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Aerosolized spread of bacteria and reduction of bacterial wound contamination with three different methods of surgical wound debridement: a pilot study

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SUMMARY

Background: Debridement is essential in wound treatment to remove necrotic tissue and wound bacteria, but may lead to the transmission of bacteria by aerosolization.
Aim: To investigate bacterial transmission and wound bacterial reduction induced by debridement using a cold steel curette, plasma-mediated bipolar radiofrequency ablation (Coblation®) or hydrodebridement (Versajet®) using a wound model inoculated with *Staphylococcus aureus*.
Methods: A full-thickness dermal wound was created in fresh porcine joint specimens, inoculated with *S. aureus* and incubated at 37 °C for 24 h. The specimens were surgically debrided with a curette, Coblation or Versajet, or were left untreated. During and after each debridement, aerosolized bacteria were measured by active and passive sampling. To assess the bacterial load of the wound, three quantitative swabs and one cylinder scrub sample were taken from each wound at baseline, post incubation and post debridement.
Findings: Versajet debridement resulted in significant bacterial aerosolization, but this was not the case when using a curette or Coblation. Only Coblation was able to reduce the bacterial load of the wound significantly.
Conclusion: Extra protective means should be implemented when using Versajet debridement for infected and colonized wounds. The same precautions may be less essential when using a curette or Coblation.

Introduction

Debridement is important in the care of acute and chronic wounds because it removes necrotic tissue and wound bacteria to improve the wound healing process.[1] Use of a cold steel curette is considered the gold standard debridement method, although several novel techniques have recently been introduced such as hydrosurgery debridement (Versajet®) and plasma-mediated bipolar radiofrequency ablation (Coblation®) debridement.[2,3]

A cold steel curette is the most common method for wound debridement as it only requires a curette and water for wound cleansing and the removal of visible necrotic wound material. This method is cheap and can often be performed by specially trained nurses with local anaesthesia and on an outpatient basis.

Coblation is a method for volumetric soft tissue removal established in several surgical fields (e.g. arthroscopy; spinal

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surgery; tumour resection; ear, nose and throat surgery).[4–7] The technique is based on inducing a bipolar radiofrequency current between two electrodes in a conductive medium, such as saline, and thus creating a physical plasma field that is able to break molecular bonds and dissolve tissue at relatively low temperatures.[8,9] Physical plasma is regarded as a distinct state of matter and is not to be confused with blood plasma. A previous study has shown that this technique has a general microbiocidal effect on microbes causing wound infection via a direct effect of the plasma field.[3] The Coblation probe has an integrated saline delivery tube that flushes saline continually over the electrodes, and a suction line for evacuation of saline and debrided wound material.

Versajet is a hydrosurgical device that uses a small fluid jet to create a surgical instrument. The high-pressure fluid jet is aimed directly into an evacuation tube that drains the fluid and debrided wound material.[10]

Safety aspects should always be considered when introducing new treatment methods. A previous study demonstrated that Versajet debridement increases air bacterial contamination with a potentially high risk of contaminating the peri-operative environment.[11] This potential risk for treatment-associated bacterial spread has, however, not been examined for Coblation or curette-mediated debridement.

The aims of the present study were to evaluate bacterial aerosolization and reduction of wound bacterial load induced by debridement using a cold steel curette, Coblation or Versajet using an ex-vivo porcine wound model inoculated with *Staphylococcus aureus*.

Methods

Twelve fresh porcine joint specimens were obtained and the skin was disinfected with 70% alcohol. A 75 × 75-mm full-thickness artificial dermal wound was created by sharp dissection of each specimen, and this was inoculated with 1 mL of approximately 10^6 colony-forming units (cfu)/mL of meticillin-susceptible *S. aureus* (CCUG 17621, Culture Collection University of Gothenburg, Sweden). The specimens were incubated in disinfected containers at 37 °C for 24 h, and divided into treatment groups with two specimens in each group.

