Sensor for Early Detection of Wound Infection

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Introduction

Infection is a common problem of surgical sites and chronic wounds resulting in prolonged hospital stays, non-healing wounds and increased mortality of patients. The identification of infection is a complex issue as not all signs such as redness (rubor), heat (calor), swelling (tumor), pain (dolor) and impairment of function (functiolaesa) can be consistently observed. Therefore, clinical examination by itself is not very reliable for the diagnosis of wound infection. A study, using quantitative biopsies of ulcers, showed that 28 % of participants had bacterial counts greater than 105 lacking clinical signs of infection [1]. As the recruitment of neutrophils is one of the earliest events in wound repair, analysis of neutrophil-derived enzymes could lead to a new perspective in wound status monitoring. Here, we present a new sensor-based strategy for fast diagnosis of wound infection based on the detection of neutrophil derived myeloperoxidase (MPO).

Methods

Electrochemical detection of hydrogen peroxide (H_2O_2) is used to determine the MPO enzyme activity in wound fluids and to assess the infection status of a wound. The system uses a working solution containing 200 µmol/l H_2O_2. Prior to the addition of wound fluid, the sensor baseline is recorded by measuring the working solution, giving a stable sensor current. Upon addition of wound fluid the sensor current drops due to the consumption of H_2O_2 by MPO, leading to a new equilibrium. The relative difference of the sensor signal between the two equilibria is used to calculate MPO-activity. Since the sensor signals are related to the working solution baseline, the system is virtually calibration-free.

The measuring system was tested in-vitro with test-solutions containing MPO activities from 0.025 to 3 U/ml in phosphate buffered saline solution (PBS) (Figure 2).

Measurement Procedure

- Collect 10 µl wound fluid
- Dilute in 100 µl 0.9 % NaCl solution
- Record sensor baseline
- Measure diluted wound fluid sample
- Calculate result

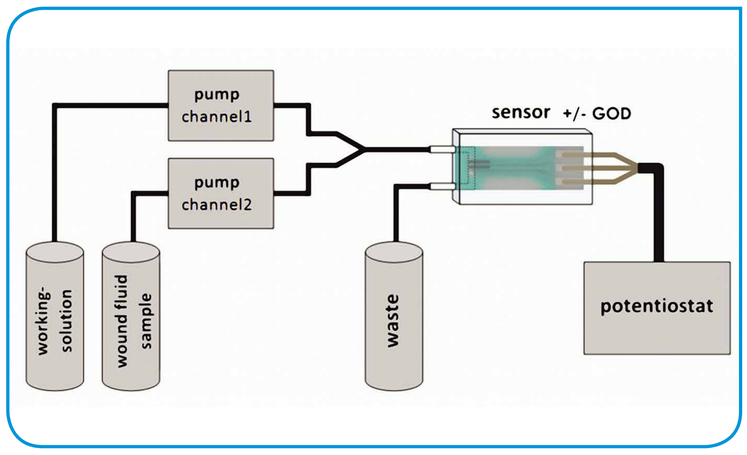

Figure 1: Scheme of the measurement system

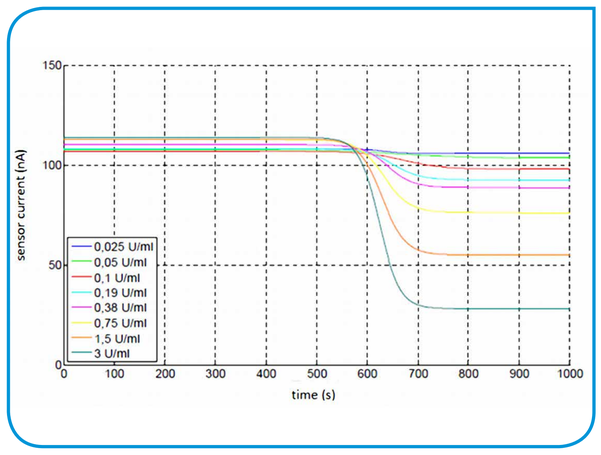

Figure 2: In vitro test results

Results

Wound exudates from post-operative wounds, ulcer and decubitus wounds were collected by swabbing the wound bed with a nylon swab followed by dilution in 0.9 % sodium chloride (NaCl) for further analysis. Wound fluids from blisters served as negative controls. The criteria for wound evaluation as infected/critical or non-infected (good healing) were based on a visual examination by a medical doctor. Wound fluid samples of infected and critical wounds showed significant elevated MPO activities, assessed as peroxidation- and chlorination activity of the enzyme (Figure 3).

15 different wound samples classified as infected, not infected or critical were measured with the new diagnostic tool. The difference between infected, critical and good healing samples was statistically significant for all shown measuring techniques. Consequently, the sensor is a suitable measurement tool to distinguish between critical and good healing wounds (Figure 4.)

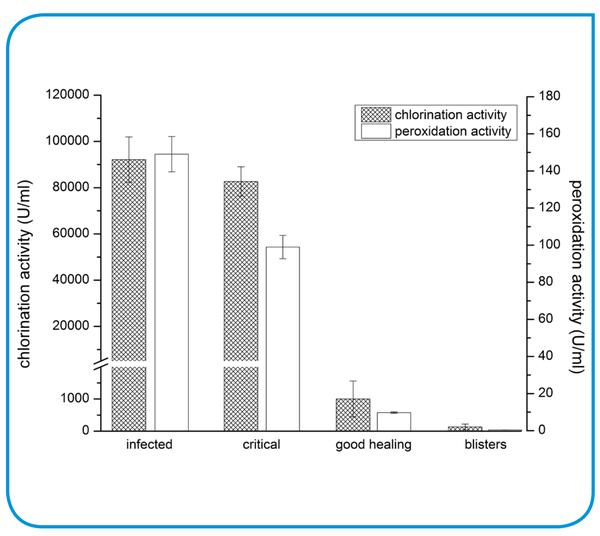

Figure 3: Elevated MPO activities in infected wounds

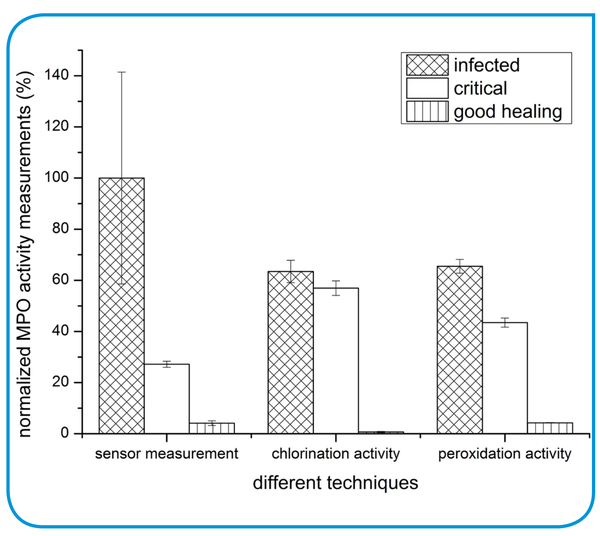

Figure 4: Sensor results compared to MPO assays

Discussion

Summarizing the results of this study, we have demonstrated the potential of a new sensor system for the detection of wound infection based on the electrochemical quantification of H_2O_2 consumed by MPO-chlorination activity. Future investigations including a larger clinical study could pave the way towards a new and **fast diagnostic system** for infection.

References

[1] T.E. Serena, J.R. Hanft, R. Snyder, The lack of reliability of clinical examination in the diagnosis of wound infection: preliminary communication., Int. J. Low. Extrem. Wounds. 7 (2008) 32–5.