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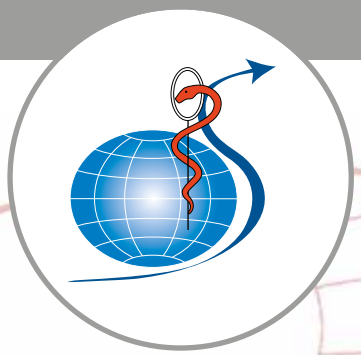

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EDITORIAL

BEST WISHES 2022

This edition of the *International Review of the Armed Forces Health Services (IRAFMS)* closes in the year 2021.

For the second consecutive year, we have had to adapt to the constraints of a complex health situation linked to the ever-active circulation of Covid on our planet.

Thus, in this centenary year of the creation of the International Committee on Military Medicine, the World Congress planned for September 2021 had to be postponed by one year, replaced for the circumstance by brilliant "*Centennial Talks*" currently available on the World Congress website: https://icmmworldcongress2021.org. On this site, as well as on the ICMM website, you will also find podcasts in which the speakers share their expertise.

We hope that in 2022 we will be able to meet again in Brussels as originally planned and that the Regional Congresses, which were also cancelled last year because of Covid, can be rescheduled for 2023 so that we can resume our scientific meetings.

During this year, the health services of our armed forces have been mobilised not only to protect our armed forces but also to make their contribution to the public health of our countries. A special issue of *IRAFMS* reported on how they responded to the effects of Covid-19, demonstrating the capabilities of military medicine in such circumstances. We would like to thank all those who contributed to this edition, but also a thank you to all the authors who contributed their expertise and experience to this journal.

We hope that the year 2022 will allow us to develop the form and content of our journal. Without neglecting the indispensable contribution of articles from presentations at our congresses but also spontaneously sent in by the personnel of our military health services, it seems necessary to us to open *IRAFMS* to the presentation of thematic files specific to the practice of medicine within the armed forces. This should allow the technical commissions (as was the case for the special issue on the centenary of the birth of Florence Nightingale) but also for all those who have a field of medical-military excellence (such as the medicine linked to parachuting, as described in our previous issue) to coordinate work that can be a reference and thus further affirm the place of our journal in this field of medicine. Finally, we believe that it is also important to be able to offer greater international visibility to articles that are often remarkable but published in national journals, to make military medicine better known. This is certainly part of the ICMM's mission! Finally, our Review will be open to all the partners (WHO, ICRC, WMA, …) in order to contribute to the communication of the information they wish to bring to the attention of our whole community.

At the end of this year 2021, the entire editorial staff of the *IRAFMS* joins me in wishing every one of you a happy holiday season, whether at home or in the field. I would also like to wish everyone good health and happiness for the New Year.

Major General (ret.) Prof. Humbert BOISSEAUX, MD
Chairman of the Scientific Council (Ad Interim)
Editor-in-Chief of the International Review of the Armed Forces Medical Services

Meilleurs Vœux 2022

Ce numéro de la *Revue Internationale des Services de Santé des Forces Armées (RISSFA)* vient clore l'année 2021.

Pour la seconde année consécutive, nous avons dû nous adapter aux contraintes d'une situation sanitaire complexe liée à la circulation toujours active de la Covid sur notre planète.

Ainsi, en cette année centenaire de la création du Comité International de Médecine Militaire, le Congrès Mondial prévu au mois de septembre 2021 a dû être décalé d'une année, remplacé pour la circonstance par de brillants "*Entretiens du Centenaire*" accessibles actuellement sur le site web du Congrès Mondial : https://icmmworldcongress2021.org. Sur ce site, ainsi que sur le site du CIMM vous trouverez également des podcasts dans lesquels les orateurs partagent leur expertise.

Nous souhaitons que 2022 soit l'occasion de nous retrouver à Bruxelles comme initialement prévu et que les Congrès Régionaux également annulés l'année dernière en raison de la Covid puissent être reprogrammés en 2023 afin ainsi de reprendre le cours de nos rencontres scientifiques.

Durant cette année, les services de santé de nos armées ont été mobilisés non seulement pour protéger nos forces armées mais aussi pour apporter leur contribution à la santé publique de nos pays. Un numéro spécial de la *RISSFA* a permis de rendre compte de la manière dont les uns et les autres sont intervenus pour lutter contre les effets de la Covid-19, faisant la démonstration des capacités d'intervention de la médecine militaire en de telles circonstances. Nous remercions tous ceux qui ont contribué à ce numéro mais au-delà, tous les auteurs qui nourrissent cette Revue de leurs expertises et expériences.

Nous souhaitons que l'année 2022 permette de faire évoluer la forme comme le contenu de notre Revue. Sans négliger l'indispensable apport des articles issus des communications présentées lors de nos congrès mais aussi spontanément adressés par les personnels de nos services de santé militaires, il nous semble nécessaire d'ouvrir la *RISSFA* à la présentation de dossiers thématiques spécifiques de l'exercice de la médecine au sein des armées. Ce doit être ainsi pour les commissions techniques (comme cela a été le cas à l'occasion du numéro spécial effectué pour le centenaire de la naissance de Florence Nightingale) mais aussi pour tous ceux qui possèdent un domaine d'excellence médico militaire (comme la médecine liée à l'exercice du parachutisme exposée dans notre précédent numéro) de coordonner des travaux qui puissent faire référence et ainsi affirmer davantage encore la place de notre Revue dans ce domaine de la médecine. Pouvoir offrir enfin une plus grande visibilité internationale à des articles souvent remarquables mais publiés dans des revues nationales, nous semble aussi important pour mieux faire connaître la médecine militaire. Cela rentre assurément dans les missions du CIMM !
Notre Revue sera enfin ouverte à nos différents partenaires (OMS, ICRC, WMA…) afin de contribuer à la diffusion des messages qu'ils souhaitent porter à la connaissance de l'ensemble de notre communauté.

En cette fin d'année 2021 toute la rédaction de la *RISSFA* se joint donc à moi pour souhaiter à chacune et chacun de bonnes fêtes de fin d'année que ce soit en famille ou sur des terrains d'opérations. Je tiens à formuler également à toutes et tous mes vœux de santé et de bonheur pour la nouvelle année.

Médecin Général Inspecteur (2s) Prof. Humbert BOISSEAUX
Président du Conseil Scientifique (par Interim)
Rédacteur en chef de la Revue International des Services de Santé des Forces Armées

Blending the Best of the Real and Virtual: A Future Concept for Preparedness Training in Healthcare and Beyond.

By RJ. STONE[1] and D. LAMB[2]. United Kingdom

Bob STONE

Professor Bob STONE, C. Psychol, FCIEHF.

Bob STONE is a Human Factors specialist and a 35-year "veteran" of the international Virtual, Augmented and Mixed Reality community. In 1993, whilst researching VR and robotics at the UK's National Advanced Robotics Centre, Bob established the world's first industrial VR team, launching a countrywide collaborative VR initiative, wholly funded by industry. Bob's research has taken him from Royal Navy vessels conducting close-range weapons and missile trials to underwater operations onboard submarines and rescue submersibles; and from search-and-rescue helicopter missions to operating theatres and medical units throughout the UK, US and South Africa. Today, as well as being an Emeritus Professor at the University of Birmingham, Bob works closely with the Royal Centre for Defence Medicine and various UK hospitals, researching the use of VR and MR for physical and mental health restoration and rehabilitation, and for the training of future military Medical Emergency Response Teams. He also has a passion for the Virtual Heritage arena, exploiting VR and AR to help make invisible rural and oceanic historic sites visible once again, particularly around the Plymouth area where he was born and bred. Bob and his Team have been awarded numerous awards over the past 30 years. In 2011, he was awarded the Ministry of Defence Chief Scientific Advisor's Commendation for his contributions to Defence Science & Technology, and, more recently, his team received the Chartered Institute of Ergonomics & Human Factors 2020 Innovation Award for their defence medical work.

RESUME

Mélanger réel et virtuel : un concept pour la formation future aux soins de santé et au-delà.

En 2016, le service médical de la défense britannique a développé un programme destiné à améliorer la préparation aux déploiements opérationnels. Cet article décrit la capacité de simulation d'un démonstrateur destiné à la formation des équipes d'intervention médicale d'urgence. Positionnés dans une enceinte modulaire, plusieurs stagiaires font l'expérience d'un scénario partagé de « réalité mixte ». Ici, des éléments physiques jugés cruciaux pour le processus de formation, coexistent avec un environnement de réalité virtuelle. Ce mélange est possible grâce à une technique innovante « Chroma Key », les utilisateurs étant porteurs de casques de réalité virtuelle qui reproduisent l'environnement dans lequel ils sont destinés à opérer. Les personnes sont donc capables de voir simultanément leur propre corps comme celui de leurs collègues en même temps qu'ils peuvent toucher et d'interagir avec les objets physiques nécessaires à leur entraînement. Ce système de formation est piloté depuis une console, l'instructeur ayant à sa disposition toute une gamme de scénarios et d'effets opérationnels préprogrammés comme par exemple le travail en ambiance nocturne ou la survenue de tirs ennemis. L'environnement virtuel peut être modifié pour passer instantanément d'un Chinook de la RAF à un véhicule Army Mastiff, une péniche de débarquement ou encore à un aéroglisseur des Royal Marines, ce qui offre des usages autres que sanitaires.

KEYWORDS: Virtual/Augmented/Mixed Reality, Training, Military, Operational Preparedness, Medical Emergency Response Team, Psychological Resilience.

MOTS-CLÉS : *Réalité virtuelle/augmentée/mixte, Entraînement militaire, Préparation opérationnelle, Equipe d'intervention médicale d'urgence, Résilience psychologique.*

INTRODUCTION

Personnel who have previously deployed on military operations perceive they have already attained a level of confidence in terms of situational awareness (SA) that includes being familiar with the extent of injuries they will likely witness during future deployments[1]. However, this confidence might diminish over time if

skills and SA are not maintained, which creates a potential stressor for those deploying on contingent operations, particularly at short notice. Repetitive training in a simulated high stress environment enables personnel to learn how to modify their behaviours and emotions[2-4]; therefore, greater confidence associated with new skill acquisition is more likely to be matched by competence when transferred to the real operational environment[5]. Furthermore, there can be significant psychological consequences of healthcare providers' roles in managing a high incidence of casualties with significant and life-threatening traumatic injuries[6-9]. Indeed, during military operations in Afghanistan, MERT personnel were repeatedly exposed to the potential psychological stressors associated with casualty care from the point of wounding to delivery to Camp Bastion[1].

From a wider perspective, the nature of international Defence engagements is changing dramatically, and becoming increasingly 'hybrid'in response to a diverse spectrum of threats and challenges. Engaging in such a rapidly changing global environment, where urbanisation, global warming and a growing world population are all having a significant impact on availability of natural resources, requires a highly adaptable force[10]. The UK military's operations are becoming increasingly expeditionary in nature, with a reliance on agile forces functioning with reduced support at long distances[11]. Therefore, forward medical teams may be required to manage casualties on unfamiliar and possibly minimally equipped 'platforms of opportunity'[12] as opposed to typical military land, air and sea assets deployed for MERT support. Indeed, this reliance may lead to adverse effects on mortality and morbidity if appropriate preparedness is not provided.

Currently, individual and small-team training is conducted within a progressive educational environment and builds upon the teaching provided in the Battlefield Advanced Trauma Life Support (BATLS) course. Trainees are exposed to practical sessions, typically involving moulage exercises using role-playing personnel, amputee actors, or, more commonly, Laerdal SimMan® 'patient simulators'[13]. It is preferable for such training to be conducted in the noise, vibration and space constraints offered by live operational platforms; however, the frequent lack of availability of those platforms, due to higher priority tasking, has resulted in the need to use much lower fidelity facilities. An example is the CH-47 Chinook helicopter rear-cabin mock-up at the Tactical Medical Wing (TMW) of RAF Brize Norton, illustrated in Figure 1.

Figure 1: Fixed Location Rear Cabin Trainer at RAF Brize Norton.

However, ground-based, fixed-location trainers have several limitations in terms of training fidelity, and are immovable, requiring trainees to travel to the place of training. They are poorly equipped to support instructors in their evaluation of individual and team performances. This is as a result of using inert, non-functioning and often incomplete items of medical equipment, such as a patient monitor or ageing and damaged SimMan® mannequins. Those same instructors are often relied upon to verbally prompt trainees with the patient's condition and physiological response to their clinical intervention throughout a training session[14]. The initial construction, running and ongoing maintenance costs are also high. Most importantly, their design is typically representative of only one MERT-relevant platform. Furthermore, they cannot be easily, or cost-effectively, reconfigured to provide training solutions for other branches of the Armed Forces, or able to recreate future platforms of opportunity in radically new operational settings.

THE PROJECT CHALLENGES

A comprehensive outline of the initial phase of this development programme can be found elsewhere[15]. However, the main aim of the project was to deliver the following:

- *An AFFORDABLE (i.e. predominantly Commercial Off-The-Shelf (COTS)-based), dynamic "context exposure" trainer capable of initially training teams of up to three members*. Note that this challenge did not encompass the training of basic/advanced clinical skills.
- *A more TRANSPORTABLE solution to the fixed location trainers currently in use (described above).*
- *A RECONFIGURABLE trainer capable of rapid scenario change to be representative of several MERT platforms.*
- *A solution with attention to instructor-led scenario settings, trainee evaluation and After-Action Review (AAR).*

EARLY MERT TRAINING CONCEPT

From the original human factors observations and end user engagement processes reported in Stone *et al.*[15] and originally described in this journal by Stone and Barker[16], it was clear that a training system based solely on VR technologies, and purely graphical interactive content, would not adequately replicate the levels of task and context fidelity necessary to achieve satisfactory training for MERT trainees (see also Stone, 2012). In particular, the

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constraints imposed by the physical confines of the operating environment would be impossible to reproduce in a VR environment alone. Such a VR set-up would typically comprise head-mounted displays, spatially tracked hand controllers, even contemporary haptic (force/touch) feedback solutions; all of which would elicit distracting perceptual-motor artefacts. Examples of this include portions of trainees' virtual bodies disappearing into elements of the recreated virtual platform, or a poor and unstable registration between their real and virtual hands and any form of computer-generated casualty. For these reasons, it was decided that a *Mixed Reality* (MR) solution, based within a transportable and reconfigurable physical enclosure was worthy of investigation. This reasoning also drove an early decision to source a COTS synthetic mannequin, a SIMBODIE, illustrated at Figure 2, to provide a simple sense of haptic feedback to the trainees, in conjunction with a computer-generated casualty that initially 'overlayed'the real mannequin. The initial view of the virtual casualty through the headset can be seen at Figure 3.

The first challenge was to replace the costly fixed-location training facility, representative of a single MERT platform (Figure 1). To achieve this a portable, small-team training enclosure prototype was developed. Essentially this was an inflatable "tunnel-like" structure (illustrated at Figure 4)[15]. The internal dimensions approximated the width and height of the rear cabin of a Chinook helicopter, which created a degree of physical confinement (context fidelity) to the trainees' workspace.

Figure 2: Realistic Casualty Mannequin.

Figure 3: Original Chinook Virtual Interior.

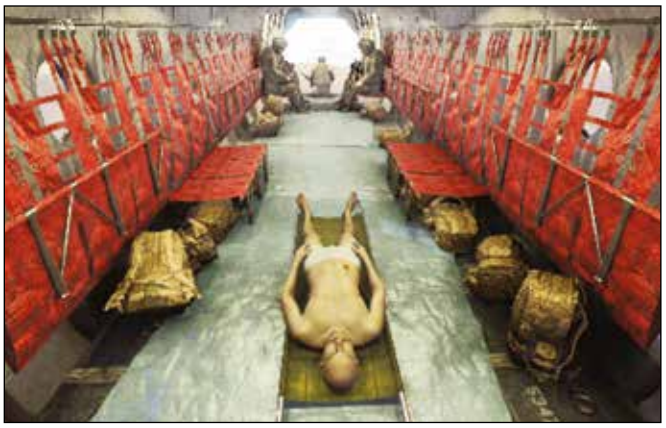


Figure 4: Original Inflatable Demonstrator and the Interior with "Space-Filling".

ASSETS

The software package used for the virtual components of the MERT MR trainer was (and still is, at the time of writing) the popular Unity game development platform, hosted on an Alienware Area 51 desktop computer equipped with two Nvidia GeForce GTX1080 graphics cards. A variety of COTS head-mounted VR displays and body tracking systems were evaluated and HTC's *Vive* headset was finally selected. The key deciding factor was the existence of 'Lighthouse'modules. These comprise a minimum of two small scanning laser units as part of an integrated position and orientation tracking system and were mounted at diagonally opposing locations within the training enclosure.

Whilst wearing their VR headsets, trainees received a realistic sense of helicopter flight via the moving topology they could see through the windows and rear ramp area of the aircraft. This video was captured by a DJI *Inspire 1* drone equipped with a Zenmuse X3 4K camera, which was flown in an elliptical flight path over a barren area of Dartmoor, in the south-west of the United Kingdom. A flat plane (or 'billboard') was created to run within the Unity game engine. The video was projected onto this billboard at run-time. To add to the in-flight illusion, high-quality Chinook engine sound effects were integrated with the visual flight sequence, provided by Boeing Defence UK Limited.

Finally, stakeholder engagement informed the design of a concept instructors' interface. This would enable instructors to view trainees' performances via within-enclosure video cameras and from selectable views from each trainee's head-mounted display. Instructors would also be able to pre-program scenarios, control a virtual patient Vital Lifesigns monitor, and digitally mark key events for the purposes of post-training AAR. All elements were then displayed within a single screen-set-up, achieved through a Samsung CHG90 49-inch, ultra-wide (32: 9 aspect ratio) display (Figure 5). The Vital Lifesigns software element of this interface can be clearly seen (in Figure 5).

CONCEPT CAPABILITY DEMONSTRATOR – DESIGN ISSUES AND SOLUTIONS

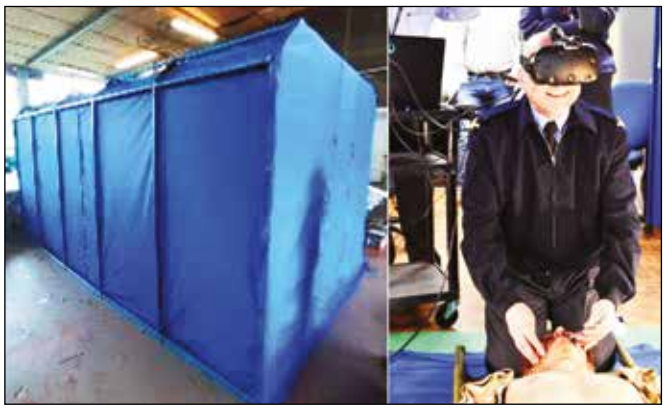
The first MERT MR concept capability demonstrator was exposed to a variety of potential end-users and stakeholders over a 12-month period. Whilst not part of a formal evaluation trial, feedback was logged and opportunities were taken to observe and record the interactions between individuals and the real and virtual technology

Figure 5: Instructor's Console – Early Development (Showing 3D Vital Lifesigns Monitor).

elements described above. As well as the key stakeholder team, 'participants'in early exposures of the MERT concept included national and international tri-Service Defence medical and human factors specialists, national and international ambulance crews, air ambulance pilots and medics, and training advisors from UK National Health Service (NHS) Hospital Trusts. Whilst feedback on the concept demonstrator was consistently positive, serious limitations were becoming apparent. For example, the accuracy and stability of the spatial registration between the physical MERT enclosure components (including the mannequin) and their virtual counterparts was judged to be less than ideal, and limitations with the head-mounted display and hand controller devices were compromising the experience of an otherwise potentially effective MR training concept. Specifically, the system's inability to support intuitive and accurate "hands-on" sensations between the virtual representations of the users' hands (controlled either using gloves or bulky hand-held control devices), the virtual casualty and the underlying physical mannequin, were deemed to be seriously limiting. Therefore, a complete re-think of how to implement MR to deliver the desired training effect was necessary.

The first decision involved modifying the HTC Vive head-mounted displays already in use in the MERT concept demonstrator, to deliver Augmented Reality (AR) experiences. This was achieved by modifying the product using a 'pass-through'camera technique (as the original HTC Vive headset does not possess any forward-looking camera capability). The technique helps to improve AR data based on transparent optics. Following a lengthy technology review, an industrial inspection camera was selected, the Ximea MQ042CG, which is capable, in a typical indoor lighting environment, of delivering a frame rate of 60fps with a resolution of 1280 x 1280. Note, in Figure 6, that a single Ximea camera is used (monoscopic presentation). Indeed, the images displayed in the HTC Vive headset are presented *biocularly* to the wearer.

Figure 6: Enclosure Comprising "Blue-Screen" and "Pass-Through" Camera- Modified VR Headset.



Once the Ximea camera had been fitted to the HTC Vive headset, the next issue was how best to integrate the real, physical objects of relevance to MERT training, within the enclosure, with their VR counterparts. Throughout the redesign process, it was important to maintain the sense of confinement identified as an important aspect of context fidelity in the earlier observational sessions. Consequently, the training enclosure was completely converted, replacing all of the previous components, with the exception of the SIMBODIE mannequin and stretcher, with blue material surfaces (Figure 6). The demonstrator now takes the form of a modular enclosure comprising inflatable cuboids ("space fillers" representing platform seating, fixed structures and equipment) that augment the sense of confinement within the training environment.

The blue material used throughout the enclosure was instrumental in achieving a credible "merging" of the virtual with the real, using chroma key techniques. Often referred to as blue or green-screen technology, chroma keying is typically used to generate special effects in video processing through the segmentation of background and foreground objects using colour cues. In the case of the MERT MR simulator, this technique can be directly applied to the video feed from the HTC Vive-mounted Ximea camera. These segmented areas are replaced by the real-time software generating, in this case, the Chinook virtual environment. To ensure the best segmentation possible, areas of the real-world environment that are to be replaced must be covered in a uniform colour, enabling the software to quickly identify what should be replaced. During early colour testing it was found that blue performed best in the segmentation process due to its strong contrast to the typically green and yellow shades of military clothing and equipment.

As can be seen in Figure 7, the MR effect delivers a significantly new technology-based training experience. It not only allows users to see their own hands and body, together with key items of physical importance to the training scenario, but also supports an accurate haptics experience as they reach out to touch those physical items; all of which is augmented within the virtual context of a MERT platform in transit, in the example shown, a Royal Marines hovercraft.

Figure 7: An Example of the MR Augmentation Process. Note the physical interaction between the user and the stretchered SIMBODIE (including the locations of the user's real feet – bottom right image), within the virtual context of a Royal Marines Hovercraft.

