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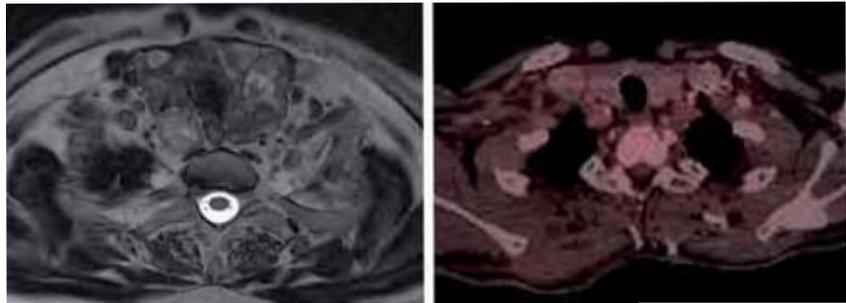
New Opportunities and Challenges in the Diagnosis of PTSD?

Hybrid imaging - PET/MRI

Improvements to the methods of diagnosis and treatment of traumatic cranio-cerebral injuries (CCIs) and post-traumatic stress disorder (PTSD) are urgently required from the point of view of the military authorities, the patients' families and society as a whole. On the basis of the results of the RAND Corporation screening survey, it is estimated that almost one in five (300,000) of the total of military personnel who have taken part in Operation Iraqi Freedom/Operation Enduring Freedom (OIF/OEF) have developed symptoms of PTSD or are suffering from depression while more than 320,000 of the OIF/OEF force have suffered a traumatic cranio-cerebral injury (22). At the same time, a cranio-cerebral injury has been diagnosed in 23 % (907/3973) of the members of one active service unit (23). This overview article considers the potential offered by the use of a hybrid technique involving the combination of positron emission tomography with magnetic resonance imaging (PET/MRI). The PET/MRI technique represents a new diagnostic option that can thus also be used in the diagnosis of non-malignant disorders. With the help of new biomarkers, high resolution, structural, functional and metabolic imaging data, there is now the prospect of detecting the early changes that occur in post-traumatic stress disorder (PTSD), something that will be of particular value in the context of military medicine.

Technical aspects and challenges

Simultaneous PET/MRI represents the new generation of hybrid diagnostic imaging methods. In comparison with the standard PET/CT technique, this new method has significant advantages: in addition to providing for high-quality contrast of soft tissue, the options of functional imaging and, unlike PET/CT, of simultaneous data acquisition, PET/MRI also requires less exposure to radiation (Fig. 1). The first whole-body scanner with integrated PET/MRI system was unveiled



▲ Fig. 1: In comparison with CT and MRI, PET is characterised by a significantly poorer level of spatial resolution. In the case of PET/CT and the new whole-body MRI/PET devices, the deviation can be up to 4.2 - 5.5 mm. Above are examples of scans of a patient with thyroid cancer; the left prepared using 3-Tesla MRI, the right with PET/CT.

ملخص

أصبح من الضروري للغاية إدخال المزيد من التحسينات على الفحوصات التشخيصية وعلاج إصابات الدماغ الرضية TBI واضطرابات ما بعد الصدمة. سواء بالنسبة للجند أو عائلاتهم أو المجتمع ككل. وبالإضافة إلى البيانات التي توصلت إليها الدراسة التصويرية «RAND Corporation» فيقدر أن نسبة 20% تقريباً من إجمالي عدد الجنود (300 ألف) الذين شاركوا في عمليات تحرير العراق الحربية الدائمة (OIF / OEF) يعانون من أعراض اضطرابات ما بعد الصدمة أو من أعراض اكتئاب. وأكثر من 320 ألف جندي (من شاركوا في عمليات OIF / OEF) كانوا مصابين بإصابات الدماغ الرضية (22). كما قد تم أيضاً تشخيص إصابة نسبة 23% (907/3973) من لواء إحدى المهمات بإصابات الدماغ الرضية (23). هذا المقال يقدم الإمكانيات التي تظهر بفضل استخدام طريقة التصوير الجمعية (الهجين) التي يقدمها جهاز التصوير بالرنين المغناطيسي والتصوير المقطعي بالإصدار البوزيتروني.

