Wound healing at high altitude: What effect does hypobaric hypoxia have on physiological response to tissue damage? A Narrative Review

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MSc Extreme Medicine
Independent Research Project: HPDM148

Introduction

High altitude environments are popular amongst travellers, and challenging terrains combined with fatigue increases the possibility of injury on expeditions. Tissue healing is a complex process reliant on oxygen (1,2,3) and it is presumed the process may be impaired in hypobaric hypoxic environments, however limited large-scale trials clearly demonstrate this hypothesis in the high-altitude environment. This narrative review looks at:

1. The role of oxygen in the wound healing process;
2. How this process is impaired in hypobaric hypoxia;
3. How known physiological acclimatisation mechanisms may affect wound healing at altitude.
4. A study design for future research will be proposed to test the hypothesis that wound healing is impaired in high altitude hypoxic environments compared to sea level

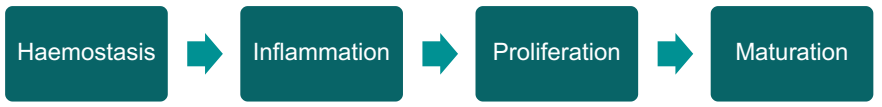

Fig. 1: Four stages of wound healing (1,2,3)

Aims & Methods

The aim is to question whether wound healing is impaired at altitude, why this could be, and whether acclimatisation mechanisms could be protective for the process following prolonged exposure to high-altitude.

Widely accessible published literature was used to summarise current understanding of the role of oxygen in wound healing, and physiological changes at altitude. The search engines "PubMed", "Medline", and "Google Scholar" were used to collect relevant articles. Primary search terms were: altitude; hypobaric hypoxia; acclimatisation; wound healing; tissue healing; and tissue perfusion. Animal studies were excluded.

Fig. 2: Physiological changes observed at altitude

Key Findings

Wound healing is known to be an oxygen dependent process made up of the 4 stages in Fig 1 (1,2,3). A key determinant of wound strength and longevity is quality and quantity of collagen, the production of which is oxygen dependent (4), therefore in hypoxic environments wounds are more prone to breakdown (as seen in critical illness and diseases where perfusion is impaired).

Physiological changes observed at altitude are summarised in Fig 2. These may represent positive adaptations where oxygen delivery is maintained in hypoxia (eg increasing Hb concentration), or illustrate physiological deterioration (eg chronic impairment in stroke volume).

From the literature search, one study was found which looked specifically at wound healing at altitude. This was a study in Saudi Arabia which found more complications from wound healing in their high-altitude clinic compared to clinics at sea level (5).

Recent studies on microcirculatory perfusion suggest that following acclimatisation to altitude, perfusion and therefore oxygen delivery to peripheral tissues were significantly improved compared to altitude naïve lowlanders.

- Davies et al (6) studied peripheral perfusion in sherpas (n=61) and native lowlanders (n=83), and found microvascular dilatation as well as oxygen offloading was significantly better in sherpas.
- Carey et al (7) completed a similar study with sherpas (n=46) and lowlanders (n=32). They found heterogenous perfusion associated with local vaso-control mechanisms to match oxygen supply with demand.
- Hansen et al (8) conclude this may be mediated by adrenergic pathways to restrain blood away from over-perfused areas

Conclusions

- Wound healing is a complex process that requires oxygen at multiple stages
- High altitude is a hypobaric hypoxic environment where oxygen delivery to tissues is impaired
- A study by Udeabor (5) demonstrated impairment in normal wound healing in a high-altitude clinic compared to sea-level clinics but more research is needed to demonstrate this on a larger scale – study design and key considerations are discussed.
- Physiological mechanisms explaining effect of hypobaric hypoxia on wound healing have been explored.
- Evidence for potential adaptations in acclimatized populations (increased haemoglobin concentration, changes to microcirculatory perfusion, genetic differences in HIF1-α expression) has been evaluated, with discussion on relevance to wound healing.

References

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