With the new MR augmentation process in place, plus the extensive changes to the interior of the MERT MR enclosure, an interim usability evaluation of the new configuration of the MERT MR concept demonstrator was undertaken. MERT personnel from TMW were asked to participate in order to capture their subject matter expertise on the developments in a more formal method than had previously been the case.

EARLY EVALUATION (CONCEPT CAPABILITY DEMONSTRATOR)

Evaluation of the early MERT MR demonstrator took place during a full-day usability workshop at the University of Birmingham. The aims of the workshop were threefold. The first was to introduce both established and new TMW stakeholders to the training concept's current stage of development. The second aim was to capture feedback on the concept capability demonstrator from primary groups who were representative of the intended target users and who could support future training content and system design modifications. The third aim was to collect benchmark data, against which future iterations of the demonstrator could be evaluated. The attendees at the workshop were eight personnel from TMW and the Army who had deployment experience as part of a military MERT, together with experience in the instructor role on MERT training courses. Participant details are shown in Table 1.

Table 1: Participant Details.

N	8 (6 male, 2 female)
Age (mean ± standard deviation; range)	39±5 years 32-47 years
Occupation (current)	RAF Paramedic (x4) RAF Emergency Nurse (x2) RAF Advanced Nurse Practitioner Army Consultant in Emergency Medicine

The workshop comprised three sessions: i) Introductory; ii) Task; and iii) Future MERT modifications. During these sessions the participants were invited to interact with the demonstrator to varying degrees, from simple observation to 'hands-on'activities. For each session the participants worked in pairs. The task elements defined for the participants were:

- *Visual inspection* – This involved opening the SIMBODIE mannequin's military tee-shirt to visually search and locate the position of the entry wound. To aid in this task, the shirt was pre-cut and stitched with Velcro to avoid having to destroy numerous items of clothing over all sessions.
- *Tactile inspection* – This involved palpating the mannequin, simulating search techniques for any medical indications via visual and tactile means.
- *Log roll* – This involved rolling the mannequin onto its side to locate and examine the exit wound from the gunshot injury.
- *Syringe application* – As a safety precaution and to avoid injury brought about by using needles when using a VR headset, the mannequin had been pre-cannulated, such that a short thin tube with a valve at the end was inserted into its arm (brachial artery location) and fixed in place. The syringe task involved attaching a syringe to the valve of the cannula, depressing, detaching, and closing the valve.
- *Intubation* – This required the insertion of a laryngoscope into the mouth of the mannequin, levering the jaw open, and inserting an endotracheal tube into the simulated trachea.

In brief, the responses from the TMW participants confirmed that the initial informal human-centred investigations of VR, AR and MR technologies with stakeholders and Defence medical experts, and the mitigations to overcome limitations, were successful. Particularly noteworthy were the activities observed in video records of the pairs of participants working around the mannequin. In many cases they were interacting visually and verbally without any obvious impairment imposed by the head-mounted display configuration. Indeed, they were even recorded exchanging needles and other fine instruments during the set tasks (Figure 8).

Figure 8: Mixed Reality MERT Training Concept Undergoing Evaluation by TMW Personnel.

Measures of "Presence" (feeling part of the virtual environment)[17], Fidelity (realism – specifically related to the Chinook VR scenario) and Technology Acceptance scores[18] were judged to be very acceptable for a mid-term usability evaluation of an innovative and quite unique concept training demonstrator. The one exception to this finding concerned the fidelity and realism of the sound effects, which attracted the lowest ratings. For the purposes of enhancing the future fidelity of the demonstrator, this result could be ignored, as the sound system used during the evaluation sessions was set to a much lower volume level than normal to permit spoken task instructions being relayed to the participants from outside the enclosure.

Discussions with participants following the evaluation sessions suggested that increased task difficulties were due to combinations of image quality (e.g. the resolution of the headset and flicker caused visual focusing problems for participants, especially during fine perceptual-motor tasks) and wearability issues with the modified Vive headset. From the standpoint of image quality, all participants reported some degree of visual discomfort, including difficulty focusing, visual fatigue, and dizziness. Some participants also noticed differing degrees of pixilation for some of the imagery. At the time of writing, new MR headsets are becoming available, again based on pass-through cameras, but with much higher resolutions than the Vives used in this project, and better synchronisation between the virtual images and the pass-through video. Additional visual problems arose as a result of virtual scene artefacts caused by variations in light and, especially, strong shadows in specific areas of the enclosure, such as the base of the end door flaps and under and around some of the larger Bergens and simulated casualty stretcher. This has been rectified by including a more distributed lighting arrangement at multiple levels within the enclosure and by ensuring that blue surface material is as taut as possible.

INSTRUCTOR CONSOLE DEVELOPMENT

The instructor console (at Figure 4) has been developed to include video feeds from each of three modified VR headsets. These show exactly what the trainees are viewing at any time. It also includes up to four closed-circuit TV views of the actual interior of the enclosure, allowing the Instructor to observe trainees' behaviours. Furthermore, the console's function "buttons" enable the MERT platforms to interchange, and a pre-programmable MERT "timeline" function enables the instructor to set up and store a scenario, together with additional effects. The latter comprises small arms fire, own-ship weapons discharge, night vision and brownout visual effects and can be selected prior to a particular training session. The console also allows the instructor to set the main parameters of the virtual onboard Vital Lifesigns monitor which, in this second phase of work, was "upgraded" from a simple visual monitor representation (as shown in Figure 5) to a TEMPUS Pro system (Figure 9). With the support of RDT Ltd (a Division of Philips Healthcare), computer-aided

Figure 9: Virtual TEMPUS Pro Display.

design (CAD) data relating to the physical form of the TEMPUS Pro were provided to the development team. Therefore, together with screen shots of the system in action, it was possible to develop a convincing virtual replica, displaying, in basic form, heart rate (in beats per minute, plus wave form), peripheral capillary oxygen saturation (plus wave form) and blood pressure (plus wave form).

ADDITIONAL CREWMEMBER AND CASUALTY "AVATARS"

The key to introducing avatars in a training context like this is to ensure there are sufficient background or "context"[19] activities. This increases the dynamic qualities of the training scenario. However, given the potential impact of introducing credible/believable animated virtual humans on the overall computational performance of such simulation, there is inevitably a trade-off between fidelity and this real-time performance. Simple, static virtual humans would not present a credible, realistic simulation scene and would, in effect, be distracting. Similarly, too much activity would equally distract trainees' attention away from the focus of the simulated scenario. Wherever possible, commercially available 3D models of British Armed Forces personnel were used to deliver appropriate avatar representations for the MERT scenario. These models were animated via an OptiTrack Flex 13 MOTIVE medium volume Motion Capture (MOCAP) facility. This system comprises 12 cameras, each of which use visual and infrared light to detect and track high-contrast markers sewn into a black Lycra suit worn by a human subject. It was possible to mimic and record the movements of the human subject to a level of detail appropriate for integrating with the 3D avatar models. Several avatars in the MERT role can be seen in Figure 10.

Improvements to the process of capturing and simulating behaviours of the avatars will continue. In addition, improvements are also required for any future physical mannequin "casualty" adopted for training. The current SIMBODIE mannequin has proven to be

Figure 10: Avatar MERT Crewmembers.

highly effective in the development programme thus far but is very limited in terms of the number of life-saving interventions it can support. Intubation, cannulation and other superficial patient checks are currently possible, and the evaluation of penetrating wounds can be undertaken by adding optional "sleeves" to the mannequin (Figure 11, upper images). Variable cardiovascular pulse effects can also be achieved by using a unique, wearable Bluetooth-controlled Soundbrenner metronome, in close contact with the mannequin's skin and at points close to where a pulse would normally be taken. More complex presentations, such as blistering caused by exposure to Chemical, Biological Radiological and Nuclear agents are also being investigation (Figure 11, lower image). The pass-through camera design of the VR headset is ideal in this respect as it supports the exploitation of AR software techniques. Indeed, textures, both static and animated, can be superimposed over the mannequin's body using

Figure 11: Mannequin Entry and Exit Bullet Wound "Sleeve" and Simulated Augmented Reality Blistering Effect.

"fiducial marker" registration (a form of barcode scanning), or the automated recognition of specific body topographies and anatomical features.

CONCLUSIONS AND NEXT STEPS

This paper summarises the achievements of, and lessons learned, from a major programme of Defence medical research and development, sponsored by the RCDM and undertaken by the University of Birmingham's Human Interface Technologies (HIT) Team, together with their partner commercial organisation Modux. The project set out to deliver an innovative solution to supporting the future training of MERTs, exploiting COTS interactive technologies emerging from the VR, AR and MR (collectively referred to as "XR") community.

Wearing camera-modified ("pass-through") VR headsets, up to three trainees surround a physical mannequin on a stretcher. They are able to interact visually and manually with the mannequin, each other and with real items of medical equipment whilst, courtesy of *chroma key* processing, experiencing the internals of a Chinook helicopter, Royal Marines landing craft and hovercraft, and an Army Mastiff vehicle, from casualty reception to discharge. A dedicated Instructor's Console supports the programming of day and night scenarios and the "triggering" of incidents (such as changes to the simulated Tempus Pro monitor, or the onset of external and internal small arms/close protection weapons discharge). Digital video images from trainees' headsets and enclosure CCTVs can be recorded. Headset-integrated eye-tracking technologies are also now being evaluated to support future analyses of trainees' reactions, interactions and attention.

Lessons learned during the course of this unique project are many and varied. For example, it has been demonstrated how vitally important it is to adopt a strong human-centred design approach from the outset, interacting regularly with as wide a range of end users and organisations as possible. The project has also exposed the significant limitations of present-day and near-term XR head-mounted displays, particularly AR headsets, and haptics technologies (delivering the sense of force and touch in a virtual environment). Future plans involve extending the platform database to include new technologies (when proven to be of an appropriate level of maturity for this application domain) and new scenarios, urban, Arctic, at-sea, to mention but three. In addition, new MERT platform representations will be regularly added to the existing 3D model database, from the BV-20 to medical compartments onboard RN casualty receiving vessels and, potentially, "platforms of opportunity" exploited for medical evacuation from areas not accessible by contemporary military assets. Indeed, the immersive GP training programme described in this special edition (reference when known) is an example of how MR could further enhance this cadre's exposure to accurate operational environments. A generic classroom becomes a ship for example, with the experience being

so convincing that students believe they are dealing with the medical emergency for real. Therefore, when the same or similar event occurs again during an actual deployment, they are highly likely to have an enhanced level of situational awareness. Avatars could also be introduced to a scenario who fulfil the multidisciplinary team roles currently missing from the training programme. The opportunities beyond healthcare are also endless and are limited only by a lack of imagination.

ABSTRACT

In 2016, a programme was launched by the UK Defence Medical Services (DMS) to improve preparedness training for operational deployments. This paper describes a unique Technology Readiness Level (TRL) 4, reconfigurable and affordable simulation capability demonstrator as a proof of concept for the future training of Medical Emergency Response Teams (MERTs). Operating within a rapid-assembly, modular, physical enclosure, multiple trainees experience a shared "Mixed Reality" (MR) scenario. Here, real physical elements, identified as crucial to the training process, appear to exist within a dynamic virtual reality (VR) context, such as the rear cabin of a military helicopter. This blending is uniquely achieved by means of an innovative Chroma Key ("blue-/green-screen") technique, which presents users, wearing camera-modified VR headsets, with integrated real-virtual views of the environment within which they are operating. They are simultaneously able to see their own bodies and those of their colleagues, and able to touch and interact with the training-relevant physical items avoiding the need for expensive haptic (touch/force feedback) wearable devices. The training system is driven by a single instructor console, enabling a range of pre-programmed operational scenarios and effects, for example, enemy small arms fire or night vision. The virtual environment can be instantly changed with the press of a single key to represent (currently) an RAF Chinook, an Army Mastiff vehicle and a Royal Marines' Landing Craft and Hovercraft, which also provides significant opportunities beyond healthcare.

Author Contributions

BS leads the team of developers and drafted the manuscript. DL is the DMS point of contact for the programme of work enabling the concept development within the MERT context and drafted/edited the manuscript.

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Competing Interests

Nil to declare

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Implementing a New Up-To-Date Tactical Combat Casualty Care Course for Military Personnel: Highlights of a 1 Year Experience at The Bahrain Defence Force.

By A. ALJAR[1] and N. LOURI[2]. Bahrain

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RESUME

Mise en œuvre d'un nouveau cours actualisé sur les soins tactiques aux blessés au combat pour le personnel militaire : L'expérience d'une année des Forces de défense du Bahreïn.

Introduction

La médecine militaire est une discipline en permanente évolution. Les écoles militaires des Forces de défense du Bahreïn ont une attention particulière à l'enseignement des premiers secours avec notamment pour tous les militaires, un cours de soins tactiques pour les blessés au combat, cours récemment mis à jour et développé par les forces armées des États-Unis.

Situation et mission

La création d'un centre de simulation complet avec une salle dédiée aux enseignements de médecine militaire offre un environnement propice à la réalisation d'un cours tactique actualisé de soins aux blessés au combat (TCCC).
Ce projet soutient la mission continue des services médicaux royaux de fournir un appui médical à toutes les unités des Forces de défense de Bahreïn.

Résultats

De mars 2019 à mars 2020, le cours TCCC destiné à tous les militaires a eu lieu 22 fois. Le feed-back a été globalement très positif et à l'issue, 447 étudiants ont été diplômés.

Discussion

Au fur et à mesure des sessions, certains contenus d'enseignement ont évolué pour mieux répondre aux besoins de nos étudiants (traductions en arabe et utilisation de notre propre approche du combat tactique).
Pour cela, toutes les ressources disponibles du dispositif ont été utilisées. L'une d'entre elles est celle d'un laboratoire de simulation où peut être par exemple simulé un incident de tir lors du test pratique final qui clôt le cours. Les étudiants bénéficient également d'une préparation psychologique pour faire face à certains événements comme par exemple à une hémorragie massive sur le terrain.
L'une des caractéristiques importantes de ce cours est qu'il vise une formation standardisée pour l'ensemble du personnel militaire.

En conclusion

La possibilité pour tous les militaires de pouvoir bénéficier d'un cours tactique actualisé sur les soins aux blessés au combat est une priorité importante pour les équipes de médecine militaire.
Ce cours doit faire partie intégrante de tout enseignement médical militaire avec des objectifs d'apprentissage spécifiés. L'un des principaux résultats d'une telle formation est de réduire les décès pré-hospitaliers évitables sur les théâtres d'opérations militaires.

KEYWORDS: Tactical Combat Casualty Care, Medical Education, Military Medicine, Medical Simulation.
MOTS-CLÉS : *Soins tactiques aux blessés au combat, Formation médicale, Médecine militaire, Simulation médicale.*

INTRODUCTION

Since its foundation in 1968, The Bahrain Defence Force has been actively involved in developing & updating its force capabilities. Military medicine is rapidly evolving & there is a huge demand to continuously evaluate & update the courses delivered to all types of military personnel, from the average combatant all the way to the advanced military healthcare provider. Within The Bahrain Defence Force, military first aid is one of the basic military sciences that officers & soldiers learn during their basic military training. It is also taught in more depth within our Royal Medical Services School's first responder course that is offered for all combatants.

The Tactical Combat Casualty Care (TCCC) guidelines[1] for the course that we are adopting, TCCC for all service members[2], was developed in the 1990s for the United States Special Operations Command[3] & continued to evolve benefiting from the many military deployments until the last TCCC guidelines published by The Joint Trauma System (JTS) Committee on Tactical Combat Casualty Care (CoTCCC) in the 5th of November 2020[1]. It covers 3 main phases: Care under fire, tactical field care & tactical medical evacuation. It is intended to be the standard of medical care for the modern battlefield for one of our major strategic allies, The United Stated Armed Forces.

TCCC courses content was made accessible in an unclassified fashion through a website: deployedmedicine.com[4]. It is run by The Defence Health Agency in collaboration with above mentioned policy making bodies within the United States Armed Forces (JTS/CoTCCC). The content includes comprehensive written & audiovisual educational content for students & instructors. The course's format is very similar to common franchise courses delivered for healthcare providers by the American Heart Association & The American College of Surgeons like the basic life support course & the pre-hospital trauma life support course.

SITUATION & MISSION

In February 2019, a new state-of-the-art comprehensive medical simulation center was established under the umbrella of The Bahrain Defence Force Royal Medical Services (Figure 1). It is intended to be a region hub & a center of excellence for the field of medical education & medical simulation. It obtained recently initial accreditation from The Society of Simulation in Healthcare (SSH), one of the largest international accrediting bodies in the field of medical simulation.

Within its premises, there is a special hall dedicated to military medicine courses (Figure 2). A military medicine team composed of educators under the supervision of a higher medical simulation committee was formed. Due to the accumulating evidence of the benefit of the TCCC course in reducing preventable pre-hospital death on the battlefield, the military medicine team made adopting an updated TCCC course a priority project for the operation of the military medicine hall (Figure 3). Part of the ongoing mission of our Royal Medical Services is providing medical support to all units of The Bahrain Defence Force. This TCCC course project constitutes the very essence of our Royal Medical Services ongoing mission at war & peace[5].

Figure 1: The Crown Prince Center for Training & Medical Research.

Figure 2: Military Medicine Hall.

Figure 3: Business Model of TCCC course at Crown Prince Center for Training & Medical research.

Phase 1: Running a high quality TCC course for all combatants across all military units at our simulation center for purpose of awarness. Maximum number possible using available resources. Proposed time: 1-3 years.
Phase 2: Recruiting instructors across all units from graduated student groups & doing instructor courses for them. Proposed time: 1 year.
Phase 3: Supervising TCCC course delivery at all military units & at military schools.
Phase 4: **A.** Makingthe updated TCCC course one of standard basic military sciences taught at military schools & involvement of TCCC course test for rank promotion. **B.** Involvement of TCCC scenarios in all military exercices supervised by unit TCCC instructors.

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RESULTS

From March 2019 to March 2020. The TCCC course for all service members was delivered 22 times. Total number of graduates of the course was 447 students. By coordination with our headquarter directorate of military training, students from various Bahrain Defence Army, Navy & Airforce units attended the course. Some courses was delivered to a group of single unit soldiers & officers. The majority of courses student groups was separated officers & soldiers from mixed military units. The priority was given to units that are actively deployed in military operations. The maximum number of students during each course is 30 students & the maximum number of students for the practical sessions is 15 students. The general feedback from students was positive & students showed interest in enrolling into more advanced courses & coming back for a refresher course in the future.

DISCUSSION

The original course content is in English[2]. We tried to deliver the course as intended in the course plan as much as possible. Our military medicine team have translated the course's one hour lecture content into Arabic. The rest of the course was left in English but direct on-the-spot Arabic translation was made when needed especially for the course videos. Instead of using the course's English TCCC card, also known in the United Stated Armed forces as the DD form 1380[6], we used our local TCCC card. This card is issued by The Military Medicine Committee of The Gulf Cooperation Council (GCC) countries. It is notable that in the update, the first person who is providing the initial treatment plays a role in the documentation although it is not necessary that he have any medical background. We notice also that in the updated course compared to its previous version, there is a big effort to increase the quality of the education material. The course became less theoretical, more practical, straightforward & to the point. In the course plan[7], the course proposed duration was 8 hours delivered over one day. We have split the course delivery time to 2 days that are 4 hours per day to maximise the amount of knowledge grasped by our military personnel. We have utilised all the resources available at our simulation centre military medicine hall. We used The Joint First Aid Kit (JFAK) containing the 7th generation combat application tourniquet (C-A-T). The recommended course equipment is outlined clearly as part of the instructor content for the course[7]. Available resources include mannequins, amputated limbs tourniquet task trainers, moulage kits & TV screen to view the theoretical educational content (Figure 2). All the resources are available in one dedicated hall for ease of course delivery & to avoid being booked for other events at our relatively busy training centre.

One of the unique resources available at the military medicine hall is a simulation lab (Figure 4) that is composed of 3 screen projector aided with sounds & smoke effects where a 360 simulated environment can be created for a variety of scenarios. The simulation lab is utilized for the course's final practical exercise test where a scenario of being engaged in a shooting incident occurs. Students are briefed before the exercise about the situation they will be in during the scenario. The scenario itself, location & timing of injuries are hidden from students. We try to simulate the randomness & surprise element during military operations by doing so. Students have to apply the knowledge & skills learned during the course in the test. The test involves the 3 phases of TCCC from care under fire while engaging virtual enemy on the screen all the way to handing over an injured soldier & TCCC card to healthcare providers once they arrive at end of scenario and assisting in medical evacuation of casualties. The benefit of practising a TCCC course in an indoor simulated environment is focusing on mastering the medical element of TCCC without interference of other field factors. Once mastery of essential TCCC skills are achieved, transition to complex field practice is the natural progression.

Figure 4: Military Medicine Hall's Simulation Lab.

In medical education, standardisation of course delivery has many benefits. Within the course, it is ensured that all individuals are exposed to the same quality of educational materials regardless of who is teaching the course. The TCCC course is intended to be taught to all the unit types of the armed forces. The course plan ensures that learning objectives are achieved whether the course is delivered in a high end training facility where all recommended education resources available or it is delivered on the field with little resources. There are comprehensive considerations & modifications for every setting in the course plan[7].

One of the main advantages of the course is that it provides psychological preparation of military personnel to deal with major injuries & massive bleeding in pre-hospital military operations scene. Use of simulated fake blood aids in creating a bloody scene while practicing on tasks trainers & during simulated scenarios. The care under fire in real situations is a very stressful event & the mental exercise of being in such a situation aids in making the soldier focus on the success of the military mission while simultaneously applying the principles of TCCC to prevent any preventable death in pre-hospital operations scene environment, combining good medicine with good military tactics. There is a great emphasis on self-aid as

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well as buddy-aid & teamwork during the course practice. Buddy-aid is one of basic essential military skills that has many applications, one of the major applications is the assistance in providing TCCC in the field. Students do scenarios in groups & are sometimes not given enough kit to deal with injuries during the scenarios and are taught what is the best thing to do in such a situation.

One of the challenges we are facing is that while course delivery ensures maximum quality with ability to find students that have instructor potential, it does not produce the desired numbers of graduates. This sheds light over quality of the course being related to the educator to student ratio within the given available resources. A mentionable challenge as well is that the course involves use of consumable materials that continuously need to be resupplied from an external provider. While some of the practice materials can be improvised & put together using locally available resources such as task trainers, other materials like the tourniquet has to be supplied from the original recommended course supplier. One of the challenges of reaching phase 4 of our business model is that our project is being operated under the umbrella of The Royal Medical Services. Widespread approval from Bahrain Defence Force headquarters requires escalation of awareness of the importance of our project through the chain of command.