概述

如何针对创伤性脑损伤(TBI)以及创伤后应激障碍(PTBS)提高诊断水平,对军人及其家属以及社会人群而言都是一个亟待解决的重要课题。基于“兰德公司”的筛查研究表明,参与伊拉克自由行动/持久自由军事行动(OIF/OEF)的士兵中近1/5的人(300000名)有PTBS或忧郁症症状;约320000名(OIF/OEF)士兵受到了创伤性脑损伤(22)。其中一支服役部队约有23%的人(907/3973)受到了创伤性脑损伤(23)。本文从总体上列出了核磁共振正电子发射断层扫描仪生成混合图像(MR/PET)的各种可能情况。

RÉSUMÉ

Il est urgent d'améliorer le diagnostic et le traitement des traumatismes craniocérébraux (TCC) et du trouble de stress post-traumatique (SPT) affectant aussi bien les militaires et leur famille que la société. D'après les données de l'étude de dépistage « RAND Corporation », on a estimé qu'un cinquième des soldats (300 000) ayant participé à l'opération Iraqi Freedom/Operation Enduring Freedom (OIF / OEF) souffrent de stress post-traumatique ou de dépression, et que plus de 320 000 soldats (OIF / OEF) ont subi un traumatisme craniocérébral (22). En outre, un diagnostic de traumatisme craniocérébral (23) a été posé pour plus de 23 % (907/3 973) des effectifs d'une brigade d'intervention. Cet article de synthèse présente les possibilités qu'offre l'utilisation combinée de l'imagerie par résonance magnétique (IRM) et de la tomographie par émission de positrons (PET scan).

ОБЗОР

Настоятельно необходимы улучшения диагностики и лечения травматических повреждений головного мозга (ТПГМ) и посттравматических стрессовых расстройств (ПСР) для военных, их семей и для общества. На основании данных скрининговых исследований «RAND Corporation» определено, что почти 1/5 солдат (300 000) Операции Освобождения Ирака/операции «Несокрушимая свобода» (ОИИ/ОНС) испытывают симптомы посттравматических стрессовых расстройств или страдают от депрессий, а более 320 000 солдат (ОИИ/ОНС) страдают от травматических повреждений головного мозга (22). Также у 23 % (907/3.973) оперативной бригады диагностировано травматическое повреждение головного мозга (23). Эта обзорная статья представляет возможности, получаемые при помощи магнитно-резонансной, позитронно-эмиссионной томографии (МРТ/ПЭТ) с выдчей гибридного изображения.

RESUMEN

El personal militar, sus familiares y la sociedad reclaman urgentemente mejoras en el diagnóstico y el tratamiento de los traumatismos cerebrales (TBI) así como del trastorno por estrés post-traumático (TEPT). A partir de los datos del estudio de cribado "RAND Corporation", se calcula que casi 1/5 de los soldados (300.000) de la operación Iraqi Freedom/Operation Enduring Freedom (OIF/OEF) presentan síntomas de TEPT o depresión y más de 320.000 soldados (OIF/OEF) han sufrido traumatismo cerebral (22). Del mismo modo, el 23 % (907/3.973) de una brigada de intervención fue diagnosticado con traumatismo cerebral (23). En este artículo general, se presentan las opciones que surgen con el diagnóstico híbrido por imágenes mediante resonancia magnética y tomografía por emisión de positrones (RM/PET).