Six different treatment regimens were used: (i) untreated control wound (positive control); (ii) cold steel curette; (iii) Coblation at default setting (7); (iv) Coblation at maximum setting (10); (v) Versajet at default setting (1); and (vi) Versajet at maximum setting (10). Active and passive aerosol sampling was also performed with no biological sample present (negative control).

The default settings of the Coblation and Versajet devices are the initial settings recommended by the manufacturers. The maximum settings of the devices have a greater effect, with higher bipolar voltage output for the Coblation device and higher saline jet flow for the Versajet device. The rationale for the maximum settings is to achieve more aggressive tissue removal.

The specimens were surgically debrided in a laboratory fume hood with no air flow. The hood was disinfected by washing all surfaces with 70% alcohol between each debridement. Curette debridement was performed by washing the wound with gauze and water, and then debriding using a 7-mm stainless steel curette (Integra Miltex, York, PA, USA), forceps and scissors. Debridements using Coblation (WoundWand®, ArthroCare corp., Austin, USA) and Versajet (Versajet® Exact 14 mm 45° hand piece, Smith & Nephew plc, London, UK) were performed in accordance with the manufacturers' instructions. The Coblation probe was connected to a Coblator IQ generator and the suction line was connected to a standard surgical suction unit with 275 mmHg of vacuum pressure. All methods of debridement involved two debridement passages over each area of the wound bed.

During and after each debridement, aerosolized bacteria were measured by active and passive sampling. Active sampling was performed with the bacterial air sampler Sartorius MD8 Airscan (Sartorius Stedim Biotech GmbH, Goettingen, Germany) with the air inlet positioned 0.2 m from the specimen and set at sampling 6.0 m^3/h. Air samples taken over 1 min (100 L) were obtained 0, 5, 15, 30 and 60 min after debridement commenced. Passive sampling was performed by placing four 90-mm Ø non-selective horse blood agar plates (Clinical Microbiology, Sahlgrenska University Hospital, Sweden) in the corners of the laboratory box, approximately 0.5 m from the wound. The plates were placed just before each debridement and collected 60 min after debridement started. Active and passive air sampling were also performed when no biological sample was present (negative control).

To assess wound bacterial load, three quantitative swabs and one cylinder scrub sample were taken from each wound at baseline (pre inoculation), post incubation and post debridement. Swabs were taken using Levine's technique for quantitative culture,[12] immersed in 1 mL of phosphate buffered saline (PBS) and then vortexed for homogenization. Cylinder scrubs[13,14] were obtained by placing a 26-mm Ø sterile steel cylinder on the wound surface and adding 1 mL of 0.1% Triton X in PBS, which was scrubbed on the wound surface with a sterile glass stirrer and then recovered by pipette. The samples were serially diluted and plated on blood agar plates. All agar plates were incubated aerobically at 37 °C for 24 h and the number of colonies was counted manually. Log cfu/m^3 was calculated from the results of the active sampling and log cfu/dm^2/h from the passive sampling. Log cfu/mL was calculated for the swab samples and cfu/cm^2 for the cylinder scrub samples. The primary aim of the study was to detect the spread of *S. aureus* in air and the number of bacteria in the wound; as such, no anaerobic cultures were performed.

One 8-mm punch biopsy was taken from each wound for histology at each time point (baseline, post incubation and post debridement) and fixed in neutral buffered 4% formaldehyde solution. The biopsies were dehydrated, embedded in paraffin, and 10-μm-thick slides were sampled from two different levels of each block with approximately 2000 μm between levels. These were stained according to a Gram-staining protocol. The histological slides were examined by an experienced pathologist fully blinded to the treatment group and sampling time point. The specimens were evaluated for focal clusters and/or defined layers of bacteria, and their position at the surface and/or in the deep tissue. The thickest clusters or layers of bacteria and the penetration depth in the tissue were then measured at three different measurement points on each section. This was undertaken using a microscope equipped with an eyepiece graticule calibrated against a micrometre slide.

For cylinder scrubs and swabs, comparisons were made in the changes of wound bacterial load post incubation and post