SUMMARY

We talked in this article about our experience running a TCCC course at our brand new simulation centre. The opening of our simulation centre with a dedicated hall for military medicine courses granted us support to adopt an updated TCCC course & to start a project to implement it in our armed forces. This project is part of our Royal Medical Services ongoing mission to provide support to all units of The Bahrain Defence Force. We shed some light on our experience on how we delivered the course. We discussed some of the notable features & advantages of the course & some challenges we faced. To conclude, we highly recommend this course to be used as the standard in military medical education. The preservation of life & the prevention of unnecessary life losses at war is core into modern nations armed forces ethos & doctrine. Multinational collaboration in this matter should be welcome & is encouraged across the nations.

ABSTRACT

Introduction
The field of military medicine is rapidly evolving. Within The Bahrain Defence Force, military first aid is one of the basic military sciences taught in military schools. We are adopting the newly updated tactical combat casualty care course developed by the United States Armed Forces, The Tactical Combat Casualty Care Course For All Service Members.
Situation and Mission
The establishment of our comprehensive simulation centre with a dedicated hall for military medicine courses & command support to establish a military medicine team created an environment where a project to implement an updated tactical combat casualty care course into our armed forces became one of our priorities. This project supports our royal medical services ongoing mission to provide medical support to all units at The Bahrain Defence Force.
Results
From March 2019 to March 2020, the TCCC course for all service members was held 22 times. Total number of graduates was 447 students. The overall general feedback was positive among students.
Discussion
We altered some of the educational content to suit the needs of our students (translations to Arabic & use of our local tactical combat causalty card). We utilised all the resources available that were recommended in the course plan. One of the notable available resources include a simulation lab where we simulate a shooting incident as part of a final practice test for students. One of the features of the course is that it aims for standardised education for all military personnel. Students are exposed to psychological preparation to deal with massive haemorrhage on the field during the course.
Summary
Adopting the tactical combat casualty care course for all service members in its most updated form is an important priority to our military medicine team. We recommend this course as the standard in military medical education for the specified learning objectives. One major learning outcome is to reduce preventable deaths in pre-hospital military operations scene.

Disclaimer: The article represents the authors own views & are not necessarily representative of the views of The Bahrain Defence Force & The Royal Medical Services. We declare no financial conflict of interest.

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Basic Life Support Awareness Assessment and Training Amongst Soldiers Admitted in COVID Isolation Centre. An Indian Experience.

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INTERNATIONAL CONFERENCES ATTENDED

- European Society of Medical Oncology ASIA Congress in 2017 held in Singapore (TRAVEL GRANT AWARDED).

- Award by **Bill and Melinda Bill Gates foundation**, and got a travel grant for top abstracts in 18th International Society of Infectious Disease held in Argentina (TRAVEL GRANT AWARDED).

- German Society of International Medicine DGIM 2018 held at Manheim, Germany (TRAVEL GRANT AWARDED).

- His research work was selected in the winning abstracts category in the 34th World Congress of Internal Medicine held in Cape Town South Africa 2018.

- 43rd ICMM World Congress on Military Medicine in 2019, in Basel Switzerland. 2 Posters and 1 Oral presentation.

- International Society of Travel Medicine held in Washington DC USA 2019 (TRAVEL GRANT AWARDED).

NATIONAL CONFERENCES

- OSMICON (National Conference) 2015 held at Hyderabad, India.
- National Tuberculosis Association Conference 2017.
- Association of Physicians of India Conference 2018 held in Bangalore, India.

PUBLICATION OF ORIGINAL ARTICLES

- 10 articles published in international and National Journals.

COMMENDATIONS

- Received Commendation Letter from Deputy Inspector General of Coast Guard, Southern Command for Participating in the Rescue Medical Operation with Indian Coast Guard during Kerala flood in Aug/Sep 2018.
- COAS Commendation for case management during covid 19 pandemic

SPECIALISATION: MD – Internal Medicine.

RESUME

Évaluation, sensibilisation et formation à la réanimation de base (BLS) parmi les soldats admis dans un centre d'isolement Covid - Une expérience indienne.

Introduction : *La BLS est une compétence nécessaire et utile à chaque soldat. Nous avons donc souhaité utiliser efficacement la période d'isolement des soldats touchés par la covid pour évaluer leurs connaissances en réanimation de base et construire un programme de formation. Le but était également de garder ainsi les soldats motivés et impliqués.*

Méthodes : *Il s'agit d'une étude prospective d'une durée de 10 jours effectuée au cours du mois d'août 2020. 150 patients âgés de 18 à 80 ans, testés positifs à la Covid et isolés dans l'établissement de soins Covid de Jalahalli ont été inclus.*
Le questionnaire a été distribué par voie numérique aux patients et les données ont été collectées, compilées et analysées grâce au logiciel Excel.

Résultats : *Lors de la pré-évaluation, les patients avaient un bon niveau de sensibilisation aux gestes de premiers secours, à la gestion des chocs électriques, des chutes et des étouffements. Par contre, le niveau de sensibilisation était moindre concernant la BLS, la noyade, les blessures causées par la chaleur. Après formation, une amélioration significative a été notée sur différents sujets tels que les blessures causées par la chaleur, le BLS et la noyade avec des scores d'amélioration de respectivement 100 %, 95 % et 116 %, comparé au pré-test.*

Conclusion : *Des compétences en réanimation de base sont essentielles pour chaque soldat confronté à des situations de danger vital. L'utilisation de la période d'isolement des soldats touchés par la covid pour dispenser une formation a montré toute son efficacité. Motivés et engagés dans le programme de formation BLS cela a également aidé à une récupération plus rapide et réduit le stress lié à la covid.*

KEYWORDS: BLS, First Aid, Non-medical professional.
MOTS-CLÉS : *BLS, Premiers secours, Professionnel non médical.*

INTRODUCTION

International Federation of Red Cross and Red Crescent Societies (IFRC) felt the need for creating awareness about the importance of First Aid and BLS amongst the general public. In the year 2000, it was decided that every second Saturday of September will be celebrated as World First Aid Day. An article published in the Times of India based on a large-scale survey revealed that 98% of the population surveyed were not trained in BLS[1].

When an unforeseen and unfortunate accident or mishap occurs, the Platinum Ten minutes and the Golden Hour are of utmost importance with respect to stabilizing the situation and reducing the chance of a fatality. This is where a skilled first aider has an important role to play, in saving the situation even before paramedics arrive. We felt the need to educate and train the population about necessary actions to save the life of an injured person and take him to a hospital before any mishap occurs by using correct patient evacuation techniques.

Life-threatening emergencies can occur anytime and anywhere. The lack of training and incompetence to deal with these emergencies can have tragic and legal consequences. Basic resuscitation skills, including prompt and effective cardiopulmonary resuscitation (CPR), increases the survival rate following cardiopulmonary arrest[2]. BLS is a very useful course to be mastered by everyone because a precious life can be saved and the patient can be attended to till medical help arrives. Many such BLS mass programs have been conducted worldwide with great success. The BLS training conducted in Arizona showed that a state-wide CPR public awareness campaign increased bystander CPR rates from 28.2% to 39.9% and improved out-of-hospital cardiac arrest (OHCA) survival rates from 3.7% to 9.8%[3]. A study in Brazil found that difficulties in performing bystander CPR were due to inadequate knowledge & training, absence of skill, lack of confidence, and fear of litigation[4].

During the Covid pandemic, we planned to utilize the isolation period of the patients to impart BLS and First Aid training to these cases. We trained them in BLS and First Aid including management of common emergences like-: Cardiac arrest, Snake bite, Choking, Electric shock, Burns, Poisoning, Heat, and cold injuries, Fracture & drowning.

MATERIALS AND METHODS

Our study was a hospital-based prospective study done in an isolation hospital. The study duration was 10 days during August 2020. The population available for the study was 150.

Inclusion criteria: Patients of both sexes between age group 18-80 years.

Exclusion criteria: Age less than 18 years or more than 80 years, physically impaired, critically ill & unwilling patients.

Primary objective: To assess the basic knowledge of BLS & First Aid amongst the patients.

Secondary objective: To train the patients on BLS and other common emergency and first-aid.

Tertiary objective: To assess the effectiveness of our training program.

- First, we have conducted an online test among 150 patients to assess their basic knowledge of BLS and common emergencies.
- Next, we conducted classes to educate them on BLS and first aid techniques with practical demonstration and audio-visual classes. The classes were taken based on the Indian First Aid manual – Indian red cross society and National Health Portal[5, 6].
- Finally, we conducted a post-training online exam to assess the effectiveness of our training program.

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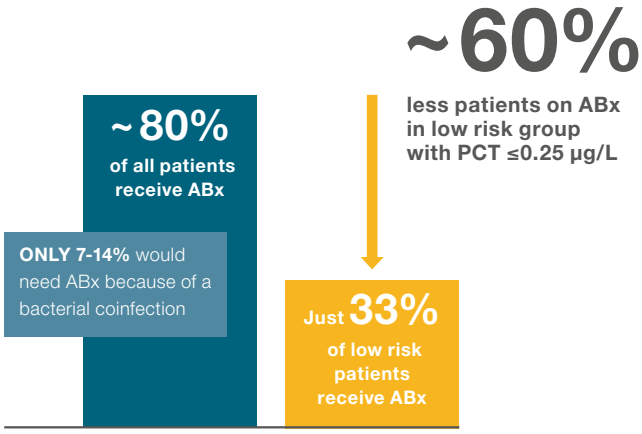

Antibiotic treatment of COVID-19 patients[1]

Reference: 1. Williams EJ et al., preprint doi: https://doi.org/10.1101/2020.06.29.20136572 posted July 2, 2020.

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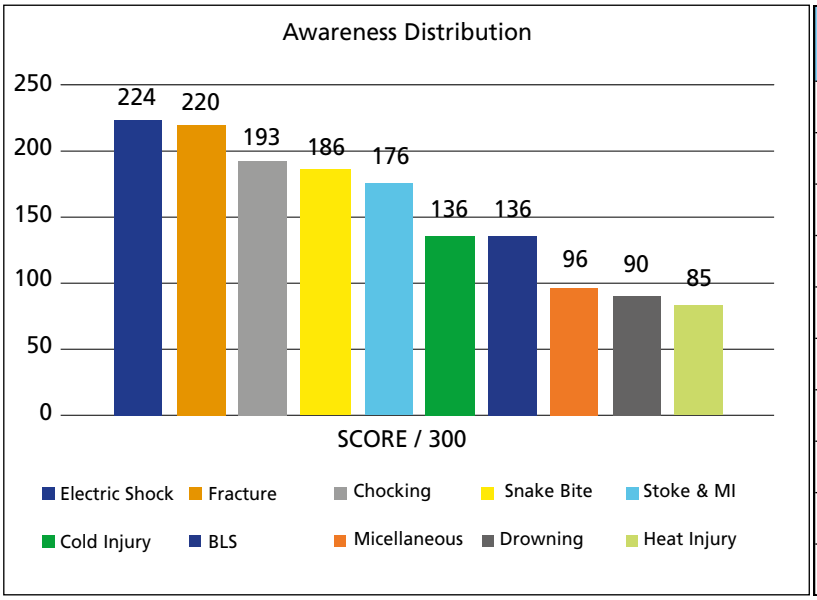
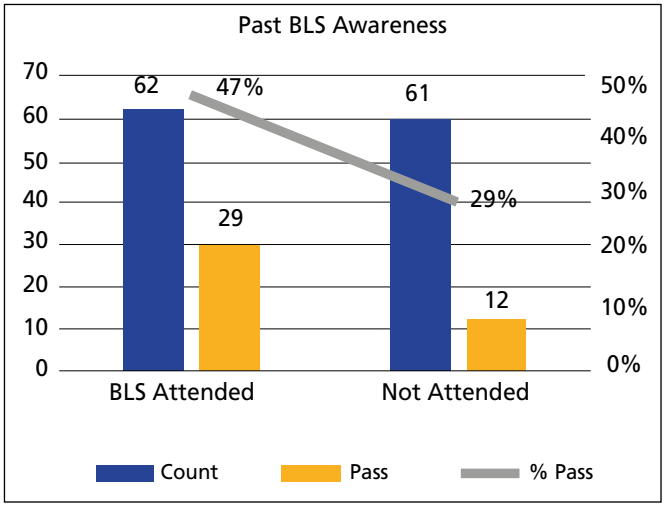
RESULT

Graph 1: Knowledge about Electric shock, Fracture, Choking were good, Snake bite, stroke, MI, Cold Injuries, BLS were moderate and awareness about Drowning, heat injury and miscellaneous topics (Seizure, burns, bleeding) were low.

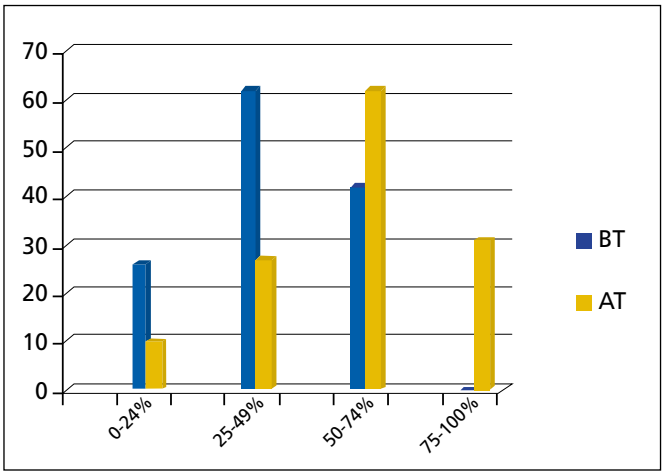


TOPIC	ORDER OF MERIT	AWARENESS
Electric Shock	1	GOOD
Fall	2	GOOD
Chocking	3	GOOD
Snake Bite	4	MODERATE
Stroke & MI	5	MODERATE
Cold Injury	6	MODERATE
BLS	7	MODERATE
Drowning	8	LOW
Miscellaneous	9	LOW
Heat Injury	10	LOW

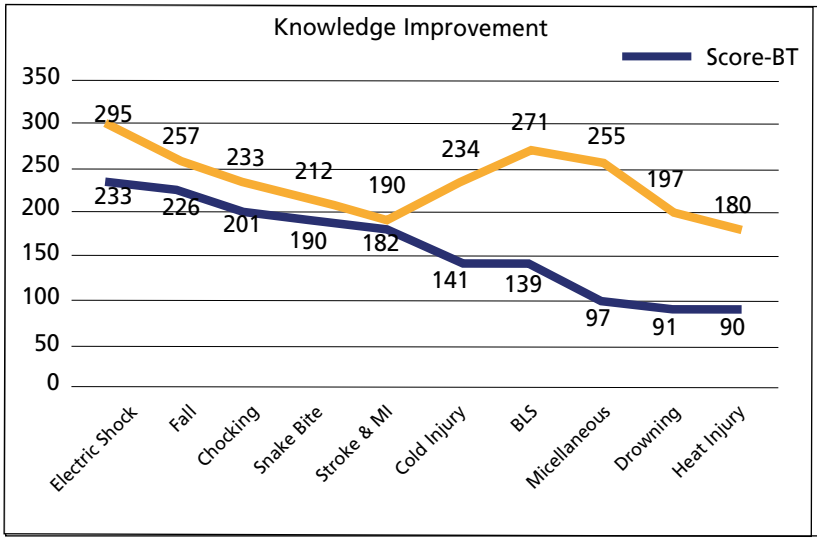
Graph 2: Out of 62 patients who were aware of BLS, only 29 crossed 50%marks.



Graph 3: Compares awareness Before Trg (BT) & After Trg (AT). The failure rates came down amongst those trained and their pass percentage (>50%score) increased.



Graph 4: shows there is significant increase in the knowledge levels of all the topics post training. Improvement was most in awareness about cold injury, heat injury, drowning and miscellaneous topics.



TOPIC	SCORE-BT	SCORE-AT	% ↑
Electric Shock	233	295	26.6%
Fall	226	257	13.7%
Chocking	201	233	15.9%
Snake Bite	190	212	11.6%
Stroke & MI	182	190	4.4%
Cold Injury	141	234	66.0%
BLS	139	271	95.0%
Miscellaneous	97	255	162.9%
Drowning	91	197	116.5%
Heat Injury	90	180	100.0%

DISCUSSION

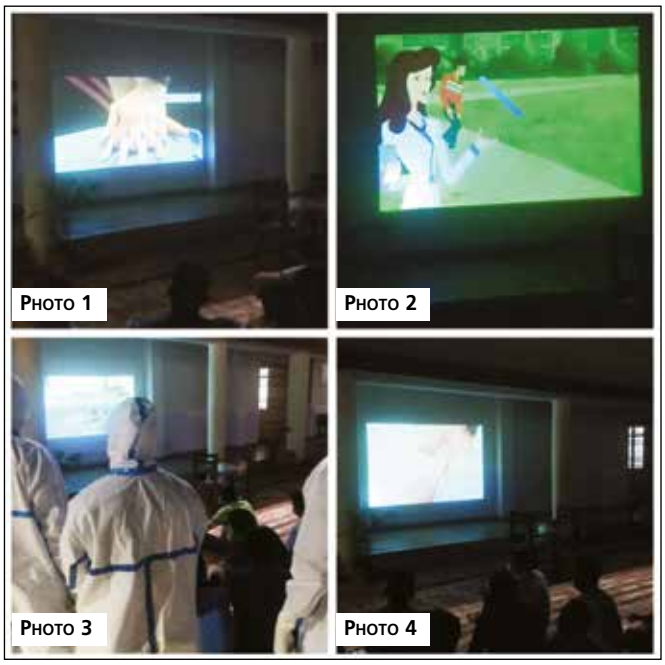
Basic life Support is a skill which everyone should learn as it can help save a life. In our study when we assessed the study group, we found the knowledge about BLS and common emergencies was average regarding most topics and lesser in rarer events like drowning & cold/heat injuries. A study done in Saudi Arabia by Mohd, Sajad et al revealed that only 50% population was aware of common injuries[7]. Studies done in Poland and Turkey on awareness about life support showed that 75% and 40.7% of their study population were aware of the management of common emergencies and basic life support technique[8, 9, 10]. Another set of studies in Jeddah and Hong Kong revealed awareness levels of 39% and 12%[11, 12]. The initial assessment of our study population revealed 35% of awareness.

Post BLS training the score improved by 95%. The reason for improvement could be due to our training which included both live demonstration and audio visual training and individual doubt clearing sessions.

Figure 1: Live Demonstration.
1) Left lateral positioning.
2) Heimlich manure training.
3) Demonstration with social distancing.
4) BLS (CPR demonstration).

Snake Bite: Since India is a tropical country, awareness about snake bites was adequate amongst the study group. Every year there are 250,000 incidents of snake bites in India even though we are not home to the largest number of venomous snakes in the world. There are approximately 11000 fatalities in India despite of no shortage of anti-snake venom in the country[13]. A study done by Chincholikar SV, Bandana revealed that the awareness about first aid measures was lower in all subjects even though the knowledge about symptoms of snake bite was high[14]. We too observed similar results in our study pertaining to knowledge assessment about snake bite which was 48%. Post-training there was an improvement in knowledge about management of snake bite of 11.6%.

Figure 2: Audio and Visual Demonstration.
1) BLS (CPR demonstration).
2) Management of Snake Bite Lecture.
3) Demonstration with social Distancing.
4) Carotid pulse assessment.



Choking: In a study conducted in Saudi Arabia among parents about first aid in scenario of choking only 6% of parents were aware of the management[15]. In our study we have found that awareness about choking was 51.5%among our patients and post-training this increased by 16% based on test scores. The fact that we had some paramedics in our study group may have contributed to the higher initial scores.

Electric shock: Our study population was fairly well aware of first aid and management of electric shock during pre-assessment. Nearly 60% of them knew what the initial actions should include. This was in contrast to this study SachilKumara&AnoopK. Verma conducted in north India which showed poor awareness regarding aid & CPR for an electric shock victim[16]. Post-training improvement in awareness amongst our group was nearly 26%.

Heat injuries: In a study done in the USA the knowledge about heat-related injuries was high. Over 91% of participants reported receiving training on heat-related illness; hence they were well aware of the management of heat injury cases[17]. In contrast, in our study the knowledge about this topic was very lowat 23% even though India is tropical country. Post training there was a significant improvement in knowledge in the management of heat injuries.

Cold Injuries: Cold injuries have always been a threat to military forces operating in cold climates. In addition to frostbite (which occurs in freezing weather), there are several cold injuries such as trench foot, chilblain, and hypothermia which can occur even when the temperature is above freezing[18]. In our study during the initial assessment 36% displayed good knowledge about the subject. This went up to 66% post-training.

CONCLUSION

We conclude that knowledge in basic life support skills is essential for every soldier. It is bound to be utilized at

some point in time and can help save a life. We efficiently used the isolation period of the soldiers in training them and improving their skill level. The soldiers were positive and were involved during the entire training which kept them motivated and engaged during the isolation period. We emphasize that such training programs will aid in mental health upliftment of soldiers admitted as a patient during covid as he will be engaged in the training program, learn a new skill and increase his level of confidence in managing medical emergencies, at the same time keep him motivated which will aid in faster recovery.

ABSTRACT

Introduction: BLS is a life-saving skill that will be useful at the need of the hour for every soldier. We wanted to effectively utilise the isolation period of soldiers admitted in the covid ward. So we made a training program in which we assessed their knowledge in BLS and a common emergency them trained them in BLS and management of common emergency. The idea behind the study was to productive utilization time, impart life-saving skills and keep the soldiers motivated and involved.
Methods: Ours is a prospective study with a study duration of 10 days during the month of August. 150 Covid patients who were isolated in Covid care facility Jalahalli were included in our study.
Inclusion criteria: All Covid positive patients between age group 18-80.
Exclusion criteria: <18 & >80, not willing to give consent. The questionnaire was distributed digitally to the patients and the data was collected and compiled in an Excel sheet and analysed.
Results: The patients had a good awareness level in first aid and management of electric shock, fall, and chocking. Moderate awareness level and less awareness in BLS, drowning, heat injury during pre assessment. Post-training significant improvement was noted in topics like heat injuries, BLS, and drowning with 100%, 95%, and 116% respectively when scores were compared with a pre-test.
Conclusion: We conclude that knowledge in basic life support skills is essential for every soldier as it will be very useful at the need of the hour and help save a life. We efficiently used the isolation period of the soldiers in training them and increasing their skills in BLS. During their entire period of admission, they were motivated and engaged in the BLS training program which helped in faster recovery and reduced their mental stress related to covid.

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Rapid Deployment of an Intermediate Hospital Capacity.