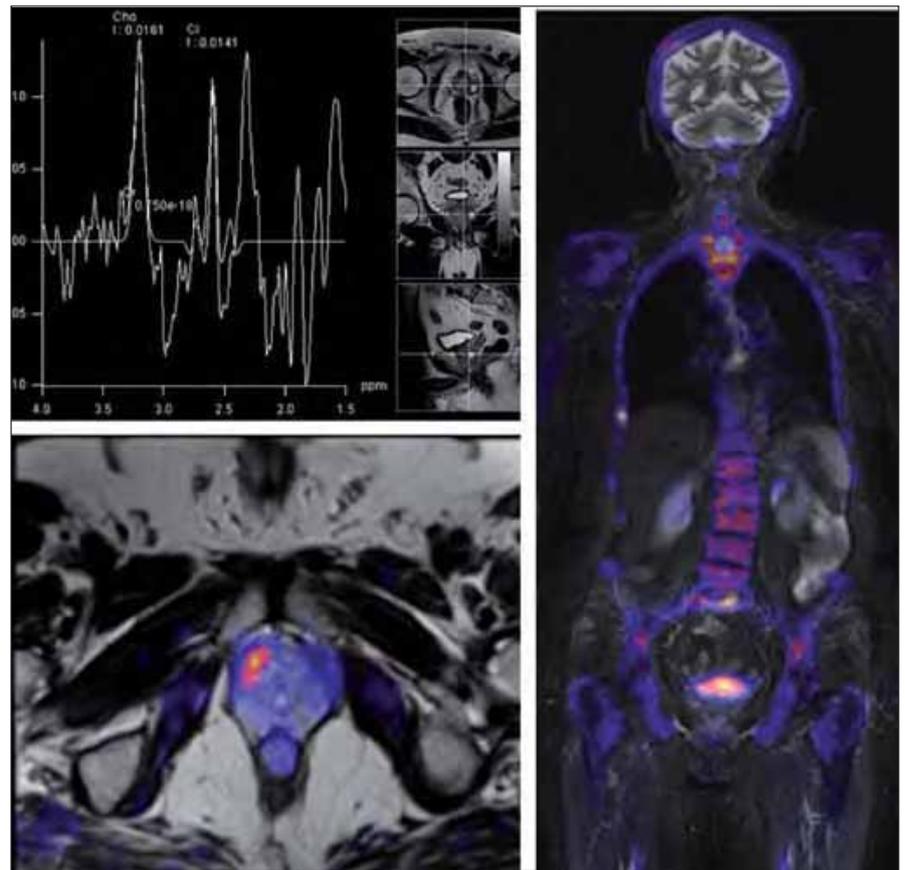
in November 2010 (Siemens Healthcare Biograph mMR). The Biograph combines a 3-Tesla MRI scanner (the technical equivalent of a Siemens Verio system) with a complete PET system that is integrated in the device's gantry. The most commonly used radiotracer is [18F]-2-fluoro-2-deoxy-D- glucose (or [18F]-FDG), a radioactively-labelled sugar that exhibits differing accumulation profiles in the various body tissues determined by the rate of glucose metabolism. The breakthrough with regard to managing to combine the PET and MRI techniques was achieved by means of replacing the conventional photomultiplier with semiconductor-based avalanche photodiodes, which are resistant to strong magnetic fields (9 - 14). Thanks

to the simultaneity of image acquisition by the PET and MRI systems, the image superimposition problems associated with patient positioning and physical movement artefacts have been eliminated (6, 7).

This scanner also exhibits several fundamental technical differences to the standard PET/CT device. There are two factors that influence the quality of the acquired PET data; the use of avalanche photodiodes in place of a photomultiplier and the level of attenuation correction of the PET data that can be achieved with the hybrid device thanks to the incorporated MRI system. In the case of standard PET/CT scanners, the CT equipment is used to estimate attenuation by means of transformation of CT Hounsfield units to attenuation factors at 511 keV (15).

Of course, the MRI signal cannot provide information on the radiodensity of tissue and thus cannot be used directly for attenuation correction of PET results. The *modus operandi* of the Biograph mMR involves use of an attenuation map generated on the basis of a two-point Dixon MRI sequence (19). The Dixon sequence makes it possible to estimate the level of accumulation of radiotracers in four different types of tissue (fat, soft tissue, lungs and background/air) in the body as a whole and produces an attenuation map on the basis of the relative radiodensity of these materials (16, 17). The results are equivalent to those obtained using the CT attenuation correction method (18), and the technique can thus be seen as viable.

This hybrid imaging technology has the potential of being able to enhance the quality of results that have been achieved with hybrid PET/CT, particularly in oncological indications and the imaging of neurodegenerative processes. Hybrid PET/MRI imaging could also play a major



▲ Fig. 2: Scans of a patient with clinical indications of the presence of prostate cancer but negative punch biopsy results. MRI spectroscopy (top left) initially confirmed the clinical indications of the presence of prostate cancer because of the information provided by the spectrum. Thanks to the metabolic information provided by PET/MRI, the site of the carcinoma can be precisely localised (bottom left) together with detectable metastatisation (right).

role in future in the field of military medicine in terms of research and clinical aspects; for example in the investigation of dramatic/informatory signs and the attempt to objectify the underlying organic causes of complex syndromes, such as post-traumatic stress disorder (PTSD).

