

# Minimizing the risk of infection in the operating department: a review for practice

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Much press speculation has projected the controversy of infection control amidst raised public concern over fatalities caused by nosocomial infections. Attention to detailed ultra-cleanliness can never be compromised in the preservation of life, health and wellbeing of the evermore discerning patient. Moreover, complacency to best practice and theatre etiquette potentially endangers a practitioner's own protection, and infringes their Code of Conduct substantiating possible professional disciplinary and/or legal action. To be well versed is to be well armed.

## Introduction

Despite the ever-changing nature of advances in technology, surgery and microbiology, it is the purpose of this paper to provide an overview of methods by which the risks of infection in the operating department may be minimized. Furthermore, the broad and diverse speciality of controlling infection which dominates the operating department perpetuates the continual implementation of preventative strategies whose familiarity to the practitioner may inadvertently breed a complacency to be avoided. Subsequently this paper also serves as a generic refresher and influential guide for the registered professional and student alike in reviewing practice – a measure never to be exhausted. From the history of infection control to the process of waste disposal, areas of discussion include: the principles of microbiological aspects, how infection is transmitted, preventing and controlling infection, and the legal considerations governing perioperative clinical practice relevant to infection control.

According to Gilmour (2005) the estimated cost of hospital acquired infection (HAI) in 1986 was £111 million, moreover Dimond further compounds that the National Audit Office documented approximately 100,000 cases of HAI, costing the National Health Service (NHS) £1 billion in the year 2000 (Dimond 2003). The burden of financial cost and also the 'cost of human life' is born from the evolution of improved treatment and surgical intervention, prolonging life

expectancy. Therefore, the more vulnerable older patient living longer has a greater susceptibility to infection than ever before (Gilmour 2005). Between 2004 - 2005 two outbreaks of *Clostridium difficile* (*C dif*) killing thirty people, at a cost of human life, forced new legislation with the publication of the Health Act 2006 which introduced the new *Code of Practice for the Prevention and Control of Health Care Associated Infections* (DH 2006, Gilmour 2007).

## History

Historically many ancient civilizations documented the provision of hospitals, with the Romans first adopting high standards within large hospitals, a concept more akin to the kind we know today. They employed orderlies or *nosocomi*; a derivative of the original Greek/Latin 'nosocomial' meaning 'hospital' recently better associated to the term '*nosocomial infection*' or '*HAI*'. The development of hospitals and treatment has been synonymous with infection theory, reforming over centuries. From fumigation with incense to dispel miasmatic air during the bubonic plague, to the scientific advent of more modern infection theory as depicted epidemiologically in the work of Venetian Fracastoro (1483-1553), varied methods of infection control have been attempted. Later, ligation of blood vessels rather than cautery in amputation, as perpetrated by French surgeon Paré in the sixteenth century, further accentuates how infection control has evolved over time to meet societal biomedical demand to combat

pathogens, resistant or otherwise (Ayliffe and English, 2003.).

## Microbiology

Pathogens are disease-causing micro-organisms unseen to the naked eye. Upon invasion of bodily tissue, colonization and multiplication of these microbes results in infection rendering an adverse reaction to the host. Regions of the body accommodate commensal or natural flora colonies of microbes, however despite being harmless, if transported to another bodily area infection could ensue. Select micro-organisms termed 'opportunistic' attack causing infection when the immune system is compromised or defence lowered. Evident in AIDS (acquired immune deficiency syndrome) patients, the microbe *Pneumocystis carinii* produces respiratory infection in this way (Keyworth 2000).

Keyworth (2000) elaborates that pathogenic micro-organisms take several taxonomic forms: viruses (possibly influenza or human immunodeficiency virus), fungi (example: thrush/*Candida albicans*), parasites (helminths and protozoa which are eukaryotes possessing a nucleus), and bacteria (possibly *C dif*). Bacteria, classified by shape are prokaryotic or self-contained cells *lacking* a nucleus. Not all are pathogenic but those which are introduce tissue damage and disease by physically injuring affected cells via enzyme or toxin release (Sherwood 1997). Ayliffe *et al* (2000) advise that the bacteria

## When micro-organisms are introduced by an external agent an exogenous infection will prevail

*Staphylococcus aureus* is the most common source of surgical wound infection, with MRSA (meticillin-resistant *Staphylococcus aureus*), its variant strain, being resident in hospitals globally for many years. Accounting for 61% of all surgical site infections (SSIs) (Daly et al 2005), MRSA has immense potential to be endemic and inadequate hand-washing is hailed as its most likely mode of transmission (Damani 2003).

### Transmission

To minimize transmission by removing or stabilizing microbes (as in antiseptics), we must comprehend the methods by which they cross-infect to protect both patient and professional. In order to transmit, the chain of infection must sustain five elements and these comprise:

- the infectious agent
- a reservoir in which to flourish
- the means to transmit (whether airborne, directly such as shaking hands, indirectly through handled objects, or via a viable quantity; for instance a droplet)
- a susceptible host with vulnerability dependant on health, age and finally
- a portal of entry for microbes possibly accompanying invasive surgery or through mucous membranes (Deane 2007).