By G. BOGHAERT[1] and M. VRANCKX[2]. Belgium

Gautier BOGHAERT

Captain Gautier BOGAERT is currently active as a military physician at the 3EMI in Marche-en-Famenne as well as a physician in the emergency department at the CHU of Mont-Godinne with a focus on pre-hospital medicine.

His academic training includes a Bachelor in Medecine from the Université Libre de Bruxelles and a Master in Medecine from the Université Catholique de Louvain from which he graduated in 2017. During the same period, he completed his military training at The Royal Military Academy. He then specialized in Acute Medecine until 2021 at the Université Catholique de Louvain.

RESUME

Déploiement rapide d'une capacité hospitalière intermédiaire.

Introduction
Une étude rétrospective de cas décrivant le déploiement d'une capacité hospitalière intermédiaire au sein d'un hôpital civil en Belgique durant la seconde vague de la Covid-19 en novembre 2021.

Evénements
Sur demande de la province du Hainaut, pendant la deuxième poussée d'hospitalisations pour la covid-19 en novembre 2021, une capacité hospitalière intermédiaire a été déployée dans un hôpital civil. Le personnel se composait entièrement de militaires faisant usage du support logistique ainsi que technique de l'hôpital hôte. Ceci afin d'accueillir des patients sarscov-2 de la province du Hainaut nécessitant des soins dans le but de libérer des lits pour des malades critiques.

Résultats
Il aura fallu 3 jours pour atteindre la capacité opérationnelle initiale une fois l'ordre donné. Hébergeant un total de 18 patients avec une occupation maximale de 9, soit 60 % de la capacité intermédiaire. La mission a pris fin après 15 jours suite à une baisse de demandes d'admission. Tous les patients ont finalement rejoint leurs domiciles excepté un ayant nécessité une prise en charge aux soins intensifs. L'index de comorbidité moyen de Charlson était de 4,1 avec un score NEWS2 à l'admission de 4,7 en moyenne. Le score moyen sur l'échelle du statut fonctionnel post-covid-19 à 3 mois était de 2.
La satisfaction générale des patients était élevée et aucun d'entre eux n'a émis de regrets quant à leur prise en charge par du personnel militaire.

Discussion et Conclusion
Ce modèle d'unité hospitalière hybride en collaboration civile et militaire est innovant et viable. Bien que n'ayant jamais atteint sa capacité maximale suite à une baisse de la demande d'admissions, cela a offert un support très apprécié aux hôpitaux locaux.

KEYWORDS : Belgium, COVID-19, Support to the nation, Medical relief, Military.
MOTS-CLÉS : *Belgique, COVID-19, Aide à la nation, Aide médicale, Militaire.*

INTRODUCTION

The Second wave of the 2020 COVID-19 pandemic in Belgium saw an unforeseen number of patients needing hospital and intensive care treatment, saturating most of Belgium's hospitals.

One of the missions of the Belgian Defence falls under the label of "aid to the nation". Therefore, it offered all of its available means in order to support the nation in its fight against the pandemic, while maintaining its current operational capabilities. The Defence supplied mainly medical and paramedical manpower, as well as

its expertise, logistics, CBRN and training capabilities. In addition to these, it also intervened in medical transport of infected patients with a diversity of ground, fixed and rotary wing ambulances.

DESCRIPTION OF EVENTS

During Belgium's second COVID-19 wave, a critical level of hospital bed occupation had been reached. Phase 2b was activated across the whole of the province of Hainaut on 02/11/2020; therefore, increasing the number of beds needed to be created for COVID-19 patients. One of the identified problems in creating an appropriate number of beds was that a fair number of patients were showing improvement but weren't quite ready to be discharged; therefore, occupying acute beds needed for sicker patients and backlogging the system. Although not required at the time, one of the solutions offered by the Belgian Defence during the first wave was to deploy an Intermediate Hospital Capacity (IHC). Upon request of the governor of the province of Hainaut, such an ICH was offered in order to partially relieve the pressure on hospitals of the province during the second wave.

INTERVENTION

1. Facility

On 09/11/2020 an Intermediate Hospital Capacity unit was deployed in support of all hospitals of the province of Hainaut. It was grafted onto the André Vésale hospital from the C.H.U. of Charleroi within a dedicated, unoccupied, ex surgical ward. It had an intermediate operational capacity of 15 patients, to be expanded to a full operational capacity of 26 beds if needed. The staff was provided by the Belgian Defence, while all the necessary technical support was provided by the host hospital.

In order to maintain critical ethical and care standards, all patient were to benefit from equivalent technical support, nursing and medical care as any other unit within the hospital. Although these patients required a lower level of care, standards of care had to be maintained.

The staff was provided by the 14th medical battalion with support from other units and made the following medical personnel available for the mission :

- 3 Doctors : 1 with an acute medicine background, 2 general practitioners.
- 1 Physiotherapists.
- 8 Nurses : 1 senior nursing officer, 3 senior nurses with intensive care and emergency backgrounds, 3 junior nurses.
- 8 EMT (Emergency Medical Technicians) : 1 EMT alfa and 7 EMT bravo.
- 1 additional administrative staff member was provided as well.

All aforementioned staff were on site and available 24/7 and planned for a maximum period of 1 month. Extended variable shifts were implemented to accommodate patient load and optimal staff rest.

Note : Some of the doctors and physiotherapists changed during the mission due to other critical military and civilian obligations.

2. Patient admission process

Patient admission criteria were based on both medical condition and hospital of origin. Each hospital of the province was allocated available beds according to their bed saturation relative to their absolute patient capacity. This allocation was assessed on a day-to-day basis and a cut-off of 5 admissions a day was set to maintain optimal workload and patient reception.

Medical admission criteria

- Firstly, only documented COVID-19 patients were eligible; confirmed either through PCR, CT thorax or both. Both contagious and non-contagious patients were accepted.
- Secondly, in order for a patient to be admitted, they had to have reached beyond the supposed apex of their disease and demonstrated a positive clinical trend over the last 24 hours. However, stable patients over the past 24 hours were also potentially included on a case-by-case basis depending on the expected clinical course.
- The following cut-off for vital signs and supplemental oxygen levels were arbitrarily defined. They were mainly focused on respiratory parameters given the expected type of patients. Respiratory rate had to be below 24 per minute and patients should not show other signs of respiratory distress. Oxygen saturation had to be above 92 % with less than 6 L/min of supplemental oxygen through either nasal cannula or rebreather face mask.
- Lastly, each patient had to have a well-documented DNR code.

Patient vetting

On a voluntary basis, patients were referred through to a senior Emergency Physician of the local hospital where an IHC was deployed who acted as safeguard and whose function was to make an initial assessment based on both admission criteria and available beds. If patients were deemed eligible for transfer, the acting senior medical officer would contact the referring centre and discuss the case. Based on all aforementioned information, a decision was taken to either accept, refuse or adjourn for future evaluation.

This model of hybrid patient evacuation coordination cell was managed by the senior medical officer given its critical clinical insight and acumen.

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Once the patient was accepted, the referring centre would make all the necessary arrangements for transfer.

3. Patient care

An integrated care model was deemed necessary in order to achieve optimal patient care. Despite military hierarchy, transversal management and communication were spontaneously favoured as they allowed ease of communication. Each key player, from the EMT to the physician, all being experts in their field, could provide insightful information regarding patient care.

Upon admission, all patients would get an initial assessment by one of the clinicians, as well as a physiotherapist. Physiotherapists would set accessible patient goals and provide one to two daily sessions of respiratory and general rehabilitation based on patient-by-patient assessments in conjunction with the assessments of the rest of the medical team.

Patients would benefit from a daily physician evaluation. Treatments were adapted according to local protocols and medication availability. COVID-19 specific treatments were modelled on the local hospital guidelines. As per local protocols, external transfers would be screened for MRSA. Other nosocomial germs such as ESBL were screened depending on patient history.

From a nursing perspective, given the heterogeneous backgrounds and level of experience in ward care, each team was composed of at least one senior nurse. As part of an integrated care model, each nurse would be allocated patients for which they would be responsible. Given the special legal setting of the mission, some of the nursing procedures were delegated to EMTs according to their level of experience, with military EMTs being trained and required to provide a broader spectrum of delegated procedures in mission settings compared to their civilian counterparts; for example, drug preparation and administration.

As a part of rehabilitation, patients would be stimulated to partake in their care and daily activities as much as possible; enhancing autonomy, sense of self efficacy and allowing to evaluate their needs for at-home support when discharged.

All other services were provided by the host hospital. Of those, social workers were useful in finding new appropriate accommodation for discharged patients.
If a need for higher level of care arose, referrals for ICU or specialist ward admissions were possible despite patient hospital of origin.

Upon discharge, patients were offered a 6 week follow up out-patient appointment with a pulmonologist.

4. Isolation and PPE

The ward was divided into three zones :

- The green zone, consisting of the medical and nurses offices, break-room and medical supplies room. Social distancing was of course applied and surgical masks were worn.
- The orange zone, defined by the hallway where surgical masks and a protective gown would be worn. This zone would allow personnel to change their PPE between care sessions.
- The red zone, where contagious patients were located. As well as N95 masks and face shields, single use PPE was used on top of the equipment already worn in the orange zone. It was removed after each session of care within a room.

Care was bundled as much as possible to avoid back and forth movements between the different zones in an effort to avoid contamination and waste of precious PPE. Teams would function by always having someone outside the red zone to provide support to the personnel within it.

A distinction was made in patients that completed their quarantine and those who didn't. Non-contagious patients were cohorted in separate rooms and care was scheduled first to them as to not re-contaminate them and save on PPE.

Patient contagious status was known prior to admission. Quarantine duration would last 14 days from the beginning of the symptoms or from the first positive PCR or CT thorax if there was any doubt regarding the timeline. Patients also had to be 3 days fever-free and showed an improvement in their respiratory symptoms. A duration of 28 days was applied for more severe cases. A case was defined as severe if, at any point during their disease, the patient required ICU admission, had a lesion affecting ≥ 75 % of a lung on CT thorax, respiratory rate ≥ 30/minute or a PaO2/FiO2 ≤ 300mmHg. To help with discharge and out-patient care, when required, this 28-day quarantine could be shortened by up to 14 days on the following conditions :

- Three days fever free and strong improvement in respiratory symptoms.
- Two successive negative PCR tests spread across at least 24 hours.

When the out of hospital social and care setting allowed it, contagious patients were discharged home. They were provided with the needed written isolation instructions. The out-patient care team would then also be informed of the remaining duration of isolation.

DATA GATHERING

All patient data was collected once approval was obtained using the hospital computer file. At 3 month post discharge a dual mail or phone survey was conducted. The first survey goal was to asses self reported functional outcome using the PCFS (Post-COVID-19 Functional Status scale)[1].

The second survey evaluated overall patient satisfaction with their care as well as whether or not they would have preferred to undergo treatment in a civilian unit. Both scores were compounded to obtain a score out of 10, each question accounting for 5 points.

OUTCOMES

Feasibility reconnaissances were done by the Senior Medical Expert (SME) on the fourth of November 2020. On November the 7th 2020, once the mission was deemed viable and the needed agreements with the host hospital were reached, the involved personnel were issued an initial order. Important to note is that the personnel wasn't then under any particular notice to move.

All personnel arrived on the 9th at 8am. On this day the following took place :
Initial briefings, induction courses in the local IT, local practices, PPE, hygiene and installation in living quarters. On the 10th all medical personnel was dispatched over two different sites to immerse themselves in COVID-19 units. Once accustomed, general organization, SOP and local practices were discussed with all medical personnel to validate and adjust them if need be. Initial operational capacity (IOC) was set on Nov 11th 2020 at 11am; 59 hours after arrival on site and 72hours after receiving the initial order. On that same day, the first patient was admitted at 11:18 am.

From then on, patients started to arrive progressively, reaching a peak on the 17th of 9 patients simultaneously in the ward, meaning 60 % of the intermediate capacity. Going from there, admission request started to drop as hospital progressively closed their COVID-19 units and resumed their regular activities. The average bed occupancy per day was 4,93 patients, or 32,8 % of the intermediate capacity. In light of the drop in interest in our available beds, and in awaiting of a formal approval from upper echelons; a temporary halt to new admissions was set as to allow patients to finish their treatment course whilst avoiding admissions whose length of stay might exceed the mission duration. On the 25th the last two patients were discharged, adding up to a total duration of 18 days of which 15 involved actual patient care.

The total amount of days of stay in our unit was 92, with an average length of stay of 5,11 days (sd 1,696). Important to note is that a patient had to be transferred to the ICU and subsequently died. One patient stay was also increased by 4 days due to an isolated social reason, bringing down the average length of stay for medical reasons to 4,88 days.

Not every patient is alike in their chronic and acute burden as shown below. The mean Charlson co-morbidity index[2] was 4,166 (SD 1,863) with a NEWS2[3] score upon admission averaging to 4,722 (SD 1,938).

The most commonly observed complications on arrival and during the patients stay are laid out in the following graph (Graph 1) :

All but 3 patients were discharged back to their previous residences. Of those 3 patients one sadly passed away after being transferred back to the ICU and 2 had to undergo further revalidation but could ultimately return home.

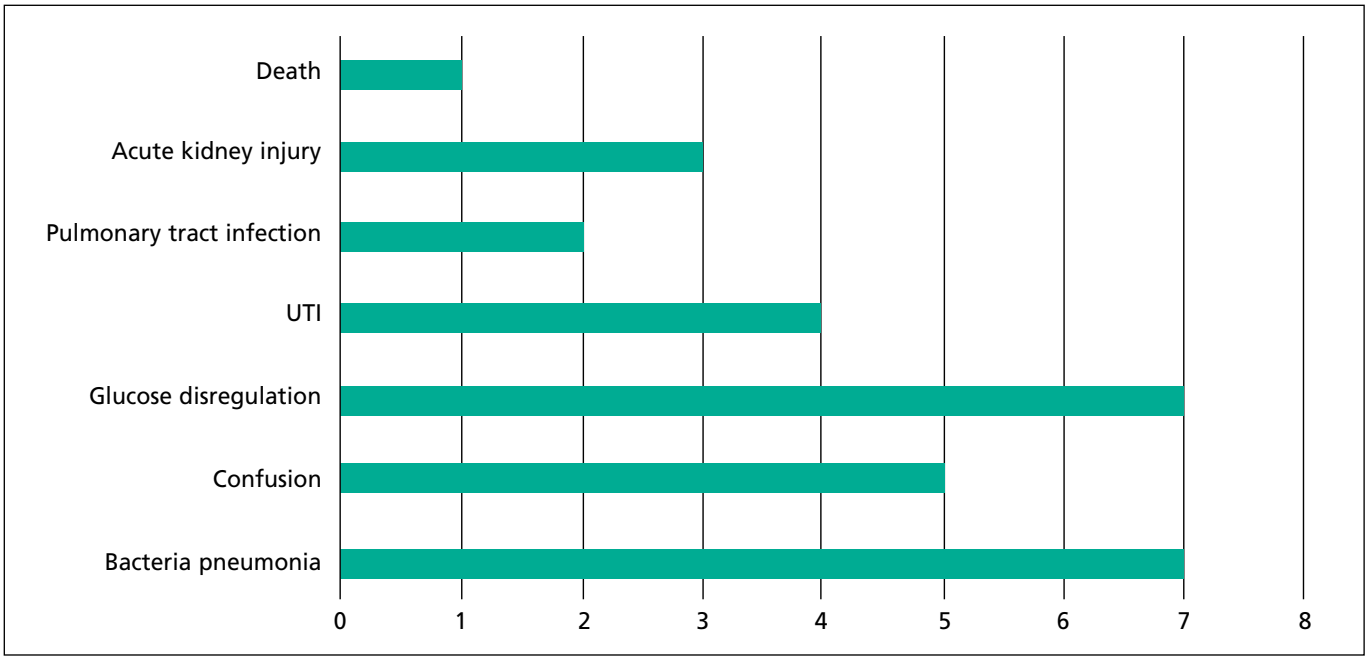
Regarding self reported PCFS score at 3 month, the average was 2 (SD 1,236).

Finally the average satisfaction score was 8,58/10 (SD 1,191).

DISCUSSION

Upon reviewing the available literature and information, a lot of means were deployed by various European military forces[4, 5] to help absorb patient flow. Most of them building up on already existing military hospitals or deployable capacity and detaching personnel to already existing civilian teams or structures. Our particular model seems quite unique in the facts that it created an entirely new unit by regrouping scattered personnel resources and centralizing them within a civilian hospital; effectively creating a hybrid model as

Graph 1 : Complications observed expressed un absolute numbers.



each party had to adjust in order to offer qualitative and meaningful care.

Maximum capacity was never reached. This was due to a drop in demand soon after deploying. This may reflects the time it took to come up with this model and the combined inertia of the different actors. The 4 days it took to achieve IOC may have had an impact as well but reflect a good responsiveness from the involved personnel and a willingness to adjust to exceptional working conditions. There is little doubt about whether full capacity would have been viable on the short term but, a longer mission may then be compromised in the absence of personnel turnover.

As already known, more sarscov-2 patient needing admission have predisposing factors[6] which is partially reflected in the Charlson co-morbidity index[7] of 4. Our patients recruitment criteria impact was reflected in an admission NEWS2 score of 4,7 which is still below the recommend threshold of 5 triggering immediate clinical review[8] but 10 of the patients still exceeded said threshold, one of which ultimately needing ICU. The lack then of a specific and validated sarscov-2 severity scale is reflected in our arbitrary chosen admission criteria. Better admission criteria should be investigated for future implementation.

Al discharged patients eventually returned back to their residence but only one was free of symptoms at three month and three experiencing severe limitations and dependence on other to care for themselves.

Patients seemed satisfied with the provided care, none of which expressing regrets as to have been cared for by military personnel.

Finally on a more subjective note, the moral support to the population and medical staff provided by this kind of action is not to be underrated.

CONCLUSION

This model of IHC was ultimately viable and may be an interesting model in case of future similar catastrophe.

ABSTRACT

Introduction

A retrospective case study describing the deployment of an Intermediate Hospital Capacity within a civilian hospital in Belgium during the second wave of COVID-19 in november 2021.

Events

Upon request from the province of Hainaut during the second surge of COVID-19 hospitalisations in Belgium in november 2021 an Intermediate Hospital Capacity was deployed within a civilian hospital. Staffed entirely by military medical personnel and using the hospital logistical and technical support in order to accommodate sarscov-2 patients needing further care from the province of Hainaut in order to free beds for critically ill patients.

Outcome

From the initial order until initial operational capacity it took 3 days. Hosting a total of 18 patients with a peak occupancy of 9 patients, reaching 60 % of the intermediate capacity. The mission was put to an end after 15 days due to a drop in transfer requests. All patients could ultimately regain their previous homes but one that required transfer to intensive care. The patients mean Charlson co-morbidity index was 4,1 with a NEWS2 score upon admission averaging to 4,7. The average score on the Post-COVID-19 functional status scale at 3 month was 2. Overall patient satisfaction was high with none expressing regret about having been taken care of by military personnel.

Discussion and Conclusion

This model of hybrid ward with civilian and military collaboration was an innovative and viable solution. Although never reaching full capacity due to a drop in COVID-19 admissions, it offered a much appreciated support to the local hospitals.

No conflicts of interest to declare from either of the authors.

The writing of this article was subjected to an ethical evaluation by the ethical committee of the Chu of Charleroi. All patient data has been anonymized and has been gathered with their written informed consent.

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Nerve Injuries from Gunshot Wounds: What are the Microscopic Lesions on the Continuous Part of the Partial Sections?

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RESUME

Traumatismes balistiques des nerfs : Quelles lésions microscopiques sur la partie continue des sections partielles ?

But *: Les sections partielles de nerf sont fréquentes dans les plaies balistiques. Des lésions nerveuses par étirement ont été décrites lors des plaies balistiques au sein de la zone de cavitation temporaire. Le but de cette étude était de rechercher des lésions histologiques sur la portion continue d'une section partielle de nerf sciatique par projectile chez le porc.*

Matériel et méthodes *: 6 cuisses de porcs euthanasiés 24 heures auparavant ont été prélevées puis ont été conservées dans une chambre froide à 4 degrés. Les cuisses ont été réparties en 3 groupes de 2 cuisses pour subir des tirs par 3 types de projectiles différents : basse vélocité, haute vélocité et fusil à grenaille. Les nerfs ont été prélevés puis analysés en laboratoire d'anatomopathologie.*

Résultats *: Aucune lésion de grade II, III ou IV n'a été vue sur la partie en continuité des nerfs sectionnés quel que soit le projectile utilisé.*

Conclusion *: Cette étude n'a pas mis en évidence de lésion histologique significative sur la portion continue de nerfs sciatiques de porcs partiellement sectionnés par des projectiles de haute ou basse vélocité. Un aspect macroscopiquement intact de la partie non sectionnée du nerf a donc toutes les chances de récupérer spontanément dans les semaines suivant le traumatisme. La réparation de la portion sectionnée devrait se faire par une greffe fasciculaire respectant la portion continue. Pour nous cette greffe doit être effectuée de façon secondaire précoce, aux alentours de 3 à 6 semaines en raison des difficultés de dissection lors du second temps.*

KEYWORDS: Ballistic injury, Nerve injury, Nerve repair, Projectile.
MOTS-CLÉS : *Lésion nerveuse, Lésion balistique, Projectile, Réparation nerveuse.*

INTRODUCTION

Ballistic injuries of peripheral nerves are common in a war context or civilian environment[1-3]. The lesions related to high-velocity projectiles may be caused by the passage of the projectile itself, crushing tissues (permanent cavitation), or by the pressure wave resulting from the transfer of the kinetic energy, stretching the adjacent tissues

(temporary cavitation)[2]. However, it has been shown that if the cavitation effect increases when the speed of the projectile is greater than 600 $m.s^{-1}$, it is also present with projectiles whose kinetic energy is lower and is visible macroscopically starting from 300m/s[1, 4].

The nerve can be damaged by a bullet at high velocity in three ways: it may be a complete section, a partial section or a continuous nerve no longer transmitting the nervous signal[5]. In clinical practice and literature, the most commonly used classification to describe nerve damage is the Sunderland classification[6]. Grade V corresponds to a total transection of the nerve and grade IV to total destruction of the nerve except the epineurium. Grade III is a lesion of the axon, myelin and endoneurium. Grade II is a lesion of the axon and myelin. Grade I corresponds to segmental demyelination.