Potential applications of the hybrid imaging technique

Imaging of intestinal structures and whole body scanning

In terms of quality of soft tissue contrast, computed tomography is noticeably inferior to magnetic resonance imaging. For this reason, MRI is the method of choice when it comes to diagnostic oncological investigation, such as scanning of the intestinal organs in the pelvis (prostate). In addition, MR spectroscopy and MR perfusion imaging are assuming increasingly important functions in confirmatory diagnosis of prostate cancer. As

the effectiveness of PET has already been demonstrated in an array of such diagnostic situations, it can be assumed that the combination of PET with MRI will prove to be superior to that of PET with CT in this indication range (1 - 5). Major potential applications will be in confirming non-malignancy of neoplasms if punch biopsy results are negative, in targeted (MRI/PET-guided) biopsy and diagnosis in the presence of biochemical recurrence. In addition, the technique is ideally suited for use in whole-body staging (Fig. 2).

Neuroimaging

In contrast with the type of CCIs most commonly encountered in the civilian environment that are usually the result of falls, sports-related traumas, etc., almost 70% of combat-induced CCIs are a result of exposure to blasts plus other injuries, i.e. the effects of the explosion and other factors. It is not easy to identify objective alterations in the cerebral region in symp-

tomatic patients with combat-related apparent CCIs using the conventional computed tomography or magnetic resonance imaging techniques. It has already been shown using the first hybrid PET/MRI that the concurrent acquirement of morphological, functional and metabolic data is possible and that this has several related advantages (19, 20). PET/MRI may well come to completely replace the double scanning technique (i.e. PET/CT with MRI). In patients with PTSD, structural and multiregional volume deficits can be detected; one feature that has been repeatedly observed is a reduction in hippocampal volume (HV) that is more marked in untreated patients with severe PTBS than it is in patients with the same disorder who are undergoing treatment. Meta-analyses have found that HV reduction is also present in patients with trauma-associated injuries and not in patients who have not suffered trauma, whereby it is unclear whether this alteration is trauma-induced or was a pre-existing condition in the trauma patients. Hybrid techniques such as PET/MRI that allow imaging of morphological and functional aspects may help us better understand the various pathophysiological processes that occur in post-traumatic stress disorder (24); see Fig. 3 and Fig. 4.

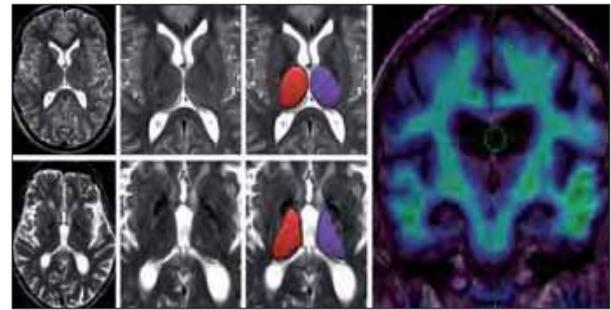
Summary

The detection and objective characterisation of the subtle but clinically significant abnormalities associated with CCIs and PTSD are important requirements and represent a challenge to modern neuroimaging skills.

