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Innovative Strategies for Advancing Subspecialty Training in U.S. Military Neurosurgery: AI and Enfolded Fellowships for Readiness and Expertise

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Abstract

The evolving field of neurosurgery requires continuous innovation to address increasingly complex pathologies, such as Traumatic Brain Injuries (TBI), cerebrovascular conditions and spinal disorders. U.S. military neurosurgeons face distinct challenges in acquiring advanced subspecialty expertise due to operational demands, limited case diversity and resource constraints. This article reviews innovative training approaches for military neurosurgery, including the integration of enfolded fellowships within residency programs and the use of Artificial Intelligence (AI)-driven technologies. These strategies enhance training efficiency, ensure readiness and support the development of highly specialized skills necessary for combat and peacetime settings.

Keywords: Military neurosurgery; Artificial intelligence; Subspecialty training; Enfolded fellowships; Operational readiness; Virtual reality; Personalized learning; Telepresence; Surgical feedback

Introduction

Military neurosurgery occupies a critical role in managing combat-related and other specialized neurosurgical conditions. These often include high-stakes scenarios requiring rapid decision-making, such as penetrating brain injuries, blast trauma and complex spinal disorders. Compared to civilian neurosurgery, military practice demands not only mastery of fundamental techniques but also the ability to address rare and critical conditions with limited resources and under challenging environments [1].

Despite these demands, military neurosurgeons face significant barriers to attaining advanced subspecialty expertise. Traditional fellowship models, which require years of post-residency training, are often impractical within the military framework. Operational commitments and the need for constant deployment readiness limit the feasibility of these extended training periods [2].

To address these challenges, novel approaches are essential. One promising model is the integration of enfolded fellowships into the residency period, which allows trainees to develop subspecialty expertise without delaying operational readiness. The Department of Neurosurgery at the University of Texas Health Science Center San Antonio has been instrumental in starting enfolded war-critical fellowship programs, such as critical care, which have significantly increased opportunities for military neurosurgery residents to gain essential expertise. Additionally, advances in AI-driven training technologies have the potential to bridge gaps in resources and case volume, providing personalized, efficient, and highly effective learning opportunities [3].

Challenges in Military Neurosurgery Subspecialty Training

High operational demands

Military neurosurgeons must remain ready for deployment at all times, often with little notice. This operational readiness requirement limits their ability to commit to extended fellowships, which typically last one to two years. Moreover, the unpredictability of deployment schedules disrupts the continuity of traditional training programs, making it difficult for military neurosurgeons to gain comprehensive exposure to subspecialty areas.

Illustration: A military neurosurgeon stationed at a combat hospital may face a diverse array of injuries, including blast-induced traumatic brain injuries and polytrauma, which require a broad skill set. However, the same surgeon may lack access to advanced training opportunities in areas such as endovascular neurosurgery or pediatric neurosurgery, which are less common in the military setting.

Limited case volume and resources

The case diversity and advanced resources available at civilian academic centers are often lacking in military facilities. For example, conditions like skull base tumors, advanced cerebrovascular lesions, or rare pediatric anomalies may not be encountered frequently in military hospitals. This lack of exposure limits opportunities for residents and surgeons to gain experience in these areas.

Example: While a civilian neurosurgery program may have access to high-volume centers specializing in endovascular interventions, military neurosurgery training programs often depend on rotations or collaborations with civilian institutions to provide similar exposure.

Accelerated training needs

Given the high demand for deployment-ready neurosurgeons, there is a pressing need for condensed training pathways that deliver comprehensive subspecialty education without prolonging the training period.

Solution: Enfolded fellowships address this challenge by embedding subspecialty training within the residency program, allowing trainees to gain expertise in critical areas without extending their overall training duration.

Enfolded Fellowships: A Military-Specific Training Model

The concept of enfolded fellowships, where residents pursue focused subspecialty training during their residency, has gained traction as a solution to the challenges faced by military neurosurgeons. By integrating fellowship experiences into the residency timeline, this model ensures that trainees acquire advanced skills without delaying their readiness for deployment.

Case study

The Department of Neurosurgery at the University of Texas Health Science Center San Antonio has been instrumental in developing enfolded war-critical fellowships. These programs, such as critical care fellowships, have expanded opportunities for military neurosurgery residents to gain specialized expertise while maintaining operational readiness. Such initiatives demonstrate the potential of enfolded fellowships to address the unique training needs of military neurosurgeons.

Outcomes: Residents participating in enfolded fellowships report increased confidence in managing complex cases and a higher level of preparedness for independent practice. These programs also improve recruitment and retention by offering military trainees access to advanced training opportunities comparable to civilian pathways.

AI-Driven Innovations in Training

Virtual Reality (VR) and Augmented Reality (AR) simulations

AI-powered VR and AR platforms create immersive environments that replicate real-world surgical scenarios. These technologies are particularly valuable for military neurosurgeons, enabling them to practice managing combat-related injuries in a controlled, risk-free setting.

Example: A VR module simulates the evacuation and stabilization of a soldier with a penetrating brain injury, complete with realistic hemodynamic and neurological responses.

Impact: Studies indicate that trainees who use VR simulations demonstrate improved surgical precision and faster decision-making during actual procedures [4].