The management of these nerve ballistic injuries is nowadays standardized thanks to hindsight of many clinical series[5, 7-10]. Initially, the wound must have a trimming and debridement during which the paralyzed nerve must be explored[11]. The goal is to make the diagnosis according to the classification of Sunderland and to make the difference between a total transection, a partial transection or a continuous nerve which will recover:

- In case of total transection, the nerve must be repaired. Direct suturing may be attempted but it is rarely possible in ballistic trauma because there is a loss of nerve substance. With exception, it is necessary to perform a nerve grafting that will be done in a secondary way, once the other lesions treated and the risk of infection removed. It is then desirable to fix the nerve ends to prevent their retraction and limit the length of the future graft.

- If the nerve is continuous and consistent at palpation (excluding a grade IV injury) it is probably a grade I, II or III that is likely to recover: in this case, no emergency surgical repair is necessary. If it is a grade I (neurapraxia), recovery will be complete[12]. If it is a grade II or III, recovery may be partial and a secondary surgical revision may be necessary within 3 to 6 months if the evolution is not satisfactory.

- The most delicate situations, and the most frequent in case of gunshot wounds, are the partial transections. The severed part (grade V) must be repaired but the evolution of the continuous part is uncertain. It should be noted that emergency stimulation is of no help since the Wallerian degeneration has not yet occurred[13].

This study focuses on the delicate management of partial nerve damage caused by bullets.

The objective of this experimental study was to investigate the histological lesions observed on the continuous part of a sciatic nerve partial transection caused by different types of projectiles in pigs.

MATERIALS AND METHODS

This experimental study has been conducted with the participation of the Surgical School of Paris (*AGEPS – Assistance Publique des Hôpitaux de Paris*) and of a French Special Weapons and Tactics team (*Groupe d'Intervention de la Gendarmerie Nationale - GIGN*) based in Versailles.

Collection of anatomic parts

They were collected at the Surgical School on pigs euthanized by injecting potassium into a solution of sodium chloride. The thighs were removed by coxofemoral disarticulation with a scalpel in the hour following euthanasia, then stored in a cold room at 4 °C. After these 24 hours, they were extracted from the cold room.

Ballistic protocols

On each thigh, the sciatic nerve was located, and its path marked on the skin. Before the shots, the thighs were hung to a wooden board using a hook. The shooter was at a distance of 5 meters from the target. Several types of projectiles were tested to form 3 groups according to the caliber of the projectile:

- A 9-mm group, where the firing of a 9 x 19mm Gold Dot ammunition was carried out by an HKMP 5. This is a low velocity projectile usually fired by handguns.

- A 7.62-mm group, where the firing of a munition of 7.62 x 39mm was made by an AK47. It is a high-velocity projectile (731 $m.s^{-1}$) used by many war rifles, including the AK47 Kalashnikov, which is predominant in terrorist attacks and current armed conflicts.

- A 12-mm group, where the firing of a munition of caliber 12 9B diameter 8.5 x 65mm was carried out by a Sensied shotgun. These are multiple, low-velocity projectiles used by riot gun-type weapons that cause deleterious soft-tissue lesions and whose beads can be lodged intraneurally.

After each shot, the sciatic nerve was spotted. If the nerve showed no lesion, the shot was repeated. If the nerve had a partial transection, it was included in the study (Fig. 1). If the nerve had a complete section, it was excluded. The shots were made in sufficient numbers to include 2 nerves in each group.

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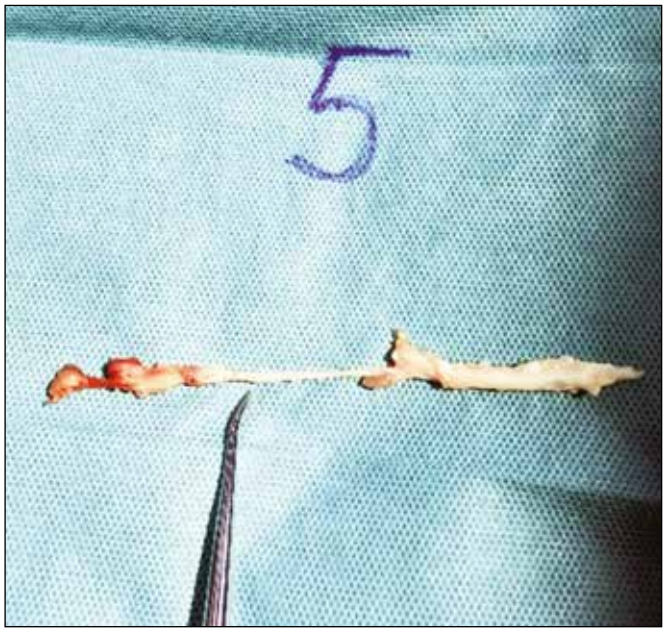
Figure 1: Partial section of a sciatic nerve caused by 12-mm caliber.

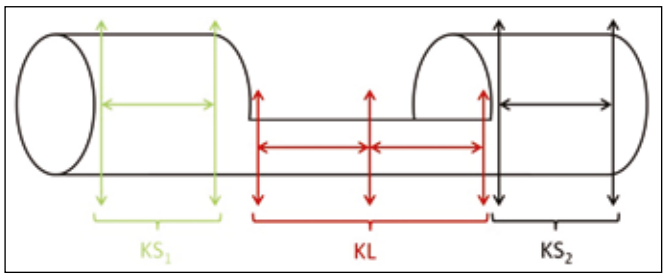


Anatomopathological analysis

Once the partial transection was found, the sciatic nerve was removed in its entirety and the injured area identified by simple points. Samples were fixed with formalin. They were each included in 3 tissue cassettes: two cassettes "control" in healthy zone and a cassette in damaged zone. Healthy area cassettes KS1 and KS2 had two transverse sections and a longitudinal section of 1.5cm. The injured area cassette KL had three transverse sections and two longitudinal sections of 1.5cm (Fig. 2). The cassettes were embedded in paraffin. They were stained with standard HES (Hematoxylin Eosin Safran) staining. For each cassette, two slides of different depths of cut were made.

The slides were observed using the LEICA DM 2000 microscope with magnifications of x25, x50, x100 and x200. Several elements were systematically investigated on the slides: axonal lesions, myelin sheath, endoneurium, perineurium and epineurium. The presence of red blood cells outside vessels, demonstrating their extravasation, was also sought. All slides were analyzed by a senior pathologist.

Figure 2: Microscope slide location in nerve.



RESULTS

No complete section was obtained. On two occasions, no lesion was to be found, forcing the shooter to repeat the shot. These failures occurred in the first group (9-mm caliber). Macroscopic observations of the injuries are presented in Table 1.

The slides in non-injured areas (Fig. 3) and in injured areas were then compared. In non-injured areas, no disruption was observed in the different nerve structures using the optical microscope. On the other end, injuries of axons or endoneurium and epineurium were observed in samples 4 (7.62 caliber), 5 and 6 (12 caliber) (Fig. 4). New slides were obtained to eliminate an artifact related to the preparation of the slides. Erythrocytes were not to be found outside the vessels. Moreover, from a histological point of view, there was no difference between the lesions caused by a high velocity projectile and those caused by a low velocity projectile.

DISCUSSION

It is known that the passage of such a projectile induces a temporary cavitation zone which corresponds to the overpressure delivered by the kinetic energy of the bullet and causes a stretching of the tissues which causes lesions. Suneson *et al.*[14-16] studies in pigs have shown that even when the projectile passes away from the sciatic nerve, lesions are possible on the myelin sheath and vasa nervorum. The objectification of these lesions while the projectile has passed away from the nerve can therefore presume microscopic lesions involvement of the portion in continuity during nerve partial sections.

According to Oberlin[5], any ballistic wound accompanied by a neurological deficit requires early nervous exploration (within 8 to 10 days) to assess the lesion: absence of macroscopic lesion, partial (most commonly) or total transection. This attitude is in opposition to those of some authors in the Anglosphere who recommend waiting 3 months before exploring such lesions, arguing that it is often neurapraxias that will recover spontaneously. The disadvantages of this practice are

Table 1: Macroscopic observations of the nerve samples.

Sample	Calibre (mm)	Sample size (mm)	Size of injured area (in mm)	% of the area in continuity relative to the total diameter
1	9	55	25	70
2	9	70	20	NA[a]
3	7.62	116	30	60
4	7.62	87	27	50
5	12	115	55	70
6	12	86	15	70

[a] Presence of muscle in the sample preventing the measurement.

Figure 3: Microscope slides of non-injured areas.
1: Longitudinal section of a nerve in a non-injured area magnification x25 A: epineurium; B: perineurium; C: endoneurium; D: axons.
2: Transverse section of a nerve in a non-injured area magnification x25 A: epineurium; B: perineurium; C: endoneurium; D: axons.
3: Transverse section of a nerve in a non-injured area magnification x200 A: endoneurium; B: vessel.

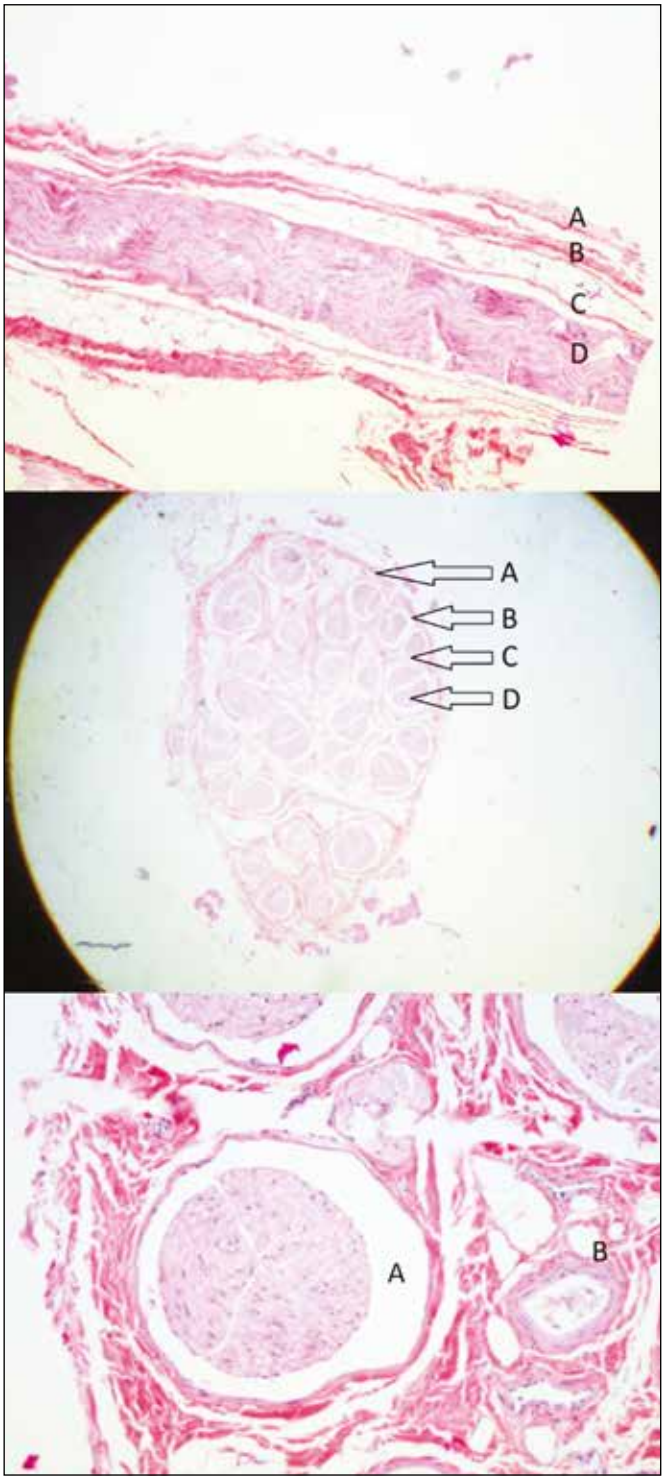
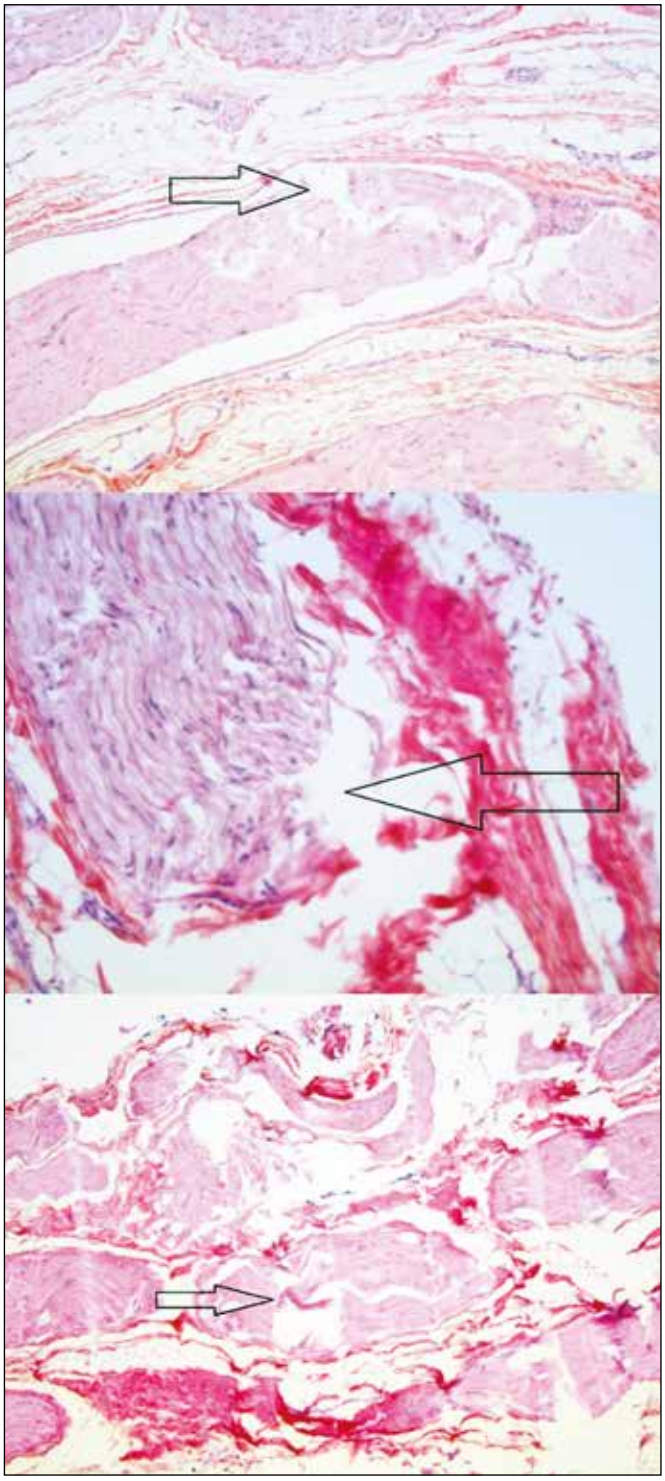


Figure 4: Microscope slides of injured areas.
1: Longitudinal section of a nerve in an injured area magnification x100, sample 4. Suspicion of severed axons.
2: Longitudinal section of a nerve in an injured area magnification x200, sample 5. Suspicion of lesions in axons and endoneurium.
3: Longitudinal section of a nerve in an injured area magnification x50, sample 6. Suspicion of lesions in axons, endoneurium and perineurium.



that if the section is complete, the ends will retract and the graft will have to be long and that if the section is partial, the dissection will be particularly difficult since the continuous part of the nerve will be taken in the adjacent neuroma. The difficulty will be maximal if it is a neuroma in continuity after a Sunderland Grade IV injury.

For these reasons, we follow Oberlin's recommendations and practice the nerve exploration as early as possible. The disadvantage of early exploration is that predicting the evolution of the continuous segment of a partially sectioned nerve is difficult because the stimulation cannot be used in the first days. The seemingly healthy (and consistent at palpation) fascicles can

indeed correspond to Sunderland Grades I, II or III, whose recovery potential is not the same. Grades IV injuries are, on the other hand, easily discarded at palpation or when opening the epineurium. Nevertheless, this experimental study seems to show that there is no significant histological lesion on the continuous part after partial ballistic sections, with low or high velocity bullets.

However, these results should be handled with care because a number of biases are present in this preliminary study:

- First, the pigs were euthanized before shooting. This is probably the biggest bias because a nerve injury is the result of the physical lesion of the structures composing the nerve, but it also depends on the neural response to the lesion which is a series of degenerative processes that take place the following days the lesion and precede a possible regeneration[17]. Conducting a study on animals euthanized 24 hours before shooting excluded these biological processes. This choice not to carry out research on living subjects is explained by logistical constraints. On the one hand, the authorizations of ethics committees for research on live animals are difficult to obtain. Moreover, the technical platform for firing firearms on ventilated intubated animals is not available in France. However, we assumed that the physical effects of temporary cavitation could have been visualized in dead specimens.

- Moreover, after being taken, the nerves were immersed in formalin for several weeks before being analyzed in the anatomic pathology laboratory. This results in a retraction of the nerves which has made longitudinal cuts of the nerves in the direction of the axons difficult without causing damage during cutting. We thus found, under the microscope, solutions of continuity of the structures composing the nerve on certain slides without being able to affirm if they were lesions induced by the projectile or by the knife doing the cuts for the setting in cassette.

- The anatomic pathology technical processes can also be debated. The standard HES staining used in this study does not distinguish myelin but it was the only one available in our pathology laboratory. The staining used to distinguish myelin using Klüver-Barrera[18] optical microscopy is only available in anatomical laboratories specialized in nerve damage. The possible damage to the myelin sheath has therefore not been demonstrated in this study. This is an important bias because myelin is an essential component of the nerve, the damage of which can be used to determine the grade of the nerve lesion in the Sunderland or Seddon classifications[6, 19]. Thus, the Sunderland Grades I (or Seddon neurapraxias) could not be observed.

- Finally, the number of samples analyzed was low and the analysis was not a blind analysis.

Because of these biases, the absence of lesions found does not necessarily mean that they do not exist in the continuous portion of a nerve partially severed by a bullet, particularly in the case of high velocity projectiles. Indeed, it has been proven that the temporary cavitation effect caused by these projectiles is a source of stretching at the periphery of the projectile path, which can lead to microscopic nerve damage[14-16]. In the case of a partial nerve transection, the continuous part of the nerve is *de facto* in the temporary cavitation zone. It would therefore have been logical to find microscopic lesions on the samples obtained with 7.62mm caliber. Due to the lack of analysis of the myelin sheath, it is therefore possible that Sunderland Grade I lesions have been present in the continuous part of the nerve. On the other hand, there was no grade II or III. Thus, one cannot exclude the presence of Sunderland Grade I microscopic lesion, which recovers spontaneously, but we can exclude a priori the presence of grade II or III injuries which are at risk of incomplete recovery.

To our knowledge, this has never been shown in the literature. Kim *et al.*[20] published a series of ballistic brachial plexus lesions. When confronted with a partial transection and the continuous portion did not transmit action potentials, they resected this portion and examined it in anatomic pathology. The resected portions were all grade IV. It was therefore sub-total lesions since only the epineurium remained in the continuous portion of the nerve. There was certainly a selection bias in his study because only lesions that did not recover spontaneously were explored in a secondary way: it is not surprising that only grade IV lesions had been found. In our study, no grade IV lesion was observed because sub-total ruptures were excluded outright.

It can be concluded from this preliminary study that during the primary exploration of a nerve partially severed by a projectile, whether with high or low velocity, the macroscopically undamaged portion of the nerve appears to have at most Sunderland grade I injuries which will recover spontaneously. In the initial phase, it is advisable to take a lot of precautions with the part of the nerve remaining in continuity. When there is a loss of substance in the sectioned portion, the repair will be done by a fascicular transplant respecting the continuous portion. For us, this transplant must be done in a secondary way early, around 3 to 6 weeks. It should be noted that since this is a partial lesion, there is no risk of retraction of the severed ends (thus no need for fixing them). This period will allow to 1) treat the associated lesions, particularly to perform definitive bone stabilization and soft-tissue coverage; 2) treat possible early infection of the wound; and 3) wait for the Wallerian degeneration to begin. During secondary repair, the use of stimulation will make it possible to judge the functionality of the continuous portion if it contains motor fibers. It is essential for us to perform this secondary transplant as soon as possible because of dissection difficulties during the second stage: dissection is easier after 3 weeks than after 3 months! This 3-week period is to be discussed because it is the period during which the patient has a systemic inflammatory syndrome and the tissues are rearranged. We therefore

think that it is necessary to wait for the fourth week without further delay: the risk of iatrogenic lesion of the continuous portion of the nerve is indeed important when it is necessary to dissect the adjacent neuroma in a scar environment.

CONCLUSION

This preliminary study did not reveal any significant histological lesion on the continuous portion of sciatic nerves of pigs partially severed by high or low velocity projectiles. Although the existence of myelin sheath involvement could not be studied, it appears that Sunderland Grades II and III lesions can be eliminated. A macroscopically intact segment of the non-severed part of the nerve is therefore likely to recover spontaneously in the weeks following the trauma. However, further study is needed by including more specimens and studying the myelin sheath by specialized analytical methods.

ABSTRACT

Objective: Partial sections of the nerves following ballistic injuries are frequent. Nerve damage by stretching has been described in ballistic wounds in temporary cavitation. The goal of this study was to investigate the histological lesions of the continuous part of a partial section of the sciatic nerve following gunshot in pigs.

Material and methods: Six thighs from pigs euthanized 24 hours beforehand were collected and stored in a cold room at 4 °C. The thighs were divided into 3 groups of 2 thighs to undergo shots using 3 different projectiles: low velocity, high velocity and shotgun. The nerves were removed and analyzed in the pathology laboratory.

Results: No grade II, III or IV were seen on the continuous part of the cut nerves, whatever the projectile used.

Conclusion: This study has not shown significant histologic lesion on the continuous part of the pigs' sciatic nerves partially cut by high or low velocity projectile. The macroscopically-intact segment of the partially severed part is thus likely to spontaneously recover in the weeks following the trauma. The repair of the sectioned portion should be done by a fascicular transplant respecting the continuous portion. For us, this graft must be carried out in an early secondary way, around 3 to 6 weeks because of dissection difficulties during the second stage.

Conflict of interest: none.

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Comportements des militaires maliens des forces spéciales présentant une maladie parodontale : de l'apparition des premiers symptômes à la consultation dentaire.

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SUMMARY

Behavior of Malian special forces soldiers with periodontal disease: from the appearance of the first symptoms to the dental consultation

Introduction
Periodontal diseases are inflammatory infections of microbial origin that affect and/or destroy one or more elements of the periodontium (gingiva, cementum, periodontal ligament, and alveolar bone). These diseases can have a deleterious impact on the health of the military and, in fact, on the operational capacity of the forces. These diseases are frequent among the Malian military population. The objective of this study is to analyze the attitude of Malian soldiers of the special forces confronted with these diseases and their level of knowledge of these diseases.

