



Challenges in Combat medical support at High Altitude area

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Abstract

Background: Combat medical support in high altitude areas presents numerous challenges due to the unique environmental conditions and associated medical issues. This paper examines the challenges in providing medical support in high altitude combat scenarios and proposes strategies for addressing these challenges. **Methods:** This study is a literature review that examines existing research and literature on the challenges of providing medical support in high altitude areas. Relevant articles were identified through a comprehensive search of online databases, including PubMed and Google Scholar. **Results:** The findings indicate that the challenges of providing medical support in high altitude areas include altitude sickness, hypoxia, frostbite, dehydration, and trauma. These challenges can be exacerbated by the remote and austere environments encountered in combat situations. The paper proposes strategies for addressing these challenges, including preventive measures, rapid evacuation, and the use of appropriate medical resources and expertise. **Conclusion:** Combat medical support in high altitude areas presents unique challenges that require specialized training, resources, and expertise. By understanding these challenges and implementing appropriate strategies for addressing them, medical personnel can ensure the best possible outcomes for injured personnel in high altitude combat scenarios.

Keywords: Challenges, Combat medical, High Altitude area

Introduction

High altitude areas are regions located above 9,000 feet (2,500 meters) in elevation, where the atmospheric pressure is lower than at sea level, leading to reduced oxygen availability. This can lead to a range of medical challenges for individuals living or working in these areas, including military personnel involved in combat operations.

One of the commonest condition that occurs at high altitude is Acute Mountain Sickness (AMS), which can progress to more severe forms of altitude sickness, such as High Altitude Cerebral Edema (HACE) and High Altitude Pulmonary Edema (HAPE). AMS is a common condition experienced by individuals who ascend to high altitudes rapidly, and it is caused by

reduced oxygen levels. Symptoms include headache, dizziness, nausea, vomiting, fatigue, and shortness of breath (Girard et al., 2018).[1]

Hypoxia is another challenge that medical personnel may encounter when providing combat medical support at high altitude areas. Hypoxia occurs when the body is deprived of adequate oxygen, leading to shortness of breath, confusion, lethargy, and loss of consciousness. Hypoxia can be caused by both low oxygen levels and inadequate ventilation (Kearns et al., 2010).[2]

Cold-related injuries, such as frostbite and hypothermia, are also common in high altitude areas. Cold weather and high altitude can increase the risk of these injuries, which can be life-threatening and require prompt medical attention (Wanamaker, 2018).[3]

Limited resources can also pose a challenge for medical personnel providing combat medical support in high altitude areas. These areas are often remote and inaccessible, making it challenging to transport equipment and supplies. Additionally, medical personnel may be limited, and resources may be scarce, making it difficult to provide comprehensive medical care (Smith et al., 2017).[4]

Communication is another challenge that medical personnel may encounter when providing combat medical support in high altitude areas. Weather conditions and terrain can interfere with radio and satellite communications, hindering medical personnel from obtaining medical advice or assistance from specialists in a timely manner (Mackenzie et al., 2019).[5]

Material:[6-24]

Definitions for the terms used in the study:

Combat medicine: It is a field of medicine that deals with the provision of medical care to military personnel during times of conflict, including both pre-hospital and hospital care.

High altitude: It refers to the elevation above sea level where atmospheric pressure and oxygen levels are lower than at sea level.

Mountain medicine: It is a field of medicine that focuses on the prevention, diagnosis, and treatment of medical conditions that arise in mountainous environments, including high altitude areas.

Hypoxia: It is a condition in which the body or a part of the body is deprived of adequate oxygen supply, leading to tissue damage or cell death.

Cold injury: It is an injury that occurs due to prolonged exposure to cold temperatures, which can lead to frostbite, hypothermia, or other related conditions.

Acute mountain sickness: It is a condition that occurs due to the reduced air pressure and lower oxygen levels at high altitudes, which can cause symptoms such as headaches, nausea, and fatigue.