Vulnerable or immunosuppressed patients, prevalent in the operating department, are susceptible to infection endogenously (ie: commensal - originating from the body) or exogenously. When micro-organisms are introduced by an external agent an exogenous infection will prevail. For example, exposure to contaminated devices or the potentially serious *Aspergillus* (a significant microbe present in the atmosphere), will infect those who are severely immunosuppressed (Barnett 2000) hence preventative measures against transmission must be undertaken. Endogenous infection caused by such spores as *Escherichia coli* which constitute 5 - 10% of clean-contaminated or contaminated surgical wounds, may be reduced by antibiotic prophylaxis as conveyed by Ayliffe et al (2000). Furthermore, limiting exogenous infection is the ultimate aim around which the operating department and its physical environment are designed.

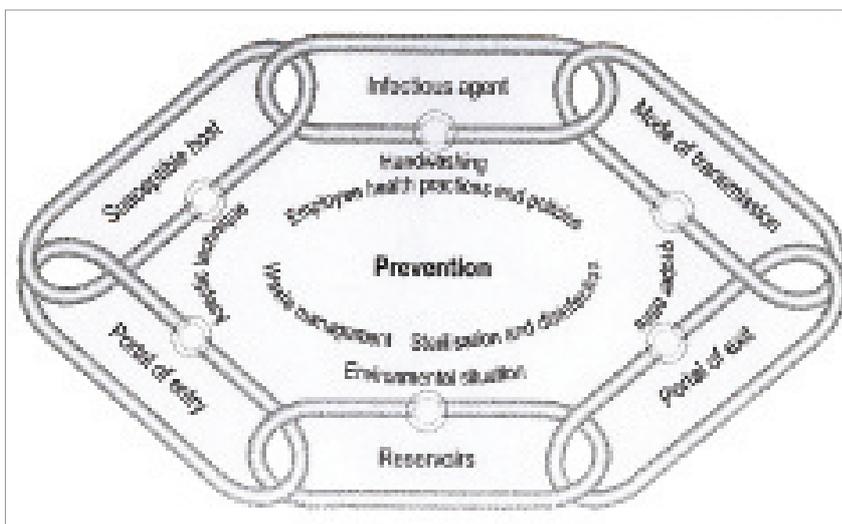
### Theatre design

Externally the operating department accommodates a *sterile zone*, *dirty zone*, and *clean or protective zone*. The sterile area is restricted and incorporates preparation rooms, operating theatres and scrub areas. Appropriate surgical clothing and headwear, and possibly masks should be adorned, although the wearing of masks

to benefit patients is currently a debateable issue. The semi-restricted *clean zone* houses anaesthetic and recovery rooms, and staff changing facilities. Central to the removal of waste - the *dirty zone* contains a control area. These areas divided into the aforementioned zones are normally situated away from air movement and general traffic - conducive to the remaining hospital. This facilitates space allocation and minimizes movement - a major factor in bacterial spread. Design is also centred on enabling the controlled movement of patients, personnel and supplies, to further assist in the prevention of contamination (Deane 2007).

Phillips states that the OT (operating theatre) facilitates the supply of regulated, filtered air with frequent circulatory air changes and scavenger systems to prevent the accumulation of anaesthetic gases - pollutants derogatory to health (Phillips 2007). Air changes may be up to 600 per hour in the ultra clean laminar systems where uni-directional airflow can be directed horizontally or vertically from units located in the walls or ceiling. Importantly, staff movement should be limited as the efficacy of the system will be jeopardized. The laminar system, particularly instrumental in orthopaedics, impacts a significant effect in lowering infection rate due to its design, hence bettering sterile technique (Phillips 2007). Deane (2007) emphasizes that orthopaedic prostheses are susceptible to becoming infected, therefore airborne infection transmission should be *strictly* abated.

Reducing the air currents that are created by swinging doors is successfully achieved in modern theatres where sliding doors are installed. Any micro-organisms cannot be disturbed by a swinging door causing air disturbance. Doors must remain closed during and between procedures, this suppresses a mix with outside air containing higher rates of microbes. Closed doors maintain positive air pressure within the OT which forces air out of the room thus suspending micro-organisms from entering. Dual filters working in succession enable positive air pressure: the first ought to be 30% effective and the other 90% respectively (Phillips 2007). →



Source: Gilmour 2005 p 86

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HEPA (high-efficiency particulate air) filters are an alternative to laminar airflow and plenum (positive air pressure) ventilation systems - they are up to 99.7% effective in removing dust particles (Phillips 2007). Nonetheless, Ayliffe *et al* (2000) recommend the plenum system distributing air equally within theatre space from ceiling diffusers. They also stipulate an air-change of 20 times per hour in accordance with NHS Estates. Phillips reports that theatre temperature should be thermostatically maintained within 20 °C to 23 °C, and humidity between 30% and 60% but favoured no less than 50% to 55%. Except specialist overhead surgical spotlights creating intense light, general theatre lighting should ideally be recessed to prevent the collection of dust containing micro-organisms. All surfaces should be fire resistant, stainless, waterproof, seamless and easy to cleanse, with floors continuing up the sides of the walls for around 6 inches to aid cleaning and prevent bacteria traps (Phillips 2007).

