Application of ozone fumigation for controlling and managing a hospital outbreak caused by multi-drug resistant *Acinetobacter baumannii*

Safety, Efficacy and Feasibility

by

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Summary & Recommendations

In spring 2009 the ITU at Northwick Park Hospital experienced a major outbreak caused by *Acinetobacter baumannii* that resulted in closure of the ward. The spread came from a general surgical ward. All ITU patients were at some time colonised or infected and the clinical environment became heavily contaminated. The successful outbreak management consisted of environmental decontamination with ozone, isolation and decolonisation of patients, and segregation of staff. The ozone fumigation reduced the environmental contamination with *Acinetobacter baumannii* from 38.3 % to 5.7 % and after some adjustment *Acinetobacter baumannii* was completely eradicated from the environment. The general surgical ward was not approached with the same determination as staff were not segregated. Consequently, in spite of complete elimination of *Acinetobacter baumannii* from the environment the outbreak flared up now and then. It is concluded that the use of ozone fumigation is safe, efficient and feasible and it has been an essential tool in managing the outbreak. However, it must be supported by good infection control practices. Ozone fumigation may also be used against *Clostridium difficile* and other resistant bacteria.

Introduction

Ozone is widely used in industry and community and to some, to some degree, in medical treatment. It has only seldom been used in clinical, hospital environment[s]. Recently, researchers have focused on the implication within contaminated clinical environments and reports are appearing where the environment is cleaned with UV light or hydrogen peroxide vapour. Ozone is comparable to hydrogen peroxide vapour but has the distinct advantage that the area does not need to be emptied completely. It is possible to leave bed, linen and electronic devices in the area and thereupon include it in the decontamination process.

A recent outbreak caused by *Acinetobacter baumannii* was successfully managed and controlled by the use of ozone.

The aims of this report are to describe the technique for decontaminating a clinical hospital ward or bedroom by the use of ozone. It will also document the safety, efficacy and feasibility of the technique.

Materials

In addition to normal cleaning equipment the following are needed

- Ozone Ultra Pro 16 g/hr ozone generators with ozone destruct capability
- humidifier
- fans
- A UV Photometer for measuring ozone concentration within treatment area and handheld ozone monitors for scanning the perimeter
- ozone data collection software programme
- Heavy plastic and tape
- Microbiological laboratory support for culturing and identification of Acinetobacter *baumannii*.

Methods

Environment

The preparation of the clinical environment intended to be decontaminated is an essential part of the operation. The room should have a normal good aesthetic cleaning removing all splashes, dust, etc. that normally would impede the efficacy of ozone.

Obviously, no persons, patients or staff will be within the treatment area during the actual decontamination. However, it may be beneficial to leave equipment such as bed, commode, or electronic devices within the area for concomitant decontamination. The area should not be too cluttered as for example mattresses left on the floor will hinder decontamination of that part of the floor.

The air conditioning system should be switched off and the inlet and outlet should be sealed by heavy plastic and tape. Door openings and other air communications to clinical areas will also need to be sealed creating an enclosed unit for ozone treatment. It may be useful to establish artificial partitioning or a wall of plastic and wooden frames as it will ease the decontamination of larger departments.

The final step before the ozone decontamination is to raise the relative humidity to 70 – 80 % using a humidifier. One or more fans should also be used in order to distribute ozone evenly to all parts of the room. Ozone concentration should be monitored within as well as outside the treatment area. This will ensure bactericidal concentrations (approximately 5.0 ppm for 15 – 30 minutes) are realised and will prevent exposure of patients and staff to toxic levels (>0.05 ppm). Ozone monitors and alarms should therefore be placed within as well as adjacent to the treatment area.
At the end of the process ozone will be actively destructed and no people will be allowed in until the ozone concentration is less than 0.05 ppm.

Microbiology quality control

Ozone decontamination is considered for outbreaks where an excessive number of patients are colonised or infected with a multiresistant bacteria such as MRSA, ESBL, VRE and *Acinetobacter baumannii*. It may also be considered for *Clostridium difficile*. It follows that the rate of colonised or infected patients will always be known.

Microbiological samples from the clinical environment are collected before and after ozone treatment. The test sites are

- **NON-CLINICAL**
  - **nursing station, corridors, sitting room, sluice, etc**

- **BEDROOMS**
  - **direct contact areas**
    bed, floor, bed lamp,
  - **no touch areas or no direct contact areas**
    high on walls, ceiling, air condition inlet

The swabs were sampled from at least 25 cm^2 and placed directly in nutrient broth and incubated over night at 35°C. It was then plated onto CLED agar for another 18 hours. Oxidase negative, gram-negative rods were further identified with API 20NE. Only *Acinetobacter baumannii* resistant to carbapenems, amikacin and cefpodoxime were recorded. The organism was only sensitive to colistin and borderline sensitive to Tigecycline.

The pre- and post- ozone decontamination were compared.