Methodology
This is a descriptive cross-sectional study that took place from June 2 to December 31, 2020 in the dentistry department of the Bamako Military Hospital Infirmary. Any special forces soldier presenting for the consultation with periodontal disease was included in the study. Each member completed a questionnaire on their behavior from the onset of the first symptoms of periodontal disease to their dental consultation and knowledge of the periodontal disease.

Results
A total of 485 military personnel were included in the study. Only 15.9% of soldiers consulted a dental surgeon as a first-line treatment after the onset of the first symptoms of periodontal disease, the others preferring self-medication or consultation with a doctor. Many soldiers (43.3%) do not seek to make an appointment with a dental surgeon until 15 days after the onset of symptoms. The majority of soldiers (64.3%) justify this delay in consultation by their ignorance of the possible consequences of periodontal diseases (loss of teeth, deterioration of the general condition, etc.) and the interest in a treatment. early dentistry. Almost one in two soldiers (46.4%) want to be more informed about periodontal disease.

Conclusion
While studies have shown the omnipresence of periodontal diseases within the Malian forces and their deleterious impact on the operational capacity of the armies, it is clear that their current treatment is not satisfactory. The military's ignorance of what

these diseases are and their consequences frequently results in delayed consultations, which are a source of complications. A periodontal health awareness campaign would help the military understand the value of early odontological management of periodontal diseases and provide information on methods of preventing periodontal disease. This would make it possible to improve the oral health of the military and the operational capacity of the forces at a lower cost.

MOTS-CLÉS : Retard de consultation, Maladies Parodontales, Militaires, Forces Spéciales, Bamako, Mali.
KEYWORDS: *Factors, Delayed consultation, Periodontal diseases, Military, Special forces, Bamako, Mali.*

INTRODUCTION

Les maladies parodontales ou parodontopathies sont des maladies infectieuses multifactorielles caractérisées par des symptômes et signes cliniques pouvant inclure une inflammation visible ou non, des saignements gingivaux spontanés ou provoqués, la formation de poches en rapport avec des pertes d'attache et d'os alvéolaire, une mobilité dentaire et peuvent conduire à des pertes de dents[1, 2]. La caractérisation de la maladie parodontale nécessite la réalisation d'un sondage parodontal, la prise de clichés radiographiques et le relevé d'indices standardisés (indice de santé gingivale et parodontale, etc.)[3]. Des études ont montré une prévalence de la maladie parodontale de 27 à 41 % au sein de différentes populations civiles africaines[4, 5]. Une prévalence beaucoup plus élevée (82,7 %) a été montrée au sein de la population militaire malienne[6]. Cette différence également constatée dans les pays occidentaux pourrait s'expliquer par le fait que les militaires représentent un groupe à risque de développer des maladies parodontales du fait des contraintes physiques, psychologiques et environnementales auxquelles ils sont exposés[4, 7-9]. Les symptômes associés à la maladie parodontale, notamment les douleurs, peuvent altérer les performances des militaires voire les empêcher d'accomplir leurs missions. Par conséquent, promouvoir une bonne santé parodontale au sein de la population militaire n'est pas seulement bénéfique en termes de santé publique[10-12] mais aussi de maintien de la capacité opérationnelle des forces[13]. Deux types d'action sont possibles pour améliorer la situation actuelle au sein de l'armée malienne : prévenir la survenue des maladies parodontales et, en présence d'une maladie déclarée, la prendre en charge rapidement pour rétablir la santé parodontale et la capacité opérationnelle des militaires. Au sein du service d'odontologie de l'Infirmerie Hôpital Militaire de Bamako, nous avons constaté de manière empirique que les militaires tardaient à consulter suite à l'apparition des premiers symptômes de la maladie parodontale. Ceci conduit à une aggravation de la situation clinique, à une dégradation du pronostic, à la nécessité de traitements plus complexes et plus longs et à une diminution plus importante de la capacité du militaire à accomplir sa mission. L'objectif de notre étude est d'objectiver la réalité de ce retard de consultation et d'en comprendre les motifs, ceci afin de pouvoir proposer des mesures correctrices.

METHODOLOGIE

Il s'agit d'une étude transversale de type descriptif qui s'est déroulée du 2 juin au 31 décembre 2020 au sein du service d'odontologie de l'Infirmerie Hôpital Militaire de Bamako (IHB).

Le service d'Odontologie de l'Infirmerie Hôpital de Bamako (IHB) est composé d'un bureau du chef de service (Parodontologiste), de deux salles de soins (cabinet I et cabinet II), d'une salle pour le laboratoire de prothèse mobile, d'une toilette, d'un magasin, d'un bureau pour le major du service. Ce service est soutenu par un Chirurgien-dentiste Parodontologiste, un Chirurgien-dentiste généraliste, deux Assistants dentaires, deux Techniciens Supérieurs en Odontologie, deux Techniciens Prothésistes, une Secrétaire.

Ce service assure la prise en charge des affections bucco-dentaires, la formation initiale et continue des professionnels de la santé; conduit les travaux de recherche dans le domaine médical (bucco-dentaires).
Les critères d'inclusion pour participer à l'étude étaient les suivants :

- Etre militaire en service dans les Forces de Défense et de Sécurité du Mali (le Groupement Spécial d'Intervention de la Gendarmerie Nationale (GSIGN), la Force Spéciale Anti-terroriste (FORSAT), la Compagnie

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d'Intervention Rapide (CIR) de la Garde ou le Bataillon Autonome des Forces Spéciales (BAFS).

- Consulter à l'IHB pour une maladie parodontale durant la période de l'étude. Pour que le militaire soit inclus dans l'étude, l'existence de la maladie devait être confirmée par le praticien suite à un examen clinique et radiographique. Afin de supprimer le risque de biais inter opérateur, l'examen des patients a été réalisé par un seul clinicien.
- Donner son consentement éclairé pour participer à l'étude.

Chaque participant inclus dans l'étude s'est vu remettre un questionnaire anonyme élaboré pour l'étude afin de recueillir ses données sociodémographiques (âge, sexe, catégorie et armée d'appartenance) et des informations relatives à son attitude face aux symptômes de la maladie parodontale (consultation, automédication, etc.) et ses connaissances de cette maladie (signes cliniques, étiologie, conséquences, etc.).

Les données ont été traitées par le logiciel épi-info version 3.5.3.

RESULTATS

Au total, 506 militaires se sont présentés à la consultation odontologique de l'IHB entre le 2 juin et le 31 décembre 2020. Les 485 militaires répondant aux critères d'inclusion ont été inclus dans l'étude. Ces 485 militaires sont des hommes (100 % de l'échantillon) jeunes (âge moyen de 26 ans (19 à 52 ans)). Les militaires du rang sont majoritaires (63.7 %) (cf. tableau I).

Ces militaires souffrant de maladies parodontales ont consulté à l'IHB pour moitié en raison de douleurs (43,1 %) ou pour moitié en raison d'une tuméfaction gingivale (40,6 %) (p = 0,7) (cf. tableau II). Face à l'apparition des symptômes, seuls 15,9 % des patients ont consulté un chirurgien-dentiste en première intention. Les autres militaires se répartissent en deux populations égales (p = 0,6), ceux qui ont consulté un médecin (43,7 %) et ceux qui se sont soignés eux-mêmes (40,4 %) avec un recours à des traitements médicamenteux (antalgiques, bain de bouche, etc.) ou à des soins traditionnels (donner des précisions) (cf. tableau II). Seuls 15,9 % des militaires ont cherché à obtenir un

Tableau I : Caractéristiques socio-démographiques de l'échantillon de l'étude.

Caractéristiques socio-démographiques		Nombre	Pourcentage (n=485)
Age	18-27	146	30,1
	28-37	297	61,2
	38-47	33	6,8
	48-57	9	1,9
Sexe	Homme	485	100
	Femme	0	0
Grade	Officier	27	5,6
	Sous-officier	149	30,7
	Militaire du rang	309	63,7

Tableau II : Attitude des militaires de l'apparition des symptômes de la maladie parodontale à la consultation dentaire.

Symptômes et réaction face aux symptômes de la maladie parodontale		Nombre	Pourcentage (n=485)
Symptôme ou signe clinique déclencheur de la consultation	Douleurs	209	43,1
	Tuméfaction de la gencive	197	40,6
	Mobilité dentaire	72	14,9
	Autre	7	1,4
Attitude face à l'apparition des symptômes de la maladie parodontale	Automédication	107	22,1
	Soins traditionnels	89	18,4
	Consultation médicale	212	43,7
	Consultation dentaire	77	15,9
Délai entre l'apparition des symptômes et la demande de rendez-vous à l'IHB	< à 7 jours	77	15,9
	8 à 14 jours	198	40,8
	15 à 30 jours	153	31,6
	Plus de 30 jours mais moins d'un an	56	11,6
	Plus d'un an	1	0,2

rendez-vous auprès d'un chirurgien-dentiste dans la semaine qui a suivi l'apparition des symptômes. Les autres militaires ont attendu pour moitié entre 8 et 15 jours après l'apparition des symptômes (40,8 %) et pour l'autre moitié au-delà de 15 jours (43,3 %) (p = 0,7) (cf. tableau II).

Lorsqu'il est demandé aux patients d'expliquer pourquoi ils ne sont pas venus consulter plus précocement, la majorité (64,3 %) répond qu'ils n'en voyaient pas l'intérêt car ils ne pensaient pas que le tableau clinique associé à la maladie pouvait évoluer et s'aggraver avec notamment des conséquences systémiques et un impact sur leurs activités opérationnelles. La majorité des patients suggèrent d'ailleurs que l'amélioration de l'information relative aux maladies parodontales (complications, prévention, traitement) permettrait de réduire le retard de consultation (cf. tableau III).

On peut effectivement constater un faible niveau de connaissance des militaires en matière de santé et de maladie parodontales (cf. tableau IV). Lorsqu'on les interroge quant à l'étiologie des maladies parodontales, seuls 14,2 % des patients font un lien entre cette maladie et une mauvaise hygiène bucco-dentaire. La première cause de maladie parodontale évoquée par les militaires est l'hérédité (38,8 %) (cf. tableau IV). Les militaires ont une idée assez précise des symptômes associés aux maladies parodontales puisqu'ils évoquent en premier la tuméfaction gingivale (29,7 %) et la douleur à la mastication (26,8 %).

DISCUSSION

Représentativité de l'échantillon.

La répartition par âge au sein de notre échantillon s'explique par le fait que tous les patients sont des militaires. Si on retrouve dans notre échantillon une population jeune (âge moyen 26 ans), il en va de même dans d'autres études menées au sein de la population militaire malienne[6]. Les contraintes importantes inhérentes au métier de militaire expliquent que ce métier soit

Tableau III : Obstacles et incitations à la consultation dentaire des militaires présentant une maladie parodontale.

Obstacles et incitations à la consultation		Nombre	Pourcentage (n=485)
Obstacles à la consultation	Manque de moyens financiers	12	2,5
	Méconnaissance de complications potentielles de la maladie	312	64,3
	Absence de douleurs	46	9,5
	Manque de temps	115	23,7
Incitations à la consultation	Gratuité de la consultation	156	32,2
	Subvention des soins	101	20,8
	Meilleure connaissance de la maladie parodontale et de ses complications	225	46,4
	Augmenter la capacité de prise en charge médicale (plus de personnel)	3	0,6

Tableau IV : Connaissances de militaires concernant la maladie parodontale.

Connaissances de la maladie parodontale par les militaires		Nombre	Pourcentage (n=485)
« Selon vous, qu'est-ce qui est à l'origine de la maladie pardontale ? »	Mauvaise hygiène bucco-dentaire	69	14,2
	Hérédité	188	38,8
	Microbes	78	16,1
	Mauvais sort	37	7,6
	Ne sait pas	113	23,3
« Selon vous, quels sont les signes et symptômes de la maladie parodontale ? »	Douleurs au chaud, au froid, au sucré	76	15,7
	Douleurs spontanées	89	18,4
	Douleurs à la mastication	130	26,8
	Mobilité dentaire	46	9,5
	Tuméfaction	144	29,7

principalement exercé par des individus jeunes. Sur la base du critère d'âge notre échantillon est représentatif de la population militaire mais non de la population civile dont la moyenne d'âge est plus élevée[14]. Il en va de même avec le sexe-ratio (100 % d'hommes). Le métier de militaire est principalement exercé par des hommes et exclusivement ou quasi exclusivement exercé par des hommes en ce qui concerne les forces spéciales. En cela notre échantillon est représentatif des forces spéciales d'autres armées. Enfin, toutes les armées reposent sur une pyramide des grades comparable avec un nombre limité d'officiers et une large base constituée de militaires du rang[15]. En termes de pourcentage de la population militaire, les sous-officiers se situent entre ces deux populations. Notre échantillon présente cette même répartition et est comparable à la pyramide des grades des autres armées[15].

Au total, malgré la taille limitée de notre échantillon et le fait que l'étude ait été menée sur un seul site, il s'avère que notre échantillon peut être considéré comme représentatif de la population militaire malienne et plus particulièrement de ses forces spéciales.

Attitude des militaires de l'apparition des symptômes à la consultation dentaire

L'analyse des données de l'étude montre que les militaires n'ont pas le réflexe de consulter un chirurgien-dentiste dès l'apparition de symptômes liés à la maladie parodontale. Comme pour la plupart des pathologies bucco-dentaires, c'est la douleur qui amène le patient à consulter. La tuméfaction est l'autre motif de consultation du fait de l'inquiétude que peut générer ce symptôme pour le patient et de son caractère évolutif (augmentation du volume et des douleurs) en l'absence de drainage.

Lorsque les premiers symptômes apparaissent, les militaires s'en remettent à l'automédication et aux soins traditionnels qui n'ont que peu d'effets sur les maladies parodontales ce qui conduit à l'aggravation des symptômes, à une perte de capacité opérationnelle et à la nécessité de traitements plus complexes et plus longs[16]. Pour les militaires qui choisissent de consulter un professionnel de santé, la majorité préfère consulter un médecin plutôt qu'un chirurgien-dentiste. Cependant, dans le domaine bucco-dentaire, la consultation médicale ne suffit pas à traiter les pathologies. Le médecin va prescrire des médicaments et/ou drainer un abcès mais cela ne permettra que de soulager temporairement le patient, ces traitements n'étant efficaces que sur la conséquence des maladies parodontales et non sur leurs causes. Cette consultation médicale doit donc être l'occasion pour le médecin d'orienter son patient vers un chirurgien-dentiste sans quoi, une nouvelle fois, cette consultation ne fera qu'augmenter le retard de consultation chez un chirurgien-dentiste et aggraver le tableau clinique du patient.

Ces attitudes des patients (automédication, consultation médicale, etc.) se traduisent par un délai de prise de rendez-vous chez un chirurgien-dentiste après l'apparition des premiers symptômes de la maladie de plus de 15 jours chez 43,3 % des patients. Ce délai certes long reste cependant inférieur à celui constaté dans d'autres études[16]. Quoi qu'il en soit, ces semaines qui s'écoulent avant d'initier le traitement ont un impact délétère sur la santé des patients, sur le pronostic de la maladie parodontale (risque de ne plus pouvoir conserver une dent, etc.) et sur la capacité opérationnelle des forces.

Motifs du retard de consultation

L'analyse des résultats de l'étude montre que la majorité des militaires se rend compte qu'elle présente des symptômes de la maladie parodontale (mobilité dentaire, douleur à la mastication, tuméfaction, etc.). Il est intéressant de noter que seuls 2,5 % des militaires évoquent le coût des soins comme une cause de non-consultation dentaire. Ce résultat est comparable à ce que d'autres auteurs ont constaté[16, 17]. Cet aspect pécuniaire est pourtant prépondérant dans les motifs de non-accès aux soins dans de nombreux pays notamment occidentaux. Le faible impact de l'aspect financier sur l'accès aux soins est lié au fait que les soins dentaires sont subventionnés au Mali pour les militaires. Ce sont donc d'autres raisons qui expliquent les retards de consultation dentaire des militaires à savoir le fait que les militaires :

- Ne pensent pas à 64,3 % que la maladie soit évolutive et qu'elle puisse avoir un impact négatif sur leur santé générale et leurs capacités à accomplir leur mission,
- Pensent que la maladie peut être traitée simplement avec des médicaments (automédication pour 22,1 % des militaires, consultation médicale pour 43,7 %, etc.),
- Pensent ne rien pouvoir faire contre la présence de la maladie parodontale (38,8 % pensent que c'est une maladie héréditaire, 7,6 % qu'elle est liée à un mauvais sort).

Nécessité d'une information des patients en matière de santé et de maladie parodontales.

Les retards de consultation s'expliquent donc par un manque de connaissance des militaires en matière de maladies parodontales. Pour que les militaires consultent spontanément et rapidement, ils doivent comprendre pourquoi ils doivent consulter. Pour cela ils doivent être sensibilisés à tous les aspects de la maladie parodontale : symptômes, traitement, prévention, évolution, etc. Il est également à noter que les militaires se disent à 46,4 % intéressés par le fait de recevoir de telles informations. Ils semblent donc que ce problème de retard de consultation puisse être pallier rapidement à un coût moindre puisqu'il s'agit avant tout d'informer et non de déployer de nouveaux moyens. Cette mission d'information des militaires nous semble relever des prérogatives des chirurgiens-dentistes militaires puisque leur mission première est de permettre au militaire d'être en bonne santé bucco-dentaire et ainsi de maintenir à un niveau optimal leur capacité et leur disponibilité opérationnelles[13]. Pour cela il sera nécessaire de mettre en place un véritable programme d'éducation bucco-dentaire des patients à travers de multiples lieux (casernes, restauration, service médical, etc.), sur

de multiples supports (affiches, messages oraux, etc.) et à de multiples moments de la carrière de chaque militaire (incorporation, visite médicale, etc.).

CONCLUSION

Les maladies parodontales sont omniprésentes au sein des forces armées maliennes. Ceci a des conséquences sur la santé bucco-dentaire et générale des militaires mais aussi sur la capacité opérationnelle des forces. Notre étude a permis de mettre en évidence le fait que, bien que les militaires aient conscience qu'ils présentent une maladie parodontale (ils en connaissent les principaux symptômes), ils tardent à consulter un chirurgien-dentiste. Ils préfèrent en première intention avoir recours à l'automédication, à des soins traditionnels ou à aller voir un médecin. Ces solutions ne permettent souvent que de masquer les symptômes de la maladie parodontale sans en traiter la cause. Les patients retardent ainsi leur consultation dentaire et, une fois qu'ils consultent, ils présentent un tableau clinique dégradé avec une altération de leur disponibilité et de leur capacité opérationnelles. Ce retard de consultation est lié à la méconnaissance des militaires de ce qu'est la maladie parodontale, de ses complications et de l'intérêt d'une prise en charge précoce par un chirurgien-dentiste. Pour pallier cette situation, il apparaît nécessaire de mettre en place au sein des forces maliennes un programme d'information des militaires à la santé bucco-dentaire en général et parodontale en particulier. Ce programme devrait permettre à moindre coût d'améliorer la santé des militaires et ainsi d'augmenter la capacité opérationnelle des forces.

RESUME

Introduction

Les maladies parodontales sont des infections inflammatoires d'origine microbienne qui affectent et/ou détruisent un ou plusieurs éléments du parodonte (gencive, cément, ligament parodontal et os alvéolaire). Ces maladies peuvent avoir un impact délétère sur la santé des militaires et de fait, sur la capacité opérationnelle des forces. Ces maladies sont fréquentes au sein de la population militaire malienne. L'objectif de cette étude est d'analyser l'attitude des militaires maliens des forces spéciales confrontés à ces maladies et leur niveau de connaissance de ces maladies.

Méthodologie

Il s'agit d'une étude transversale de type descriptif qui s'est déroulée du 2 juin au 31 décembre 2020 dans le service d'odontologie de l'Infirmerie Hôpital Militaire de Bamako. Tout militaire des forces spéciales se présentant à la consultation en raison d'une maladie parodontale a été inclus dans l'étude. Chaque militaire a complété un questionnaire portant sur son comportement depuis l'apparition des premiers symptômes de la maladie parodontale jusqu'à sa consultation dentaire et ses connaissances en matière de maladies parodontales.

Résultats

Au total, 485 militaires ont été inclus dans l'étude. Seuls 15,9 % des militaires ont consulté un chirurgien-dentiste en première intention après l'apparition des premiers symptômes de la maladie parodontale, les autres préférant l'automédication ou la consultation chez le médecin. De nombreux militaires (43,3 %) ne cherchent à prendre rendez-vous chez un chirurgien-dentiste que 15 jours après l'apparition des symptômes. La majorité des militaires (64,3 %) justifie ce retard de consultation par sa méconnaissance des conséquences possibles des maladies parodontales (perte de dents, altération de l'état général, etc.) et de l'intérêt d'une prise en charge odontologique précoce. Près d'un militaire sur deux (46,4 %) souhaite être davantage informé sur les maladies parodontales.

Conclusion

Alors que des études ont montré l'omniprésence des maladies parodontales au sein des forces maliennes et leur impact délétère sur la capacité opérationnelle des armées, force est de constater que leur prise en charge actuelle n'est pas satisfaisante. La méconnaissance des militaires de ce que sont ces maladies et de leurs conséquences aboutit fréquemment à un retard de consultation source de complications. Une campagne de sensibilisation à la santé parodontale permettrait de faire comprendre aux militaires l'intérêt d'une prise en charge odontologique précoce des maladies parodontales et d'informer sur les moyens de prévention des maladies parodontales. Ceci permettrait d'améliorer à moindre coût la santé bucco-dentaire des militaires et la capacité opérationnelle des forces.

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Could You Use Anaesthetic Drugs in Antarctica? Research on Pharmacological Effectiveness.

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RESUME

Peut-on utiliser des médicaments anesthésiques en Antarctique ? Etude d'efficacité pharmacologique.

