each studied nine amateur boxers and found no abnormal MRI findings. Jordan and Zimmerman⁵² subsequently examined 21 active boxers (16 professional) and one retired professional boxer. Most of both the CT and MRI studies were normal; however, the authors emphasised the superiority of MRI over CT as an imaging modality and its usefulness in delineating equivocal CT abnormalities. No clear relation between boxing exposure and radiological findings was noted.

A Swedish study comparing 22 experienced amateur boxers (mean number of bouts 54) with age matched soccer playing and athletic controls was performed.⁵³⁻⁵⁵ No significant difference was observed between the groups. Only two boxers had a cavum septum pellucidum, as did one footballer and three track athletes.

Other prospective studies such as those by Holzgraefe *et al*⁵⁶ and Butler *et al*⁵⁷ did not find any specific MRI abnormalities related to boxing. Another finding reported in autopsy studies of retired boxers was superficial siderosis of the cerebellum.⁵⁷ Although this should be detectable using MRI, no case reports exist in which this condition has been noted.

To date radiological imaging has been unsuccessful in finding any systematic evidence of brain injury in boxers. Early anecdotal reports have not been validated using newer technologies. Clearly there are considerable differences in MRI techniques, patient positioning, slice thickness, and magnet strength, all of which may influence the findings.⁵⁸

One of the abnormalities that has been reported to be of significance in

earlier neuropathological studies is a cavum septum pellucidum. The finding of this abnormality varies between 0.7% and 37% using various radiological techniques; however, this finding does not correlate with either clinical or neuropsychological deficits nor with boxing exposure (table 1).

Magnetic resonance spectroscopy

Magnetic resonance spectroscopy has been reported in ex-boxers with parkinsonism showing reduction of N-acetylaspartate in the lentiform nucleus and is thought to indicate neuronal loss. One of three boxers studied in this fashion has a cavum septum pellucidum. The specificity of this technique is not known at this time.^{59 60}

Radionuclide studies

A study reported cerebral blood flow measurements in a small cohort of amateur and professional boxers.⁶¹ The professional boxers were reported to have significant reductions in cerebral blood flow over the cortex, particularly in the parietal and temporal lobes. Another study of cerebral blood flow using HMPAO SPECT was performed in 42 amateur boxers from the armed services.⁶² There was no correlation between SPECT abnormalities and neuropsychological test performance or number of bouts fought. The relation of cavum septi pellucidum to the putative cerebral blood flow abnormalities was not discussed in either study.

CHANGES IN CAVUM SEPTUM PELLUCIDUM ON SERIAL IMAGING

An early study examining the change in size of ventricles was performed using pneumoencephalography.⁶³ In this study, two patients with cavum septum pellucidum were noted, and more importantly the size and structure of the cavum varied from day to day. About one third of patients undergoing pneumoencephalography were noted to have "bulges" in the septum pellucidum toward the ventricles between examinations including one patient in whom this change was noted over five minutes. This suggests that the septum, with or without a cavum septum pellucidum, is not a rigidly fixed structure and may vary between examinations.

Only one study has been published of the findings of serial CT scanning in active boxers.⁶⁴ In this study, 45 professional boxers in New York State had serial CT scans with a mean duration between scans of 31 months. Six (13%) showed evidence of "progressive brain injury", with three displaying progressive cortical atrophy (one with bilateral parieto-occipital encephalomalacia), and

three developing a cavum septum pellucidum on the repeat scans. The progressive CT changes were associated with losing more than 10 fights. No report of changes in previously documented cavi were noted.

CONCLUSIONS

The presence of a cavum septum pellucidum is a common and usually incidental finding on neuroimaging or neuropathological studies. In limited autopsy studies of boxers with extreme boxing exposure—for example, 400–900 bouts—a number of abnormalities have been noted that form part of a constellation of the pathological changes of dementia pugilistica. One of these features is a fenestrated cavum septum pellucidum. Despite this pathological evidence, neuroimaging studies using pneumoencephalography, CT, and MRI have failed to show consistent imaging abnormalities that correlate with this clinical state. Newer imaging modalities using high field MRI, diffusion tensor imaging, and measures of cortical atrophy may hold promise in the future if applied prospectively to this population.

SUMMARY

- The actual incidence of a cavum septum pellucidum in the adult population is not known but varies between 0.7% and 60% depending on the study cited.
- The presence of an isolated cavum septum pellucidum is unlikely to be of clinical importance and should not preclude a boxer from taking part in his or her sport. There is no evidence that a cavum septum pellucidum necessarily correlates with neuropsychological or clinical abnormalities or boxing exposure.
- The cavum septum pellucidum abnormality noted in the neuropathological studies as being suggestive of dementia pugilistica is fenestrated as well as being associated with forniceal abnormalities. A cavum septum pellucidum with intact walls is not a diagnostic finding of this condition.
- Very limited published evidence suggests that a cavum septum pellucidum may vary in morphology between examinations; however, the new development or serial enlargement of a cavum septum pellucidum on neuroimaging studies suggest the early development of dementia pugilistica particularly if associated with other evidence of boxing related neurotrauma. Insufficient prospective studies have been published to confirm this finding.

- There is no compelling evidence at this time that routine MRI (or other) neuroimaging will detect early evidence of chronic damage in boxers. Prospective studies are required to answer this question using more sophisticated imaging protocols.

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