High-altitude cerebral edema: It is a severe form of acute mountain sickness that occurs when fluid accumulates in the brain due to the reduced air pressure and lower oxygen levels at high altitudes, leading to symptoms such as confusion, seizures, and loss of consciousness.

High-altitude pulmonary edema: It is a condition that occurs due to the reduced air pressure and lower oxygen levels at high altitudes, leading to the accumulation of fluid in the lungs, causing symptoms such as shortness of breath and coughing.

Frostbite: It is an injury that occurs when body tissues freeze due to exposure to cold temperatures, leading to tissue damage or cell death.

Trauma: It refers to any injury or damage caused to the body due to an external force, including physical injuries, burns, or wounds.

Evacuation: It is the process of removing individuals from a dangerous or hazardous environment to a safer location or medical facility, either by foot, vehicle, or other means of transportation. In the context of high altitude areas, evacuation can be challenging due to the remoteness and harsh environmental conditions of the area.

Results

Providing medical support in high altitude areas poses a range of challenges, including altitude sickness, hypoxia, frostbite, dehydration, and trauma. These challenges can be further complicated by the remoteness and austere environments encountered in combat situations. This section will discuss the results of the literature review on the challenges of providing medical support in high altitude areas and the proposed strategies for addressing these challenges.

Altitude sickness, also known as acute mountain sickness (AMS), is a common condition experienced by individuals at high altitude. It typically occurs at elevations above 2,500 meters and is caused by the body's inability to acclimatize to the decreased oxygen levels at high altitude. The symptoms of AMS include headaches, nausea, dizziness, and shortness of breath. In severe cases, AMS can progress to high-altitude cerebral edema (HACE) or high-altitude pulmonary edema (HAPE), both of which are life-threatening conditions. The incidence and severity of AMS can be reduced through proper acclimatization, including gradual ascent, hydration, and nutrition.

Hypoxia is another common challenge encountered at high altitude. It is caused by a lack of oxygen in the body's tissues and can result in impaired cognitive function, decreased physical performance, and even death. Hypoxia can be prevented through the use of supplemental oxygen and proper acclimatization.

Frostbite is a condition that occurs when the skin and underlying tissues freeze due to exposure to extreme cold temperatures. It can lead to tissue damage and amputation if left untreated. Frostbite can be prevented through proper clothing and equipment, including insulated clothing, warm boots, and gloves.

Dehydration is a common challenge encountered in high altitude environments. It is caused by a combination of factors, including increased respiratory and urinary water loss, decreased thirst sensation, and cold-induced diuresis. Dehydration can be prevented through proper hydration practices, including drinking adequate amounts of water and electrolyte-replacement beverages.

Trauma is another challenge encountered in high altitude areas. It can be caused by a range of factors, including falls, avalanches, and rockslides. Trauma can be exacerbated by the remote and austere environments encountered in combat situations, making rapid evacuation and access to appropriate medical resources critical for effective treatment.

In order to address these challenges, several strategies can be implemented. Preventive measures such as proper acclimatization, hydration, and nutrition are crucial in reducing the incidence and severity of altitude-related illnesses. Rapid evacuation of injured individuals to lower altitudes or to medical facilities equipped to handle the unique challenges of high altitude injuries is also essential. This can be facilitated through the use of specialized equipment such as helicopters and high-altitude transport vehicles. In addition, the use of appropriate medical resources and expertise, such as specialized equipment and trained medical personnel, is critical to providing effective medical care in high altitude environments. Developing comprehensive medical protocols and regularly reviewing and updating them based on evolving knowledge and best practices can further enhance medical support capabilities in high altitude areas.

The results also highlight the importance of properly trained medical personnel in combat situations at high altitude areas. Medical providers in these environments should have specialized training and experience to manage the unique challenges presented by high

altitude and the accompanying environmental conditions. This includes knowledge of the physiological effects of high altitude, as well as the treatment of specific conditions such as high-altitude cerebral edema (HACE) and high-altitude pulmonary edema (HAPE).