Introduction : *Les anesthésistes peuvent être contraints à travailler dans de nouveaux milieux ou des environnements compliqués, où la dégradation des équipements médicaux ou l'altération de l'efficacité des médicaments à cause des conditions environnementales peuvent survenir. Ces situations peuvent générer un facteur d'incertitude pour la planification anesthésique avec, par conséquent, un impact sur la sécurité du patient.*

Objectif : *évaluer quatre médicaments anesthésiques (citrate de fentanyl, étomidate, bromure de rocuronium et chlorure de suxaméthonium) en utilisant la chromatographie liquide à haute résolution pharmacologique sous des conditions climatiques extrêmes en Antarctique.*

Matériel et méthodes : *Étude prospective descriptive in vitro, dans laquelle des flacons de citrate de fentanyl, d'étomidate, de bromure de rocuronium et de chlorure de suxaméthonium soumis à des conditions climatiques extrêmes sur l'île de la Déception pendant 24, 48 et 72 heures ont été évalués par chromatographie liquide à haute résolution. Les variables suivantes ont été analysées : a) indépendantes : température quotidienne (maximale/minimale), vent (maximal/minimal), pression atmosphérique (maximale/minimale), humidité relative (maximale/minimale), précipitations (maximales/minimales), insolation (maximale/minimale) et rayonnement solaire (maximal et minimal) ; b) dépendantes : détérioration de l'emballage du flacon (oui/non), type de détérioration de l'emballage du flacon (cassure/fissure), détérioration du médicament (changement de couleur/congélation/précipitation) et le pourcentage de perte d'activité du médicament; c) contrôle : date de fabrication du médicament et date de péremption du médicament.*

Résultat : *les flacons de citrate de fentanyl, d'étomidate, de bromure de rocuronium et de chlorure de suxaméthonium soumis à des conditions climatiques polaires sur l'île de la Déception (Antarctique) pendant 24, 48 et 72 heures ont subi peu de dégradation et maintiennent un profil linéaire de leur efficacité et une marge de sécurité entre 99 % et 110 % qui permet leur administration.*

Conclusions : *Cette analyse pharmacologique par chromatographie liquide à haute résolution ne déconseille pas l'utilisation des médicaments mentionnés (fentanyl, étomidate, bromure de rocuronium et chlorure de suxaméthonium) dans cet environnement extrême.*

KEYWORDS: Anesthetic drugs, Liquid chromatography of high performance, Antarctica.

MOTS-CLÉS : *Médicaments anesthésiques, Chromatographie liquide à haute résolution, Antarctique, Climat extrême.*

BACKGROUND

Between the southern summer months of November and March, Spanish Armed Forces members, along with members of the scientific community, develop different research programs in the Spanish Antarctic bases "Gabriel de Castilla" and "Juan Carlos I". The first one is located on Deception Island (62º 55´S latitude and 60º 37´W longitude), in the South Shetland archipelago, a few kilometers from the Antarctica; more than 1,000 kilometers from the closest inhabited place and 13,000 kilometers from Spain. On the other side, the "Juan Carlos I" base is located on Livingston Island, in the same archipelago as the first one. Deception Island is unique from a scientific point of view due to its seismic and volcanic activity, as well as due to the process of colonization of flora, lichens and moss that have followed the changing deposits of ashes. Moreover, both bases are considered to be two of the most hostile places from a climatological point of view (extreme temperature, high humidity, strong winds, and a notable light radiation due to the depletion of the ozone layer at this latitude) to which military personnel have been deployed[1, 2]. Thanks to these details, the status of the Kingdom of Spain (who has belonged to the Antarctic Treaty since 1982) in the international sphere is increasing, continuing the homage of the explorer, Admiral Gabriel de Castilla in 1603, and his voyage to the Antarctic continent on the navy vessels *Ciervo, Volenate*, and *Buena Nueva*, and what was likely the first human landing in Antarctica in 1819 on the Spanish warship, *San Telmo*[3].

Physicians in general (and anaesthesiologists in particular) can be obligated to work in new situations or complex environments in which medical supplies become fatigued or drug efficacy is altered due to environmental factors. These situations can generate a factor of uncertainty for anesthetic strategies, which has a subsequent impact on patient safety.

The objective of this research is to evaluate four anesthetic drugs (fentanyl citrate, etomidate, rocuronium bromide and suxamethonium chloride) subjected to extreme weather conditions in Antarctica by using high resolution pharmacological liquid chromatography (Figure 1).

MATERIAL AND METHODS

Upon receipt of authorization from the Military Hospital Research Unit (45/2016), the Ethics and Clinical Research Committee (58/2016) and from the XXX Antarctic Campaign Commander (08/22/2016), an in vitro prospective descriptive study in which vials of fentanyl citrate (Fentanest® 0.05mg/ml *Kern Pharma*, Spain), etomidate (Hypnomidate® 2mg/ml *Janssen Cilag, Spain*), rocuronium bromide (Esmeron® 10mg/ml *Schering Plough, USA*) and suxamethonium chloride (Mioflex® 50mg/ml *Braun Medical, Spain*) subjected to extreme climatic conditions on Deception Island were evaluated by high resolution liquid chromatography.

Four packs were prepared for this research. Each pack contained 2 vials of fentanyl citrate, 2 vials of etomidate, 2 vials of rocuronium bromide and 2 vials of suxamethonium chloride. The 8 vials from each drug belonged to the same brand, expiration date, lot and package. Vials were placed in a transparent plastic bag of 0.5mm thickness. Each bag was labeled with a number reflecting the number of days that bag was going to be exposed: Bag 1 (1 day), Bag 2 (2 days), and Bag 3 (3 days). Bag 0 was used as the control bag and kept inside the base accommodation under opaque conditions so as to not suffer climate stress. The 4 bags were correctly protected and traveled by plane in carry-on luggage from Madrid (Spain) to King George Island (South Shetland archipelago, Antarctica) and after that, on the Spanish National Research Council CSIC *Sarmiento de Gamboa* research vessel to Deception Island. The trip took 14 days. After visually verifying the appropriate conservation of the vials at the base Gabriel de Castilla, the climatic stress phase started. The three days of analysis were consecutive, starting at noon, February 3, 2017, and ending at noon on February 6, 2017. At the beginning of the study, the three bags of medication were placed in surgical drapes on the volcanic terrain (the drape was secured with plastic ties at the top to minimize the effect of wind). After 24 hours, Bag 1 was retrieved and stored at the base, along with Bag 0. The same procedures were repeated with Bags 2 and 3 at 48 and 72 hours respectively. We relied on the meteorologist with the expedition who was a member of the State Agency of Meteorology (AEMET) to obtain the temperature, wind, atmospheric pressure, relative humidity, rain, radiation and insolation as we carried out the study. Once the period of exposure climactic stress was over, the vials were transported by the Spanish Navy oceanographic ship, *Hespérides*, to Ushuaia (Argentina). Afterwards, they were transported via plane in carry-on luggage to Madrid (Spain), and finally, via land, to the Pharmacy Military Center in Colmenar Viejo (Madrid). The total transit time spanned 38 days (31 days at the Antarctic base once Bag 3 was ready, 5 days via water transport, 1 day via air transport, and 1 day via land transport). The liquid chromatography analysis started 6 months after the receipt of the vials at the aforementioned Pharmacy Military Center, with all vials conserved in a stable environment without being effected by the climatological changes (inside a laboratory at room temperature).

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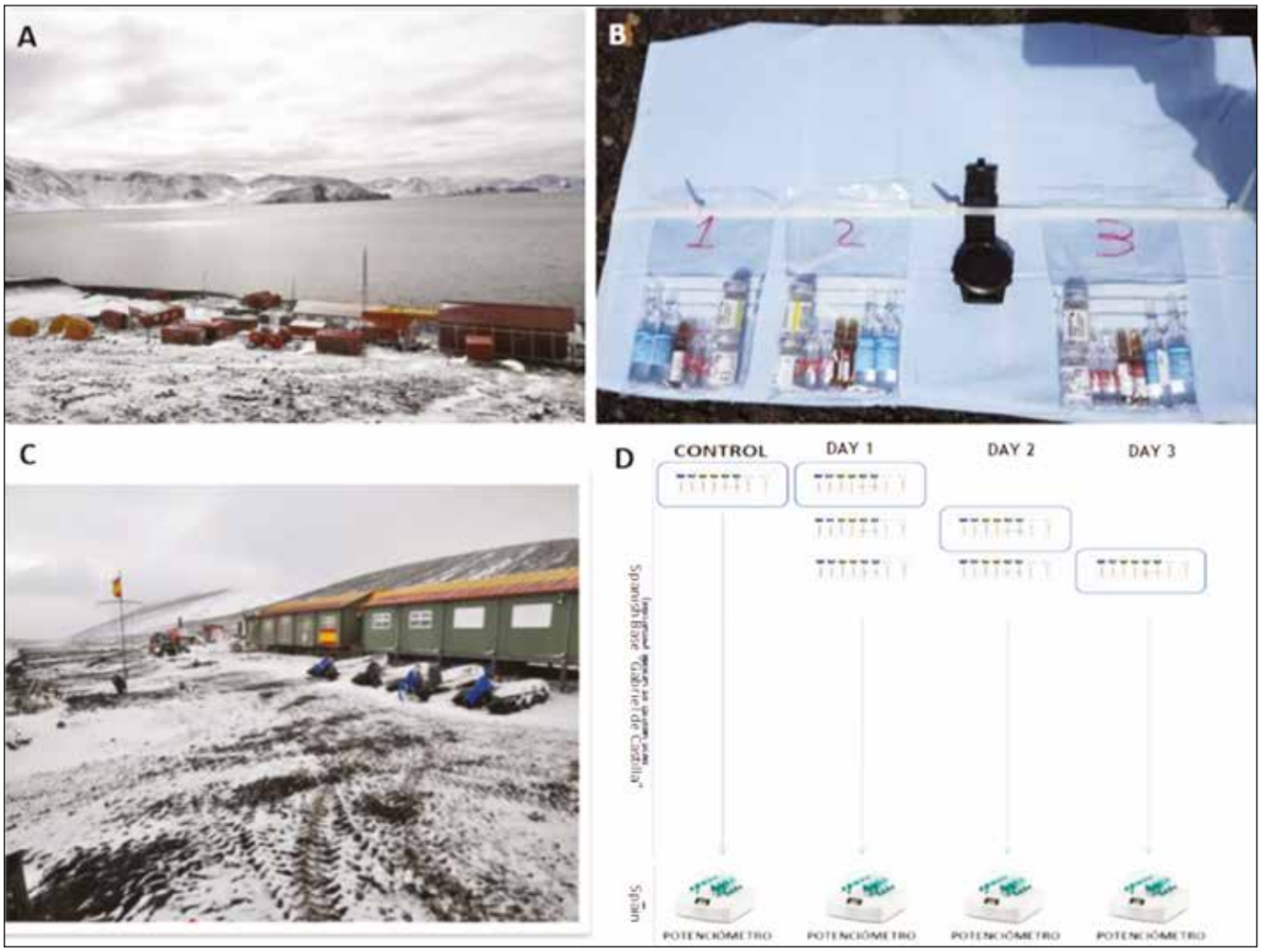
Figure 1: A and C, Spanish Base "Gabriel de Castilla" in Antarctica. B, three bags with vials. D, Control and bags 1, 2 and 3 in Gabriel de Castilla Base and in Spain.



For the pharmacists to make their quantitative determination, a HPLC chromatograph was used. Technical instruments were prepared to perform this assessment via HPLC-UC (DAD), per the USP28 NF22 parameters from 2015 (fentanyl page 3,806 Vol II, etomidate, page 3,715 Vol II, rocuronium, page 5,640, Vol III, and suxamethonium, page 5,769, Vol III). The aforementioned monographs show the range in which the concentration of the main active ingredient is suitable for administration to the patient (95% and 110% of the theoretical concentration of the active ingredient). The reference pattern used for the calibration of the corresponding vials was Day 0 (control). The vials corresponding to Day 1, Day 2 and Day 3 were considered samples. The calibration ranges from 0 to 0.05 mg/ml for the fentanyl citrate, 0 to 2mg/ml for the etomidate, 0 to 10mg/ml for the rocuronium, and 0 to 50mg/ml for the suxamethonium. Three cut off points were used for the pharmacological analysis: 0.01, 0.025 and 0.05mg/ml for fentanyl, 0.5, 1 and 2mg/ml for etomidate, 1, 2.5, and 5mg/ml for rocuronium, and finally, 10, 25, and 50mg/ml for the suxamethonium. The samples corresponding to Days 1, 2 and 3 were determined to be at 50% and tripled to interpolate the results with the linear regression line were determined. The instrumental conditions were detailed for each drug: gear, flow, injection volume, detection and temperature (exclusively for the rocuronium).

All samples are performed in triplicate in order to be ensure that there have been no internal or external errors during the technique.

All vials were within the expiration date when high resolution liquid chromatograph study started. Finally, all the vials were discarded for their use for animals or humans.

The following variables were analyzed: a) independent variables: daily temperatures in Celsius C° (highest/lowest), wind speed in knots (highest/lowest), atmospheric pressure in bars (highest/lowest), rain in L/m^2 (highest/lower), insolation (maximum/minimum) and solar radiation W/m^2 (maximum/minimum); b) dependent variables: the deterioration of the vial (yes/no), the type of deterioration of the vial (rupture/cracks), the deterioration of medicine (change in color/freezing/precipitate) and the percentage loss of efficacy of the drug; c) control factors: date of manufacturing of the drug and the expiration date of the drug.

In this investigation, it was measured in the middle of a line to ensure its linearity. For this reason, a 50% dilution of the samples was carried out with the intention of ensuring an optimal range of measurement. The calibration line was performed with different concentrations of

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the standard, so maximum value of the calibration line will always coincide with the point of maximum concentration of the standard. The spectrum obtained in each sample must be correct in terms like retention time, area and is repeated in all samples analyzed.

Daily temperatures in Celsius C°, wind speed in knots, atmospheric pressure in bars, rain in L/m^2, insolation and solar radiation W/m^2 were performed by AEMET. Insolation or insolation time is defined as the sum of time intervals during which direct solar radiation, perpendicular to the sun, exceeds the threshold of 120 W/m^2. Another definition based on the measurement of global solar radiation, delimits insolation as the sum of time intervals during which global solar radiation is 0.4 times greater than the potential solar radiation outside the Earthęs atmosphere, both measured in the horizontal plane. Solar radiation varies throughout the day from 0 kW/m^2 at night to a maximum of approximately 1 kW/m^2.

Moreover, a collection sheet was designed, along with another one for data analysis.

RESULTS

The meteorological results after the three days of the experiment were the following: daily temperatures in Celsius C° (maximum: 4.2, 4.3, and 2.3/minimum: 2.1, 1.1 and 1.3), wind speed in knots (maximum: 3, 3.2 and 5.8/minimum: 0.7, 0 and 0.7), atmospheric pressure in bars (maximum: 1003.9, 1003.9 and 1014.1/minimum: 996.8, 1000 and 1003.9), rain in L/m^2 (maximum: 0.1, 0.2 and 0/minimum: 0, 0 and 0), insolation hours (maximum: 0.17, 0.17 and 0.17/minimum: 0, 0 and 0) and solar radiation W/m^2 (maximum: 886.7, 635.4 and 369.1/minimum: 0,0 and 0).

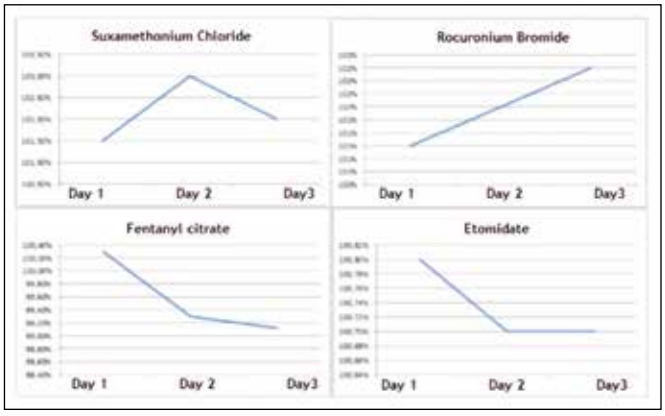
Regarding the effect on vials, we found that in no instance was there any degradation of the container, change in color, freezing, or precipitate.

In regard to the analysis by high resolution liquid chromatography, we found that suxamethonium chloride had a concentration of 101.5%, 103%, 102% on Days one, two and three respectively. Rocuronium bromide also followed a similar pattern: 101%, 101.6% and 102.2% on Days one, two and three respectively. Fentanyl citrate shows a concentration of 100.3%, 99.3% and 99.12% at 24, 48 and 72 hours of exposure to the polar climate. Finally, the etomidate maintained values of concentration of 100.8%, 100.7% and 101.8% on Days one, two and three respectively (Figure 2).

DISCUSSION

Antarctica is the highest, coldest and windiest continent. It is one of the most remote places and has the harshest environmental conditions on Earth. It is the most hostile place in which man fights to survive and work. Given these difficulties, the practice of medicine on this continent can be a challenge. The main factors to consider in providing medical care in the poles are: hypothermia, fatigue, and frostbite. You must also take

Figure 2: Pharmacological performing liquid chromatography evolution.



into account the fact that a sick person could endanger themselves, those around them, and the progress of scientific research[4-6].

The medical capabilities of the different bases and military vessels in these extreme climatological conditions are limited. This is compounded by a limited capacity for medical evacuation. Lugg[7] thinks that in determined moments of the year, it is more difficult to evacuate a patient from some Antarctic bases than it would be from the International Space Station. In the case of the Spanish base, the evacuation route via water would take four days of sailing with waves between 6 and 10 meters tall when crossing the Drake Passage. If air transport were to be used, it would have to be a military transport aircraft which, depending on the climatological conditions, could take several days for landing and takeoff[2]. Two Spanish patients have been evacuated since 1988: one for acute appendicitis and the other for urolithiasis.

The Australian Antarctic Service developed a review that showed that the medical visits made to its bases were: 39% for medical reasons (gastrointestinal, respiratory infections), 27% because of traumatic and dermatological injuries, 24% of the visits were for follow up, and 10% for prevention campaigns[8]. Collected data are also available for the New Zealand Antarctic Service: 22% were for medical reasons (gastrointestinal, respiratory infections), 42% because of traumatic injuries, 15% dermatological injuries, and 21% for dental issues[9]. The British Grant[10] details that the main needs during the campaigns of 2004 to 2006 were for trauma care, dental needs, and non-trauma-related care. The Ukrainian Moiseyenko[11] describes the medical care administered during 9 Antarctic campaigns, a lot of which was surgical and trauma care. On the Spanish bases, the care received is similar. De Diego[1] says that in 2008, 102 cases were treated, many of which were dermatological (32), trauma (30), and pulmonary (20). On the XXX campaign for the study, 30 cases were treated: 15 traumas, 6 respiratory issues, 3 digestive problems, 3 dermatology needs, 2 ophthalmological, and 1 cardiology problem. Per Soteras[5], 42% of the medical care was for trauma, 30% for medical reasons, 10% for dermatological reasons, 10% for dental reasons, and 8% for other medical reasons.

Even though the majority of the medical care given in the infirmaries on the polar base was not serious, the possibility does exist that medical attention could be needed for critical illnesses. Australia has had 6 fatalities from 1947 to 2007 from drowning, burns, precipitation, head trauma, and hypothermia. The United States has had 60 fatalities since 1946: 61% from accidents in flight, 11% due to automobiles, 7% from accidents on ships, 7% during recreational activities, 5% during base work, 5% from field work, and 4% from other causes[5]. There has been one Spanish military fatality from drowning.

Despite all of these constraints, the South Pole is supposed to be a scientific "testing ground". Scientific research on human behavior, telemedicine, cardiovascular endurance tests, mineral metabolism, thyroid metabolism, nutrition and metabolic adaptation has been carried out on Spanish bases[4]. However, few pharmacological studies have been carried out in these conditions.

This need to anesthetize the patient in Antarctica has been established since the beginning of the last century. In 1908, Marshall and Mitchell began using cocaine, atropine and chloroform to treat a patient who suffered from a penetrative ocular trauma[12]. Firth[13] detailed the first anesthesia documented in Antarctica in 1916 during the *Endurance* expedition led by Ernest Shackleton. The two doctors deployed (Macklin and McIlroy) managed to vaporize chloroform despite the low temperatures in order to anesthetize an explorer who suffered frostbite of the fingers, allowing for the success amputation of the same fingers. Over the last century and beginning of the current century, it has been necessary to use anesthesia on multiple occasions. In 1961, Doctor Rogozov, a Russian doctor on an expedition to the Antarctic had to anesthetize and operate on himself because he suffered severe appendicitis and there were no other doctors in the area[14]. In 1994, an anesthesia was administered to a biologist who suffered an olecranoid fracture due to an accident[15]. Finally, on one occasion, a doctor who was not an anesthesiologist performed a spinal anesthesia on a patient with a knee injury thanks to the support of telemedicine[16]. These experiences have forced doctors to be emergency care doctors, general practitioners and anesthesiologists, selectively chosen to be part of the different expeditions to the Antarctic polar circle.

The patients are not the only ones who suffer from the effects of the cold. Medical devices frequently are not designed to withstand extreme temperatures; plastics can break, metals are untouchable, and it is impossible to keep some fluids in their liquid state[10]. These factors have pushed an effort to continually improve the pharmacological support on Antarctic expeditions over time[17]. Hindle[18] analyzes the maximum and minimum temperatures at which these electro-medicinal devices and some drugs are effective. He specifically details that the fentanyl and suxamethonium are stable at extreme temperatures, data which coincides with our study. Per the current legislation, when the main active ingredient in a medicine is between 99% and 100% of the theoretical concentration of the aforementioned main active ingredient, it is considered suitable to use on the sick, and it is not necessary to adjust the dose. A certain drug that is enough of a percentage above 100% concentration can be considered something implicit in the analysis technique, whether it is part of the medical devices or from those crucial to the manufacturing process. After seeing the results, the criteria of the authors is that the rocuronium and the suxamethonium are very stable. In regard to fentanyl and etomidate, the lowing of the concentration is not significant when compared to the limits labeled by pharmacopeia. However, it would be interesting to monitor the study over more days at these climatological polar conditions to prove that this progression continues, and that after a certain point, the drug should not be administered to patients. The adjustment of dose if the main active ingredient were to be below the limit would not be possible since some products could present with breakdown or changes to the pH.

The limitations for this study are varied. Firstly, the number of vials and the drugs analyzed were few, the time spent outdoors was short, and the start of the laboratory analysis began late. However, from the point of view of military medicine, the exposure to unfavorable climatological situations is limited in the time allotted, and the drugs used medical attention in a tactical environment are not many. Therefore, this research could be valid and applicable in this environment and could be relevant to medical attention given in austere and extreme environments. Another limitation was the no cold critical temperature during this investigation.

CONCLUSIONS

The vials of fentanyl citrate, rocuronium bromide, suxamethonium chloride and etomidate subjected to polar climatological conditions on Deception Island (Antarctica) at 24, 48 and 72 hours suffered minimal degradation and with a lineal pattern of efficacy. This pharmacological analysis via high resolution liquid chromatography does not discourage the use of the aforementioned drugs in this extreme environment.

ABSTRACT

Introduction: Anesthesiologists can be obligated to work in new situations or complex environments in which medical supply weakens, or drug efficacy is altered due to environmental factors. These situations can generate a factor of uncertainty for the anesthetic plan, with a subsequent impact on patient safety.