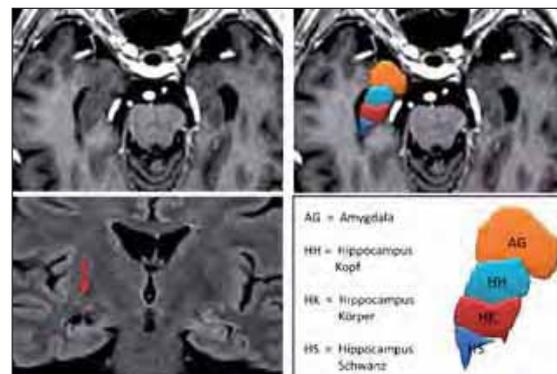
With the aid of radiation dose-sparing hybrid PET/MRI devices, it is possible to combine the advantages of both techniques – and it is necessary to combine these two as the provision of high resolution anatomical images with MRI is essential. In addition, functional methods (fMRI) such as diffusion-weighted imaging (DWI), spectroscopy and dynamic-contrast enhanced (DCE) MRI are becoming progressively more widely employed. The main technical challenge with regard to PET is to provide for appropriate MRI-based attenuation correction of the PET data. With a hybrid PET/MRI imaging device, it is possible to concurrently investigate morphological, functional and metabolic parameters with optimal spatial and chronological correlation. Simultaneous PET/MRI also opens up new options for research – in the field of cardiac imaging, investigations of cerebral functioning and the testing of new tracers in connection with specific MRI techniques. New MRI methods (such as susceptibility weighted imaging) are making it possible to more readily detect microhaemorrhaging and may prove to be of value in the screening of combat personnel following CCIs. The development of high-resolution MRI sequences could also, by means of providing better images of regions of the hippocampus, help clarify what form accumulation processes assume following CCIs and in PTSD. In this context, the PET component may also provide important insights into associated metabolic changes.

This combined, multimodal technique will thus facilitate the detection and characterisation of related abnormalities. ■

References: ref@mci-forum.com



▲ Fig. 3: Two examples of hippocampus volumetry and metabolic imaging. Seen to the top left is the image of a normal hippocampus prepared using T2 scanning. Below this is an example of hippocampal volume reduction in an elderly patient with a history of recurrent cerebro-cranial injury. To the right, in correlation with these, are the superimposed functional images (PET/MRI).



▲ Fig. 4: The hippocampus region: top left in axial T1CE imaging. In the top right, the hippocampus has been divided into regions (head, body, tail) and their volumes, together with that of the amygdala, have been measured. Bottom left can be seen an example of hippocampal volume reduction/atrophy.

[graphic AG = amygdala, HH = hippocampus head, HB = hippocampus body, HT = hippocampus tail]

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Mental Health Services in the Canadian Forces

The health needs, including the mental health needs, of Canadian Forces (CF) military personnel are a priority for the Government of Canada and the CF. As such, significant investment has been made by the CF to ensure personnel receive the highest standard of mental health care possible wherever they serve. The Canadian Forces Health Services (CFHS) has spent the past decade revitalizing its mental health care programs as well as playing a key role in the cultural change that has occurred in the CF towards mental health and those that suffer from mental illness.

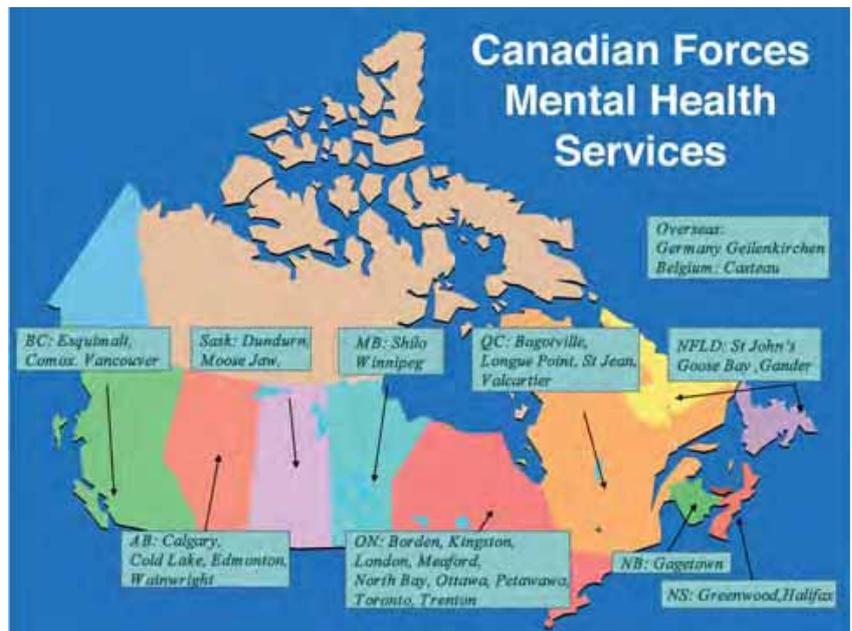
Current organizational structure of CFHS

The CFHS is comprised of the Medical and Dental branches and provides a comprehensive continuum of health care and services to CF members at home, abroad and on deployed operations.