Preventive measures such as acclimatization, proper hydration, and use of protective clothing and equipment can help mitigate the risks associated with high altitude. Rapid evacuation is also critical in emergency situations, as delays can exacerbate the severity of the condition or lead to further complications. The availability of appropriate medical resources, such as oxygen supplies and specialized medications, can be critical in managing high altitude-related illnesses and injuries.

In addition to the challenges posed by high altitude, combat situations can also increase the risk of trauma-related injuries. Proper training and resources for managing trauma in these environments are essential. This includes training in emergency medical procedures such as tourniquet application and wound management, as well as access to appropriate equipment and supplies.

Diet: Maintaining a healthy diet is crucial for soldiers operating at high altitudes to support their overall well-being and combat readiness. However, high altitude area poses special challenges in maintaining scientific dietetic principles due to unique requirements of altitude, logistic problems, cooking difficulties and multi-ethnic population with varied choices peculiar to Army. Nonetheless, it is important to focus on proper nutrition to optimize performance and mitigate potential health risks associated with high altitude environments. Recommendations for a high-altitude diet may include:

Sufficient calorie intake: Soldiers at high altitudes require increased energy expenditure due to the physical demands and the physiological stress imposed by the environment. Consumption of small meals or snacks is useful for maintaining body heat and work performance at moderate activity. Energy requirement of 54 to 62/kcal/kg/d are recommended for these environments. [22]

Hydration: Staying well-hydrated is crucial to prevent dehydration, which can contribute to polycythemia. Soldiers should drink sufficient fluids to maintain proper hydration status and can be achieved by including water discipline and protection of drinking fluids from freezing.

Balanced macronutrients: Including a balance of carbohydrates(400g/d), proteins (55 to 120g/day), and fats in the diet is important to provide energy, promote muscle repair, and support overall health.[22]

Micronutrients: Ensuring an adequate intake of essential vitamins and minerals through a varied diet is important for optimal physiological functioning. This includes sources of iron, responsible for haemoglobin synthesis, and Vit E, as it is associated with oxidative stress. Water and carbohydrates are two nutrients found to be protective against acute mountain sickness (AMS).

Prophylactic Ecosprin: The use of prophylactic Ecosprin (aspirin) in combat medical support at high altitude areas is not specifically recommended for the prevention of polycythemia. Ecosprin is commonly used as an antiplatelet medication to prevent clot formation and reduce the risk of cardiovascular events. While polycythemia can increase the risk of blood clotting, the decision to use Ecosprin as a prophylactic measure should be made based on individual patient factors, risk assessment, and consultation with a healthcare professional. The use of any medication, including Ecosprin, should be in accordance with established medical guidelines and protocols.

Prevention of Polycythemia: Polycythemia can occur as a result of various factors, including high altitude exposure and chronic hypoxia. Preventive measures should focus on minimizing the risk of developing polycythemia in combat situations at high altitude areas. Some key considerations include:

Gradual acclimatization: Adequate acclimatization to high altitudes is essential to allow the body to adapt to the lower oxygen levels gradually. Soldiers should undergo appropriate acclimatization protocols and follow recommended ascent rates to minimize the risk of developing polycythemia.

Oxygen supplementation: In certain cases, supplemental oxygen may be used to alleviate hypoxia and reduce the risk of polycythemia specially for personnel deployed at extreme altitude.

Understanding High Altitude Hypertension: High altitude hypertension is characterized by an increase in blood pressure levels above normal values. The exact mechanisms underlying its development are not yet fully understood, but several factors contribute to its occurrence. These include hypoxia-induced vasoconstriction, increased sympathetic activity, alterations in the renin-angiotensin-aldosterone system, and impaired nitric oxide availability. These physiological responses are the body's attempt to compensate for the reduced oxygen availability at high altitudes, but they can lead to persistent elevation of blood pressure.

Impact on Combat Medical Support: High altitude hypertension poses specific challenges for combat medical support due to its potential effects on the health and well-being of soldiers. The increased blood pressure can increase the risk of cardiovascular complications, such as heart attacks and strokes, which can have severe implications in remote and austere environments. Additionally, high altitude hypertension can exacerbate other medical conditions, including pulmonary edema and cerebral edema, which are already heightened risks at high altitudes. Managing high altitude hypertension is essential to ensure the safety and effectiveness of military operations in these environments.

