

Infection in orthopaedic surgery is a problem which affects both the patient and the surgeon and uses up valuable resources. If it occurs as a result of clean elective surgery, such as after joint replacement, then the implications are potentially disastrous.

In 1867 Lister<sup>1</sup> published the first reports of antiseptic surgery, demonstrating the immediate clinical benefit from the reduction of airborne organisms. The subsequent development of aseptic methods and antibiotic prophylaxis has allowed orthopaedic surgeons to perform complex surgery since infection has been controlled.

In the 1960s Charnley<sup>2</sup> introduced the concept of ultraclean air systems and suggested that the cemented prosthesis may contain a system uniquely sensitive to infection by very small bacterial inocula, which were derived from airborne particles. Lidwell et al,<sup>3</sup> in an MRC study, explored this topic further and went on to conclude that the risk of late sepsis in the joint was reduced by limiting dispersal of organisms from the operating staff by the wearing of special occlusive clothing and the employment of directional-flow ventilating systems.

There is clearly a relationship between the quality of the air in the operating room and the degree of sepsis encountered. This is particularly relevant in view of the organisms present, namely coagulase-negative staphylococci, and the current concept of infection of prostheses, proposed by Gristina,<sup>4</sup> in which infection is seen as a "race for the surface" between a biofilm and the bacteria.

The publication of the paper by Davis et al on intra-operative bacterial contamination in joint replacement in this issue of the *Journal* (p. 886) and the release of the recommendations of the British Orthopaedic Association<sup>5</sup> on sterile procedures in the operating theatre make it appropriate to review the topic in view of changes in practice.

In 1968, the MRC<sup>6</sup> produced a series of reports on aseptic methods in the operating theatre. That by Blowers

examined the topic under separate headings which seems a logical approach to this subject.

**The team.** This includes all staff who during an operation session work in or occasionally enter the operating suite in which a surgical wound or sterile materials are exposed. It includes both the operating team of surgeons, anaesthetists and nurses and also the technicians, students, porters and visitors who enter the aseptic zone.

It has long been recognised that a small number of individuals are carriers of *Staphylococcus aureus* and that they shed large numbers of staphylococci into the air. The MRC report stated that it was essential to keep the operating team as small as possible, since it had been demonstrated that bacterial contamination was much higher during an operation in which 15 people were in the room rather than six.

**Movement.** In 1948 Duguid and Wallace<sup>7</sup> showed that increased activity enhanced the dispersion of bacteria. Movement can shed up to 10 000 skin scales per minute, of which 10% carry clusters of micro-organisms. These will contain *Staphylococcus aureus* and coagulase-negative staphylococci which are frequent causes of infection after joint replacement. In a well-run and organised theatre, movement is kept to a minimum and dispersal of skin organisms reduced.

**Theatre gowns.** In 1952 it was realised that the standard theatre gowns were acceptable bacterial barriers when dry, but became permeable to micro-organisms when wet. Since then different materials have been used, culminating in the modern weaved patterns and disposable paper gowns now commonly preferred.<sup>8</sup>

**Footwear.** There is no evidence that outdoor shoes are a source of infection within the operating theatre, but the process of changing shoes or applying overshoes can result in the contamination of the hands of the clinicians.

**Headgear.** Ruffling the hair disperses many particles carrying bacteria. Usually these organisms are of the non-virulent type, but include coagulase-negative staphylococci and diphtheroids which are a potential hazard in joint replacement surgery. It is necessary to wear a hood which completely covers all of the hair, including that on the face.

**Face masks.** Face masks are used as deflectors of bacteria expelled from the respiratory tract of the wearer.<sup>6</sup> Normally, very few bacteria are dispersed when the person is silent. Hence the main purpose of a mask is to protect the

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0301-620X/99/510370 \$2.00  
*J Bone Joint Surg [Br]* 1999;81-B:754-5.

wound from direct contamination while the surgeon is talking during the operation. It is reasonable for all members of the surgical team to wear a mask when operating. It should be changed after each operation since it easily becomes contaminated. There is no evidence to suggest that there is any need for non-scrubbed staff to wear a mask if they are not in the operating area.<sup>9</sup>

**Gloves and hands.** There is little disagreement on the use of antiseptics for washing hands and this should be done in a separate area for a prescribed period of time. Most surgeons have no difficulty with the concept that after washing is completed the hands need to be dried before surgical gloves are put on either by the scrub nurse or by the surgeon himself. Currently, many surgeons wear two pairs of gloves and change the outer ones frequently during the operation because of the high incidence of perforation common to orthopaedic surgery.<sup>10</sup> Davis et al demonstrated a significant incidence of contamination of the glove tips at the end of skin preparation, confirming the need to change gloves before making the skin incision or indeed to prepare the incision site separately, before draping the patient.

**Sterile drapes.** These are used both as a general and as a local protective device in surgical practice, providing sterile cover for areas away from the operating site. The use of plastic incision drapes has been widely adopted, chiefly to hold down the surgical drapes since there has been no evidence that their use makes any difference to the rate of wound infection.<sup>11</sup>

**Drainage of the wound.** A wound which is drained has a much higher risk of becoming infected than does a closed wound.<sup>6</sup> Drainage should therefore only be used when there is a clear indication such as an infection or a potentially hazardous accumulation of blood.

**Transporting the patient to the operating theatre.** During the transfer of the patient to the operating theatre, the air may be contaminated with bacteria from the patient's clothes and coverings, from the trolley or from the bed. The air in the anaesthetic room becomes contaminated with bacteria released when the blankets are removed.<sup>12</sup> Normally, patients are moved on to clean trolleys in the reception area at which stage only clean linen should be used to transfer to the theatre suite. Provided that the theatres are well-ventilated and the instruments to be used in the operation are not exposed, this process need not be adhered to but should be the practice in badly ventilated theatres and when all the instruments are already exposed in the theatre suite.

**Collection bags.** Davis et al examined suture needles and light handles and reported that there is a high rate of contamination of the handles of operating lights. This could be rectified by the introduction of laser-controlled light sources.

**Conclusions.** We make no apology for using references which are some 30 years old for establishing the principles of the prevention of infection in the operating theatre. These need to be restated and adhered to since the use of

prophylactic antibiotics and clean-air systems has led to a relaxation of standards.

The concept that the operating field is within the curtain of air and what happens outside this is unimportant is unsound. Few enclosures are large enough for some of the more complex orthopaedic procedures and the instruments and implants used in replacement surgery may lie outside this field. Movement, especially the opening and closing of doors, gives rise to air currents and the distribution of particles containing micro-organisms which can contaminate these instruments. All movement within the theatre must be kept to a minimum even when using modern ventilation systems with air changes of 20 to 30 cycles per hour.

The recommendations of the British Orthopaedic Association<sup>6</sup> include specific statements on conduct in the operating theatre with which we agree:

- 1) All hair should be kept covered.
- 2) Staff should enter or leave through clearly identified doors in order not to disturb the air flow needlessly.
- 3) The number of people in the operating theatre should be kept to a minimum.
- 4) Traffic from the delivery area and the lay-up room must be controlled.
- 5) Drapes and gowns should be of impervious material.

It would also be valuable if all orthopaedic surgeons read the original paper by Blowers in the *Lancet* in 1968<sup>6</sup>. He laid down clear principles of theatre practice which when combined with careful handling of the tissues and the appropriate use of prophylactic antibiotics,<sup>13</sup> provide good reason to believe that infection in orthopaedic surgery can be controlled even although it is unlikely that it will ever be eliminated.

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