Material and Methods: In vitro prospective descriptive study in which vials of fentanyl citrate, etomidate, rocuronium bromide and suxamethonium chloride subjected to extreme climatic conditions on Deception Island were evaluated by high resolution liquid chromatography after 24, 48 and 72 hours. The following variables were analyzed: a) independents: daily temperature

(maximum/minimum), wind (maximum/minimum), atmospheric pressure (maximum/minimum), relative humidity (maximum/minimum), rain (maximum/minimum), insolation (maximum/minimum) and solar radiation (maximum and minimum); b) dependents: deterioration of the vial container (yes/no), type of deterioration of the vial container (rupture/crack), deterioration of the medication (color change/freezing/precipitation) and percentage loss of potency of the drug; c) control: date of drug production and expiration date of the drug.

Result: Fentanyl citrate, etomidate, rocuronium bromide and suxamethonium chloride vials subjected to 24, 48 and 72 hours under polar climatic conditions in Deception Island (Antarctica) suffered a poor degradation and linear pattern of their effectiveness, all of them with the margin of security (99% -110%) that allows its administration.

Conclusions: This pharmacological analysis by high resolution liquid chromatography does not discourage the use of the aforementioned drugs (fentanyl, etomidate, rocuronium bromide and suxamethonium chloride) in this extreme environment.

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Military Pharmacists of the Bundeswehr Hospital Hamburg Contribute to Safer Medication in Patient-Specific Oncology.

By K. KAMENIK[1], M. HINTZ[1], A. PRIGGE[1], O. ZUBE[1], I. WAKOB[2 3] and T. BERTSCHE[2 3]. Germany

Karla KAMENIK

Major Karla KAMENIK joined the German Armed Forces as officer cadet in 1998. She holds degrees in Pharmacy from Freie Universität Berlin (2004) and in Food Chemistry from Halle/Saale University (2010). At the Central Institute of the Bundeswehr Medical Service Kiel, Department of Food Chemistry, she was head of the Methods Development Laboratory. At the Pharmacy Department of the Bundeswehr Hospital Hamburg, she led the Quality Assurance and Analytical Services Department. Since 2017 she is Production Manager according to the German Drugs Act (AMG) at the hospital pharmacy.

RESUME

Les pharmaciens militaires de l'hôpital de la Bundeswehr à Hambourg contribuent à une médication plus sûre et spécifique aux patients en oncologie.

OBJECTIFS

Le but de cette étude est d'évaluer le rôle des pharmaciens militaires dans la thérapie oncologique à l'hôpital de la Bundeswehr à Hambourg et d'identifier l'impact des services pharmaceutiques cliniques pour prévenir les problèmes de prescription.

MÉTHODES

Nous avons évalué les protocoles de chimiothérapie composés sur 36 mois dans notre hôpital de 400 lits. La pharmacie fournissait aux unités de médecine interne et d'urologie des formulations de chimiothérapie comprenant des anticorps monoclonaux. Le processus de préparation a été effectué selon une procédure standard actuelle basée sur des normes internationales externes et la littérature. Dans le cadre du contrôle de plausibilité légalement requis, les problèmes de prescription ont été identifiés et classés sur la base de 8 catégories prédéfinies. Afin de résoudre les problèmes identifiés et classés, les dossiers des patients ont également été utilisés et les médecins traitants ont été contactés si nécessaire. La préparation des protocoles médicamenteux n'a été effectuée que lorsque tous les problèmes de prescription identifiés ont été résolus et que le contrôle de plausibilité est resté sans objection.

RÉSULTATS

Un total de 1 007 ordonnances de patients adultes (soldats et civils) a été analysé. Les pharmaciens militaires ont identifié 140 problèmes de prescription : 13,9 % des cycles thérapeutiques ont été affectés par au moins un problème de prescription. Considérant les valeurs médianes, 6 (Q25 : 3; Q75 : 10) problèmes de prescription par mois ont été résolus sur les 32 (Q25 : 28; Q75 : 39) processus de préparation par mois. Les problèmes de prescription les plus fréquents ont été identifiés et résolus dans les catégories "dosage du médicament" (2,7 %), "données du patient" (2,7 %) et "comédication" (2,5 %). Notre enquête a montré qu'aucun lien direct ne pouvait être établi entre une certaine substance active et un problème de prescription spécifique.

CONCLUSIONS

Cette étude souligne la pertinence clinique des interventions des pharmaciens dans les prescriptions oncologiques et l'importance des services pharmaceutiques cliniques pour prévenir les problèmes de prescription.

QU'APPORTE CET ARTICLE ?

Qu'est-ce qui est déjà connu sur ce sujet ?

- *La complexité d'une thérapie cytostatique est à l'origine de nombreux problèmes liés aux médicaments tels que des problèmes de prescription pour les patients hospitalisés.*
- *La préparation par les pharmaciens de médicaments cytostatiques adaptés aux besoins des patients a été établie comme un facteur essentiel de l'assurance qualité.*

Ce que cette étude apporte ?

- *Les pharmaciens militaires contribuent à une médication plus sûre des formulations oncologiques spécifiques pour les patients hospitalisés. 140 des 1 007 processus de préparation analysés (13,9 %) ont été affectés par au moins un problème de prescription.*
- *Les problèmes de prescription ont été identifiés et résolus dans les catégories "dosage du médicament", "données du patient" et "comédication", considérées comme étant les problèmes les plus courantes.*

KEYWORDS: Clinical pharmacists, Military hospitals, Drug formulations, Hospital pharmaceutical services, Drug prescriptions, Checklists, Medication errors, Drug safety.

MOTS-CLÉS : *Pharmaciens cliniques, Hôpitaux militaires, Formulations de médicaments, Services pharmaceutiques hospitaliers, Prescription de médicaments, Listes de contrôle, Erreurs de médication, Sécurité des médicaments.*

INTRODUCTION

Cytostatic agents play a crucial role in therapy concepts for haematological-oncological diseases. Special requirements in this field make patient-individualised compounding a particular challenge, e.g. (i) individualised dosage based on patient parameters[1], (ii) the administration of complex therapy regimens (caused by supportive drugs, different drug combinations over longer time periods, high cumulative dosages)[2], (iii) requirements during compounding with regard to patient and product protection (caused by microbiological [e.g. intravascular or intrathecal administration] and pharmacological-toxicological safety risks with carcinogenic, mutagenic, and teratogenic potential of the involved drugs), and (iv) special aspects of administration (e.g. extravasation and contamination)[3]. The compounding of patient-individualised cytostatic agents by pharmaceutical experts has therefore been established as an essential factor of quality assurance.

Within the framework of quality assurance, however, pharmacists also significantly contribute to the identification and targeted solution of drug-related problems - preferably before a problem can have relevant adverse effects on the patient[4]. It has been reported that although drug-related problems in cytostatic agents are comparatively rare, pharmaceutical quality assurance plays a key role in improving patient safety. This is particularly the case due to the potential severity of such medication errors resulting from those drug-related problems[5]. Data about the concrete extent of identified and solved prescribing problems (i.e. drug-related problems occurring in the area of drug prescribing) by pharmaceutical plausibility check, however, is only sporadically described, particularly in military hospitals. Additionally, the described prescribing problems were frequently associated only with certain aspects such as drug-drug interactions[6].

In a military hospital with low numbers of patient-specific chemotherapy compoundings, we therefore investigated the routine and legally required plausibility check that aimed at identifying and solving occurring prescribing problems.

METHODS

Patients and setting

In our study, we assessed all patient-individual compounded chemotherapy protocols over a period of 36 months from April 2016 to March 2019 in a 400-bed military hospital providing tertiary care for civilian (80% of beds) and military patients (20% of beds). In Germany, the plausibility test of every patient-specific prescription has been a legal requirement since 2012. In the period of our study, this system was already established and was carried out routinely. The in-house pharmacy supplied internal medicine and urological units with chemotherapy formulations including monoclonal antibodies. Standard operating procedures regulated all steps of chemotherapy compounding. This study was carried out retrospectively and anonymously within the framework of the statutory provisions on quality assurance. Therefore, ethics voting and informed consent were not required under these legal requirements.

Compounding process

The compounding department involved 3 pharmaceutical technicians (two of them specialised in oncological pharmacy), 2 pharmaceutical commercial employees (with a special training in the handling of chemotherapy compounding) and 3 pharmacists (one specialised in clinical pharmacy, one in advanced training in clinical pharmacy). The compounding process was carried out according to a standard procedure based on external international standards and literature[7-13].

It consisted of the following compounding steps:
(i) Creation of an IT-based standard therapy protocol with patient data (pharmacy),
(ii) prescription based on the standard therapy protocol (physician),
(iii) planning of the compounding process (pharmacy),

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(iv) plausibility check (pharmacy in cooperation with physician),
(v) preparation and execution of the compounding process (pharmacy), (Figure 1 and 2), and
(vi) batch protocol, final inspection, and documentation (pharmacy).

Plausibility check

After the physician had approved the individualised therapy protocol (i.e. prescription) and the compounding process had been scheduled in the pharmacy the pharmacist carried out a plausibility check.The basis of the check was a standard form "Plausibility control of chemotherapy plans" and was carried out for each therapy cycle. A therapy cycle may include between one and 15 preparations (depending on the scheme). Within the scope of the plausibility check, prescribing problems were identified, classified on the basis of 8 predefined categories based on current standard operating procedures (Table 1, Figure 3). The definition of the prescribing problems was also based on external international standards and literature[7-13]. The basis data for this test were usually defined in the standard therapy protocol. For example, depending on the patient's weight, the dilution volume had to be adjusted to remain within concentration limits. In order to identify and solve further problems, the pharmacist consulted further data available in electronic or paper form and asked for additional information by phone call. (Figure 4) Individual patient factors, e.g. diagnoses, age and gender, have also been considered.

Figure 1: "Labelling of the preparations".

Figure 2: "Aseptic compounding process".

In addition, the time lag to the last chemotherapy cycle was verified. Doses were also checked for plausibility. Carrier substances, concentration, and infusion duration were additionally checked. Each prescription had to be issued by an authorised medical specialist. The therapy was marked as "plausibility controlled" in the production plan. Afterwards, the compounding could be started.

RESULTS

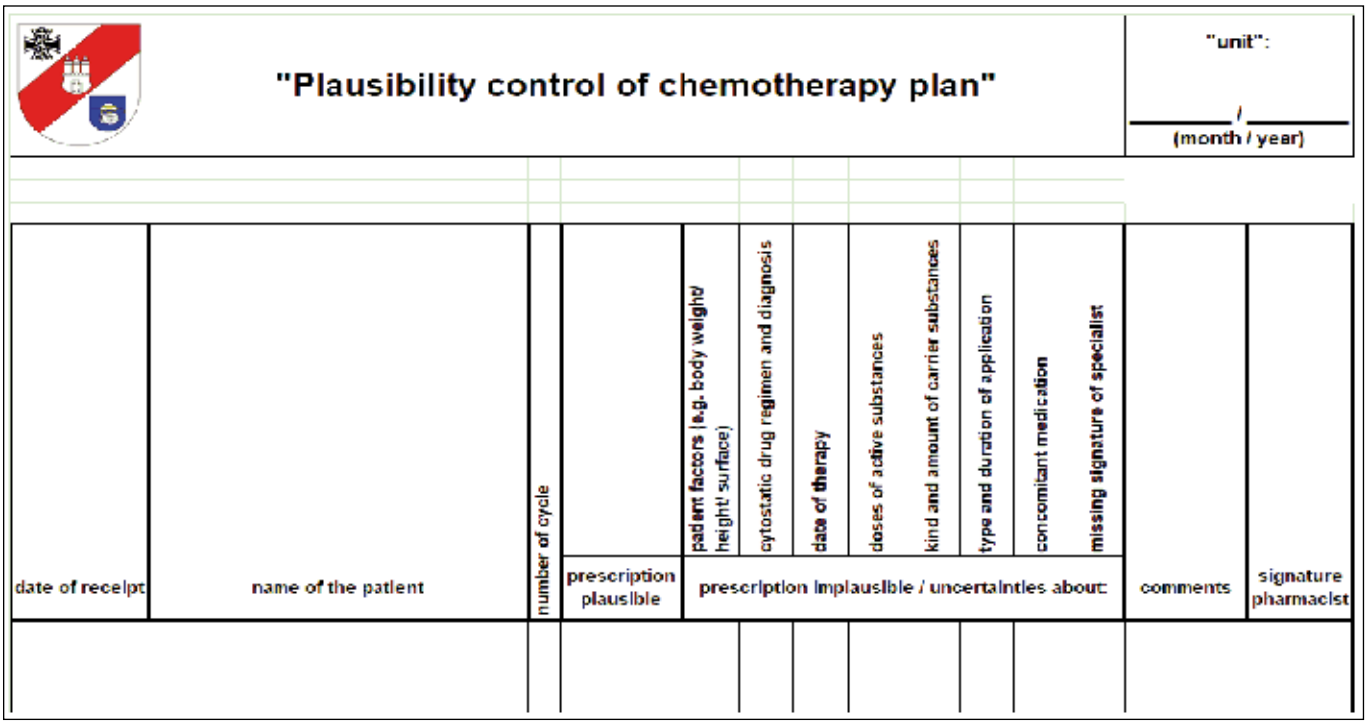
In a total of 1,007 plausibility checks, that were carried out for therapy cycles during the study period, 140 prescribing problems were identified by pharmacists and solved before starting compounding process. Among the top 3 of the cytostatic drug regimens were for internal medicine "R CHOP 14" (diffuse large B-cell lymphoma), "FOLFOXIRI + Bevacizumab" (adenocarcinoma of the colon) and "ABVD" (Morbus Hodgkin) and for urology "PEB" (testicular tumors), "Gemcitabin/Cisplatin" (urothelial and bladder carcinoma) and "PE" (testicular tumors).

13.9% of all therapy cycles were affected by at least one prescribing problem. In median 6 (Q_{25}: 3; Q_{75}: 10) prescribing problems were solved per month in the 32 (Q_{25}: 28; Q_{75}: 39) compounding processes per month in median.
Table 1 shows the frequency of all predefined prescribing problem categories based on the total number of 1,007 compounding processes. Most frequently prescribing problems were identified and solved in the categories "drug dosage" (2.7%), "patient data" (2.7%), and "co-medication" (2.5%). Our investigation showed that no direct link could be established between a certain active substance and a specific prescribing problem.

Table 1: Frequency in absolute numbers [N], frequency in percentage [P1, based on the total number of compounding processes, N = 1,007 and P2 on prescribing problems, N = 140]. Multiple categories were possible.

	Dosage of active ingredients	Date of therapy	Co-medication	Patient data	Therapy plan and diagnosis	Carrier substances	Administration (e.g. type, duration)	Authorization
N	27	9	25	27	15	5	16	16
P1 [%]	2,7%	0,9%	2,5%	2,7%	1,5%	0,5%	1,6%	1,6%
P2 [%]	19,3%	6,4%	17,9%	19,3%	10,7%	3,5%	11,4%	11,4%

Figure 3: "Form for plausibility check".



"Plausibility control of chemotherapy plan"

"unit": _____ / _____ (month / year)

date of receipt	name of the patient	number of cycle	prescription plausible	patient factors (e.g. body weight/ height/ surface)	cytostatic drug regimen and diagnosis	date of therapy	doses of active substances	kind and amount of carrier substances	type and duration of application	concomitant medication	missing signature of specialist	comments	signature pharmacist
				prescription implausible / uncertainties about:									

Figure 4: "Pharmacists carry out the plausibility check".

DISCUSSION

Our study underlines that the involvement of pharmacists also in military hospitals offers more than just an advantage in the compounding process itself as reported by others[14]. It also contributes to patient safety by a pre-compounding plausibility check.

Substantial quality improvement can be achieved by pharmaceutical validation together with other quality assurance measures such as automated manufacturing processes[15], computerised prescription and use of a bar-code system and creation/dissemination of appropriate work procedures[16]. All these measures were initially used primarily in university settings. The identified problem rate of 13.9% in our study is in line with other authors who underline the benefit of a medication surveillance performed by hospital pharmacists to prevent for instance possible negative drug-drug interactions[17].

Others reported even higher rates concerning medication

errors than reported for prescribing problems in our study. More than 43% medication errors had been committed before any safeguards were implemented in a Spanish university hospital[16]. In contrast to our survey, the mentioned study, however, included a broad range of errors addressing prescription errors, validation errors, preparation errors, dispensation errors, and administration errors. In our survey, we focused instead on the assessment of prescribing problems committed in the prescription process. We assumed that prescribing problems were discrepancies that required clarification and therefore could not automatically be described as medication errors.

Authors from a university setting in[18] used the Swedish error reporting system to evaluate errors in prescription and administration of cytostatic drugs. Among the most frequent problems were an inappropriate dosing (45%) and a wrong choice of a drug (30%). 25 (42%) of these errors occurred during drug prescription. This underlines the relevance of prescription problems, as we have done. Another relevant paper[19], additionally from university authors in this context reports a total of 92 errors corresponding to a rate of 1.4% from the total prescription numbers. The authors identified incorrect dose, incorrect duration, incorrect volume and/or inadequate vehicle as main problems. In this respect, our results were comparable because we found similar rates of prescribing problems in dosage of active ingredients. In line with our survey, pharmaceutical interventions were carried out in 100% of errors and were then implemented in all cases.

Dose calculations were discussed as an essential process step in quality assurance in the chemotherapy compounding[20]. It was a matter of concern that problems occurred disproportionately frequently in this area. The present study identified a median of 6 prescribing problems per month. Based on a median of 32 compounding processes per month, this means that in about one of five compounding processes a problem was identified and solved in our setting. This shows that the pharmaceutical plausibility checks made a substantial quantitative contribution to patient safety. Additionally, it should be emphasised, that, in our study, the identified problems had been solved in all cases before compounding was started. Constantly occurring problems, however, require a permanent plausibility check, since some problems cannot be prevented by standard operations procedures and trainings.

Though it is primarily civilian patients who have benefited from the medication error prevention described here, the setting is a particularly successful example of the development of the structural requirements for establishing and practicing medication error prevention for military use as well in order to provide an equivalent treatment of soldiers. This can be seen in much the same way that the surgeon gains expertise by oncologic indications for necessary surgical interventions in the context of military missions.

In addition, the principle should be observed that soldiers are entitled to the same medical services in the context of medical care as in the civilian sector. The identification and solution of drug-related problems, especially in the field of oncology, is currently considered standard in the civilian sector. Therefore, we intended to use this study to prove that the service is also adequately implemented in the military sector.

We see a main limitation that should be considered when drawing conclusions from the results of this study: the values collected in a 400-bed hospital during a compounding process should not be uncritically transferred to other settings especially when medical specialties different from ours and when highly specialised centers are involved.

CONCLUSION

This study points out the clinical relevance of interventions of pharmacists in oncological prescriptions and the importance of clinical pharmaceutical services to prevent prescribing problems. The insights gained here contribute to a more effective and time efficient consultation in order to protect the patient. What is more, they contribute to the optimization of drug safety in chemotherapy.

ABSTRACT

Objectives
The aim of this study was to evaluate the role of military pharmacists in oncological therapy at the Bundeswehr Hospital Hamburg and to identify the impact of clinical pharmaceutical services to prevent prescribing problems.

Methods
We assessed compounded chemotherapy protocols over 36 months in our 400-bed hospital. The pharmacy supplied internal medicine and urological units with chemotherapy formulations including monoclonal antibodies. The compounding process was carried out according to a current standard procedure based on external international standards and literature. Within the scope of the legally required plausibility check, prescribing problems were identified and classified on the basis of 8 predefined categories. In order to solve the identified and classified problems, also patient files were used and the attending physicians were contacted if necessary. The compounding was only carried out when all identified prescribing problems had been solved and the plausibility check remained unobjectionable.

Results
A total of 1,007 prescriptions of adult patients (soldiers and civilians) were analysed. The military pharmacists identified 140 prescription problems: 13.9% of therapy cycles were affected by at least one prescribing problem. In median 6 (Q25: 3; Q75: 10) prescribing problems per month were solved in the 32 (Q25: 28; Q75: 39) compounding processes per month in median. Most frequently prescribing problems were identified and solved in the categories "drug dosage" (2.7%), "patient data" (2.7%), and "co-medication" (2.5%). Our investigation showed that no direct link could be

established between a certain active substance and a specific prescribing problem.

Conclusions

This study points out the clinical relevance of interventions of pharmacists in oncological prescriptions and the importance of clinical pharmaceutical services to prevent prescribing problems.

WHAT THIS PAPER ADDS?

What is already known on this subject?

- The complexity of a cytostatic therapy is responsible for numerous drug-related problems such as prescribing problems for inpatients.
- Compounding of patient-individualised cytostatic drugs by pharmacists has been established as an essential factor in quality assurance.

What this study adds?

- Military Pharmacists contribute to safer medication of specific oncological formulations for inpatients. 140 of 1,007 analysed compounding processes (13.9%) were affected by at least one prescribing problem.
- Prescription problems were identified and resolved in the categories "drug dosage", "patient data" and "comedication" as the most common problems.

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COMPETING INTERESTS

None declared.

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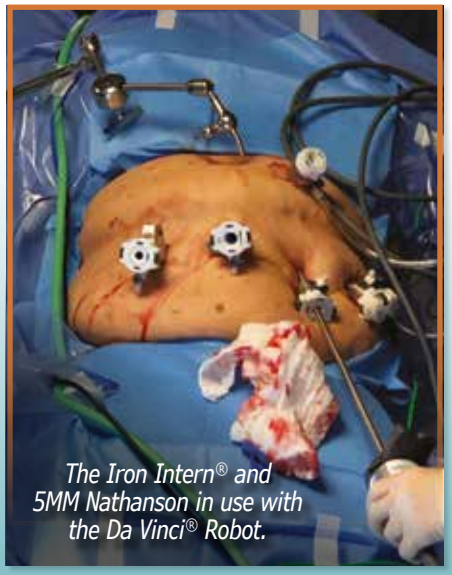

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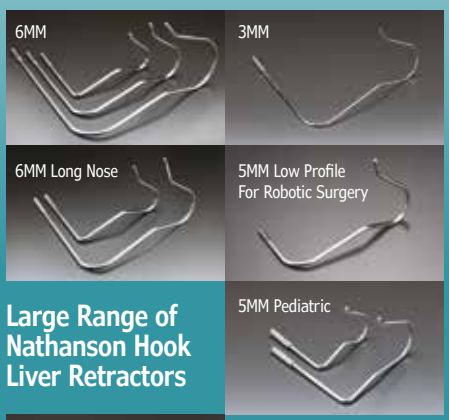

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