The organization consists of the Canadian Forces Health Services Headquarters and of intermediate headquarters strategically located across Canada to support the Health Services' clinics and other units within their respective area of responsibility.

At the operational level, the Surgeon General provides guidance and direction on all aspects of health care in the CF including developing health care policy, setting standards, establishing procedures, and responding to issues from the field as they arise. He is the final authority on all health care issues and resolves disputes on professional issues between various groups of health care workers in the CF.

The Directorate of Mental Health reports to the Surgeon General and provides a single focus for all mental health-related activities and programs within the CF and DND. A senior Mental Health clinician is appointed as advisor to the D



MH and chairs the Professional /Technical Advisory Group consisting of practice leaders for: psychiatry, psychology, social work, MH nursing, addictions and Health Service chaplains.

CF Mental Health Service Delivery

Today, there is a full range of mental health care services available to our CF members throughout all aspects of their

ملخص	概述	RÉSUMÉ	0630P	RESUMEN
<p>تندرج الاحتياجات الصحية، بما في ذلك احتياجات الصحة النفسية لأفراد جنود القوات المسلحة الكندية، ضمن أولويات الحكومة الكندية والجيش الكندي. ولذلك فقد قامت القوات المسلحة الكندية باستثمارات كبيرة لضمان حصول أفراد الجيش الكندي على أعلى مستوى ممكن من الرعاية الصحية النفسية أينما كانت مواقع خدمتهم. وقد حرصت الخدمات الصحية للقوات الكندية على تجديد برامجها للرعاية الصحية النفسية خلال العشر سنوات المنصرمة. علاوة على الدور الرئيسي الذي لعبته في تغيير ثقافة القوات المسلحة الكندية فيما يتعلق بالصحة النفسية وأولئك الذين يعانون من متاعب نفسية.</p>	<p>加拿大军队 (CF) 的军事人员的健康需求，包括心理健康需求在内，是加拿大政府和CF的优先考虑事项。因此，CF进行了重大投资以确保人员无论在哪里服役，都能够接受到最高的心理健康保健标准。加拿大军队卫生服务部 (CFHS) 在过去十年恢复了心理健康保健计划，并在CF向心理健康努力进程中发生文化变革以及对遭受精神疾病困扰的人员发挥了关键作用。</p>	<p>Les besoins de santé, y compris les besoins de santé mentale, des personnels militaires des forces canadiennes (CF) sont une des priorités du gouvernement canadien et des CF. Ainsi, des investissements importants ont été réalisés par les CF pour assurer que leurs personnels bénéficient des meilleurs soins mentaux possibles, peu importe leur lieu d'intervention. Les services médicaux des forces canadiennes (CFHS) ont revitalisés au cours de la dernière décennie leurs programmes de soins de santé mentale, tout en jouant un rôle essentiel dans l'évolution culturelle au sein des CF concernant la santé mentale et les personnes souffrant de maladies mentales.</p>	<p>Потребности в охране здоровья, в том числе и психического, в рядах вооружённых сил Канады (ВСК) являются первостепенной задачей для канадского правительства и ВСК. В связи с этим в ВСК были привлечены значительные инвестиции для обеспечения охраны психического здоровья военнослужащих на высшем уровне, где бы они не проходили свою службу. В течение последних десяти лет в медицинской службе ВС Канады (МСВСК) проводилось возобновление программ по охране психического здоровья, также эта служба сыграла важную роль в осуществлении культурных изменений в вопросах о психическом здоровье и по отношению</p>	<p>Las necesidades sanitarias, incluyendo las de salud mental, del personal militar de las Fuerzas Canadienses (CF) son una prioridad para el Gobierno de Canadá y las CF. Por eso, las CF han realizado un esfuerzo de inversión para garantizar que el personal reciba los mayores niveles de atención sanitaria mental posibles, allí donde estén. Los Servicios Sanitarios de las Fuerzas Canadienses (CFHS) han estado revitalizando sus programas de salud mental durante la última década. También han tenido un papel clave en el cambio cultural dentro de las CF respecto a la salud mental y los afectados por enfermedades mentales.</p>