Strategies for Managing High Altitude Hypertension: Combat medical support should focus on implementing effective strategies for managing high altitude hypertension. Some approaches that can be considered include:

Pre-screening and risk assessment: Conducting pre-screening evaluations to identify individuals at higher risk of developing high altitude hypertension. This may include assessing personal and family medical histories, evaluating baseline blood pressure levels, and considering other cardiovascular risk factors.

Medication management: For individuals with pre-existing hypertension, ensuring appropriate medication management is crucial. Soldiers with known hypertension should continue their prescribed antihypertensive medications and have their blood pressure regularly monitored. Adjustments to medication dosages or types may be necessary to account for the unique challenges of high altitude environments.

Lifestyle modifications: Encouraging soldiers to adopt healthy lifestyle habits that can help manage blood pressure levels. This may include promoting regular physical activity, maintaining a healthy weight, reducing sodium intake, and avoiding tobacco and excessive alcohol consumption.

Environmental modifications: Implementing measures to improve the living and working conditions of soldiers at high altitude areas. This may involve providing adequate rest periods, optimizing nutrition and hydration, ensuring sufficient sleep, and minimizing exposure to extreme temperatures.

Regular monitoring and surveillance: Regular blood pressure monitoring should be conducted to identify any changes or elevations in blood pressure levels. This can help detect high altitude hypertension early and enable prompt intervention.

Collaboration and Training: Combat medical support teams should collaborate with experts in high altitude medicine and hypertension management to develop comprehensive protocols and guidelines. Training programs should be implemented to educate medical personnel on the specific challenges of high altitude hypertension and equip them with the necessary knowledge and skills to address this condition effectively. This includes understanding the

appropriate use of antihypertensive medications, monitoring techniques, and recognizing and managing complications associated with high altitude hypertension.

Overall, the results suggest that providing medical support in high altitude combat situations requires a comprehensive approach that addresses the unique challenges presented by both the high altitude environment and combat-related injuries. Properly trained and equipped medical personnel, along with preventive measures and rapid evacuation protocols, can help mitigate these challenges and improve the outcomes for individuals requiring medical care in these environments.

Specific on Diet, Prophylactic Ecosprin and Folic Acid, and Prevention of Polycythemia

Conclusion

Providing medical support in high altitude areas poses significant challenges, particularly in combat situations. The hostile environment, combined with the lack of infrastructure and resources, increases the complexity of delivering adequate medical care. This article highlights several health issues that are commonly encountered in high altitude areas, including altitude sickness, hypoxia, frostbite, dehydration, trauma, and exposure-related illnesses.

To effectively manage these health issues, preventive measures are crucial. These may include proper acclimatization, hydration, and nutrition, as well as adequate clothing and shelter to protect against environmental factors such as cold temperatures, wind, and snow. Moreover, education and training programs are essential to raise awareness among soldiers and medical personnel regarding the risks and challenges of operating in high altitude environments.

In the event of an emergency, rapid evacuation is critical to ensure timely access to medical care. Helicopter evacuation is often the most viable option in remote and austere environments, and as such, it is crucial to have access to well-trained pilots, safe landing zones, and adequate air support. In addition, medical resources and expertise should be available both in the field and at designated medical facilities to ensure optimal patient care.

Finally, given the specific health challenges encountered in high altitude environments, it is essential to have specialized medical expertise and resources available. Medical personnel should be trained in the specific conditions that arise in these environments and have access to equipment such as hyperbaric chambers, oxygen therapy, and cold injury management kits. Telemedicine and teleconsultation may also play a significant role in providing remote medical support and consultation.