Multi-drug resistant Acinetobacter baumannii – the outbreak and intervention

In early 2009 only a single sporadic case of Acinetobacter *baumannii* was seen. However, in March Acinetobacter *baumannii* were isolated from several clinical specimens from patients in Intensive Treatment Unit (ITU) resulting in closure of the ward. Such a dramatic measure has significant repercussions on other London ITUs as they will need to receive all intensive care patients from our catchment area.
Later on, the outbreak investigation disclosed that a general surgical ward was the source of the spread.

The initial screening revealed all ITU patients were colonised or infected with Acinetobacter *baumannii*. Additionally, even after normal cleaning all clinical bed areas were heavily contaminated on sites for "direct contact" as well as "non-touch sites". It was therefore concluded that normal cleaning had failed and fumigation with ozone was needed for eradicating Acinetobacter *baumannii* from ITU.

The ozone fumigation of ITU was a major logistic operation as the care of three patients had to continue. The ITU was divided in three hermetically closed sections that in turn were fumigated. The patients were then transferred on clean beds to the first fumigated unit and the remaining two units were fumigated. A temporary plastic wall segregated contaminated patients. It had own staff and entrance. The rest of ITU was then opened for normal services.

Several weeks later the last colonised patient was transferred to the Infectious Disease Department. The segregated section was fumigated again and the entire ITU was then re-opened for normal services.

For a detailed description of the methodology and process employed please refer to the reports submitted by the contractor that implemented the treatment. These reports can be found in the appendix.

In the wake of the ITU outbreak several other rooms have been fumigated

- the used room in Infectious Disease Department
- several single bed rooms and bays in the general surgical ward

Obviously, the fumigation of a single room or even a bay with five or six beds is much easier to implement and therefore a more efficient operation than fumigation of the entire ITU.

Unfortunately, the same determined approach as in ITU was not applied to the general surgical ward. The ward could not be partitioned into a clean and a "contaminated" section and equally, no segregation of nursing staff was employed for the two units. Consequently, the outbreak flared up now and then in the ward with sporadic spread to other parts of the hospital.

The efficacy of ozone fumigation

The pre-fumigation microbiological screening for Acinetobacter *baumannii* was done to assess the efficacy of ozone fumigation. Rooms accommodating patients infected or colonised with Acinetobacter *baumannii* were routinely cleaned three times daily with chlorinated detergent. In total 188 environmental samples were processed and 72 (38.3%, range 8.3 – 75%) were positive for Acinetobacter *baumannii* before the fumigation and in spite of cleaning with chlorinated detergent. The post ozone microbiological screening showed nine (5.7%) positive swabs out of 158 environmental samples. *Acinetobacter baumannii* was isolates especially from very dusty sites not having daily cleaning such as high on the wall and top of the door.
It is interesting that 24 of all positive samples were collected from non-touch, dusty sites without daily cleaning.

Having realised that dust impeded the efficacy of ozone treatment the duration was increased to 30 minutes, and subsequent swabs were all negative.

Discussion

Ozone has been known for more than 100 years and has vast applications in industry, community and medicine. However, there is limited experience with its use for decontamination in a clinical hospital environment all though it is one of the strongest known antibacterial agents and therefore an important agent for combating the hospital scourge created by multi-drug resistant bacteria.

The key for its use is to control safety in order not to harm patients and staff. This is achieved by decanting patients into other areas sealing off the room intended to be fumigated. Handheld alarms ensure the safety of patients in adjacent areas.

The ventilation and air conditioning system must be switched off as they are often shared by several bed rooms. The detection of Acinetobacter *baumannii* at out- or inlet points are therefore of special concern. They must be sealed off in order to protect neighbouring rooms and consequently, the points will receive no ozone treatment. It is urgently needed to examine ventilation system for their role in airborne transmission of multiresistant bacteria.

One of the great benefits of using ozone is that most equipment may be left in the room. However, equipment and materials must not clutter the room as linen or mattresses piled up on the floor will obviously hinder ozone reaching that specific area. A normal aesthetic cleaning is also part of the room preparation.

A thick layer of dust on no-touch sites not cleaned daily is another concern. It is not feasible to do a daily "spring cleaning", but it should be considered to do it with regularity and to include non-touch areas such as ventilation inlet and outlet points in the ceiling.

Ozone may overcome the dust issue by prolonging the duration of treatment, but it cannot remove the dust.

By now the hospital has conducted ozone treatments six times and it seems to be a useful tool for containing and eliminating *Acinetobacter baumannii*. It will not eradicate Acinetobacter *baumannii* from patients and therefore in order to prevent future spread it must be supported by good infection control practices mainly isolation of patients and segregation of staff.

In ITU all measures were taken and the transmission was completely eliminated. Unfortunately, in the general surgical ward only the patients were isolated, but they shared the staff with other patients. Consequently, the transmission was not blocked completely, and it flared up once in a while.
A part from Acinetobacter *baumannii* hospitals are haunted by many more multi drug resistant bacteria. These may also be targeted with ozone treatment. From industry and laboratories it is known that ozone is efficient against *Clostridium difficile* spores as well as viruses.