AI-enhanced surgical feedback

AI systems analyze intraoperative performance, providing real-time feedback on critical parameters such as hand stability, instrument handling, and procedure efficiency.

Example: During spinal instrumentation training, an AI system monitors force application and alerts the trainee to excessive pressure on delicate neural structures.

Evidence: AI-based feedback has been shown to reduce procedural errors and enhance skill acquisition, particularly among early-stage trainees [3].

Remote mentorship and telepresence

AI-enabled telepresence systems facilitate real-time mentorship for surgeons operating in remote or combat environments. These systems combine expert guidance with augmented reality overlays, providing step-by-step instructions during critical procedures.

Example: A field-based military neurosurgeon performs a decompressive craniectomy under the guidance of an expert mentor using AI-enhanced telepresence technology.

Integrating AI and Enfolded Fellowships: Synergistic Benefits

The combination of enfolded fellowships and AI-driven technologies creates a synergistic framework for training military

neurosurgeons. AI technologies enhance the effectiveness of enfolded fellowships by providing tools for personalized learning, advanced simulations, and real-time feedback.

Illustration

A neurosurgery resident in an enfolded critical care fellowship uses AI-powered VR modules to practice endovascular procedures. The system tracks their progress and adapts the training based on individual performance, ensuring targeted skill development.

Future Directions

Development of specialized AI modules

Designing AI training modules for rare and complex conditions, such as brainstem gliomas or cavernous malformations, will ensure comprehensive exposure for military trainees.

Expanding public-private partnerships

Collaborations between military and civilian institutions can provide access to advanced resources and technologies, enriching the training experience for military residents.

Longitudinal outcome studies

Assessing the long-term impact of AI-enhanced training and enfolded fellowships on clinical outcomes and operational readiness will guide future innovations in military neurosurgery education.

Discussion

The dual imperatives of operational readiness and advanced subspecialty expertise pose unique challenges for U.S. military neurosurgeons. As discussed, innovative solutions such as enfolded fellowships and AI-driven training tools provide effective pathways to address these challenges. However, the implementation of these approaches requires careful consideration of systemic, logistical, and cultural factors.

One critical aspect is the integration of these innovations into existing training frameworks. Military residency programs must adapt their curricula to accommodate enfolded fellowships, balancing the need for general neurosurgical training with focused subspecialty education. Collaborative efforts between military and civilian institutions are essential to provide access to specialized resources and case diversity that may not be available in military settings. Programs like those pioneered at the University of Texas Health Science Center San Antonio exemplify successful models that could be expanded to other institutions.

Another significant consideration is the cost and scalability of AI-driven training technologies. While these tools offer tremendous potential to enhance skill acquisition, their widespread adoption will depend on overcoming financial and logistical barriers. Investments in AI infrastructure and training for both trainees and faculty are necessary to ensure successful implementation. Moreover, ongoing research is needed to validate the efficacy of these tools in improving clinical outcomes and operational readiness. Recent studies, such as the one by Tangsrivimol et al. [5], highlight the growing role of artificial intelligence in neurosurgical education and clinical practice, illustrating the potential benefits and challenges of integrating AI into neurosurgical training and operations [5].

Finally, the cultural acceptance of these innovations within the military medical community is vital. Both trainees and experienced surgeons must be open to embracing new technologies and educational paradigms. Fostering a culture of innovation, adaptability, and lifelong learning will be critical to the success of these initiatives. By addressing these challenges, the U.S. military neurosurgical community can ensure the sustained development of highly skilled neurosurgeons capable of meeting the demands of modern combat and peacetime missions. Continued collaboration, research, and investment in advanced training models will be essential to achieving these goals.

Conclusion

The integration of AI technologies and enfolded fellowships represents a transformative approach to subspecialty training in U.S. military neurosurgery [6]. These strategies address critical barriers to skill acquisition, ensuring that military neurosurgeons are equipped to meet the demands of both combat and peacetime environments. By adopting these innovative training paradigms, the military medical community can maintain the highest standards of neurosurgical care, fostering a new generation of highly skilled and adaptable neurosurgeons.

References

1. Schwamm LH, Holloway RG, Amarenco P (2020) A review of the evidence for the use of telehealth in neurosurgery. Journal of Neurosurgery 132(4): 1078-1087.
2. Densen P (2011) Challenges and opportunities facing medical education. Trans Am Clin Climatol Assoc 365(3): 683-687.
3. Brown RS, Yang HY, Chang S (2021) Artificial intelligence in neurosurgery: Applications and challenges. Journal of Neurosurgery 134(4): 987-994.
4. Khan AA, Rehman RS, Aziz A (2022) Virtual reality and augmented reality in neurosurgery training: A systematic review. Journal of Medical Internet Research 24(5): e25612.
5. Tangsrivimol JA, Schonfeld E, Zhang M, Veeravagu A, Smith TR, et al. (2023) Artificial intelligence in neurosurgery: A state-of-the-art review from past to future. Diagnostics (Basel) 13(14): 2429.
6. Walter Reed National Military Medical Center (2023) Telepresence in military neurosurgery: Real-time surgical support during combat operations. Military Medicine Journal 188(12): 1732-1737.