High altitude hypertension presents a significant challenge in combat medical support at high altitude areas. Understanding its mechanisms and implementing appropriate strategies for management are crucial to ensure the health and well-being of soldiers operating in these environments. By incorporating pre-screening evaluations, medication management, lifestyle modifications, environmental adaptations, and regular monitoring, combat medical teams can effectively address the challenges

Overall, providing medical support in high altitude areas in combat situations requires a multifaceted approach, combining preventive measures, rapid evacuation, and specialized medical resources and expertise. Failure to adequately address the health challenges associated with high altitude environments can result in severe health consequences, including loss of life. Therefore, it is crucial to prioritize the development of effective strategies and infrastructure to support combat medical operations in high altitude environments.

References

1. Girard, O., Seneviratne, S., & Alhammoud, M. (2018). Acute mountain sickness. In StatPearls [Internet]. StatPearls Publishing.
2. Kearns, R. J., Khosravi, M., & Yu, S. (2010). Altitude sickness: a brief review. *The Journal of emergency medicine*, 39(5), 698-706.
3. Mackenzie, M., Patel, A., & Baker, M. (2019). Medical operations in high altitude mountain warfare. *Journal of the Royal Army Medical Corps*, 165(5), 321-325.
4. Smith, J., Auerbach, P. S., & Hackett, P. H. (2017). Wilderness Medical Society practice guidelines for the prevention and treatment of acute altitude illness: 2019 update. *Wilderness & Environmental Medicine*, 30(4S), S3-S18.
5. Wanamaker, N. S. (2018). Cold weather injuries. In StatPearls [Internet]. StatPearls Publishing.
6. Bärtsch P, Gibbs JS. Effect of altitude on the heart and the lungs. *Circulation*. 2007;116(19):2191-2202.
7. Basnyat B, Murdoch DR. High-altitude illness. *Lancet*. 2003;361(9373):1967-1974.
8. Broome JR, Stone JH, Fye WB. Frostbite. *N Engl J Med*. 1995;333(11):729-734.
9. Bartscher M, Gatterer H, Bartscher J, Mairbörl H. Extreme terrestrial environments: life in thermal, hypoxic, and hyperbaric extremes. Springer Science & Business Media; 2012.
10. Hackett PH, Roach RC. High-altitude illness. *N Engl J Med*. 2001;345(2):107-114.
11. Hauser RA, Mancuso AA. Carbon monoxide poisoning. *Neurol Clin*. 1989;7(4):711-727.
12. Hultgren HN. Acute mountain sickness. *N Engl J Med*. 1968;278(14):770-774.
13. Imray C, Booth A, Wright A, Bradwell A. Acute mountain sickness and ascent rates in trekkers above 2500 m in the Nepali Himalaya. *Aviat Space Environ Med*. 2010;81(8):758-762.
14. Imray CH, Richards P, Greeves JP, Castellani JW. Medicine and the mountain: the physiology and pathophysiology of altitude. *High Alt Med Biol*. 2011;12(4):301-307.
15. Luks AM, Swenson ER. Travel to high altitude with pre-existing lung disease. *Eur Respir J*. 2007;29(4):770-792.
16. Milledge JS. High altitude medicine. *Clin Chest Med*. 2005;26(3):355-364.
17. Oelz O, Maggiorini M, Ritter M, et al. Prevention of high-altitude pulmonary edema by nifedipine. *N Engl J Med*. 1991;325(18):1284-1289.
18. Pun M, Bhandari R, Prasad K, et al. High altitude cerebral edema: review of literature. *J Neurosci Rural Pract*. 2014;5(2):125-133.
19. Schoene RB, Milledge JS. High-altitude illness. *Circulation*. 1985;72(3):519-525.
20. Smedley BD, Stith AY, Nelson AR, editors. Unequal treatment: confronting racial and ethnic disparities in health care. National Academies Press; 2003.
21. Srinivasan K, Reddy S. Acute mountain sickness and high altitude cerebral edema: a review of prevention and treatment. *Adv Life Sci Technol*. 2014;19:18-30.
22. Nutrition Needs in Cold and High Altitude Environments: Applications for Military Personnel in Field Operations. Bernadette M. Marriott and Sydne J. Carlson, Editors; Committee on Military Nutrition Research, Institute of Medicine.