### Medical devices

Equipment within theatre is diverse and all medical devices must be safe and sterile conforming to infection control legislation. According to Horton and Parker (2003) a medical device constitutes any appliance, apparatus, instrument, material or healthcare product used for patient purposes in diagnosis, investigation, prevention, monitoring, treatment or conception. The health and safety of medical devices was approved in 1993 as European law. Fullbrook (2007) also indicates that the European Medical Devices Directive 93/42/EEC (MHRA 1993) upholds that devices should only be used for the purpose for which they were manufactured and designed. In compliance with the directive, medical devices ought to be used under the intended appropriate conditions and accommodate a 'high level of protection of health and safety' (Council of the European Communities 1993). Further enforcing the directive, it is now incorporated into English law under the Medical Devices Regulations 2002 (DH 2002). The correct use of drapes and gowns and the implications of their cleanliness, as recommended by Standard EN13795, is a voluntary code of conduct for

manufacturers and a guide to health professionals that is not mandatory, unlike the legislation. Fullbrook describes that Directive 93/42/EEC upholds this, stating that such European Standards are configured by private-law entities and should *not* be considered compulsory. This in itself fortifies the integrity of the law distinguishing the difference in potency between a 'Standard' and a 'Directive'. Taking care not to over-govern manufacturers of medical devices, which could cause an economic effect, the law intends to safeguard the provision and use of devices and assist the practitioner.

All theatre personnel should understand medical devices and their properties, workings, and the adverse effects such as contamination and infection spread that are linked with them. Other than best practice, reduced contamination and safety is upheld either by common law or statutory direction as medical devices can carry devastating consequences if used improperly. Introduction of infection must be avoided at all costs, and all devices should be sterile according to safe practice (Fullbrook 2007).

### Sterilization

Any utensil or device which will be admitted internally to the body cavity or is in contact with broken membranes requires sterilization. Steam sterilization is effective, non-corrosive and not poisonous. It is performed in an autoclave where steam is pressurized removing any air. Complete annihilation of microbes including bacterial spores is achieved, however the high temperature of 134 °C which the autoclave can reach is destructive. In dry heat sterilization temperatures in the hot air oven reaching 160 °C - 180 °C (dependant on duration) sterilize anhydrous oils and solids. Although dry heat is convenient for items damaged by steam sterilization, cycle time and temperature may adversely affect plastics and rubbers (Parker 2004). Sporocidal chemical sterilization (disinfection) is used for items which are heat-sensitive. Several products may be used in liquid chemical immersion with varying efficacy. Glutaraldehyde, peracetic acid, chlorine dioxide and alcohols are viable chemicals used subject to risk assessment as pathogenic micro-organisms

are, pertaining to the health and safety regulation *The Control of Substances Hazardous to Health* (COSHH) Act (HMSO 2002). Raising safety implications for staff, some of these products are irritant, toxic (particularly glutaraldehyde and chlorine dioxide), highly explosive and flammable - namely isopropanol and ethanol (Horton and Parker 2003).

Turner *et al* (2000) deem sterility as the total destruction and elimination of pathogenic micro-organisms and their relative spores. Sterilization is a valid practice which destroys microbes which are resistant to disinfectants and heat (Cripps 2000). Yet Turner *et al* (2000) question the rationality of examining the first patient on an operating list with a *sterile* endoscope when subsequent patients are examined with a *disinfected* one.

Turner *et al* (2000) outline the difference between *clean* and *sterile*, defining that 'clean' is being without obvious soiling. Therefore, micro-organisms (their spores being the most resistant form of life) invisible to the naked eye may thrive in areas which appear 'clean'. This is unacceptable in surgery where sterility is of upper importance. Nevertheless as discussed, degrees of cleanliness depending on procedure and local policy differ. For instance, a laryngeal mask for intubation may be acceptably clinically clean but a bronchoscope requires disinfection. Horton and Parker (2003) define clear differences in risks of infection and these are categorized into minimal risk (for example floors, walls requiring manual cleaning), low risk (such as trolley tops, patient supports requiring manual cleaning with disinfectant), intermediate risk (for instance endoscopes, thermometers needing disinfection and cleaning), and high risk (namely surgical instruments, swabs, needles with cleaning and sterilization imperative).

Indeed NHS trusts have their own processes of decontamination for theatre equipment (example - electrosurgical equipment) before repair or decommissioning can take place. A certificate should be completed per item in duplicate before leaving the operating department in compliance with Safety Notice MDA SN 9516

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*Decontamination of Medical Devices and Equipment Prior to Investigation, Inspection, Service or Repair (MHRA 2003).* It must be clarified whether equipment has been in contact with blood, bodily fluids or pathological samples (all vehicles for infection transmission) indicating if the item has been cleaned and correctly decontaminated. Where equipment could not be decontaminated strict standard precautions apply as *all* devices or equipment must be safe to handle in accordance with Department of Health policy 1987 (Horton and Parker 2003).

### Good practice

Implemented in the 1980s, universal precautions emerged to protect healthcare workers against blood-borne pathogens. In 1996 they were renamed 'Standard Precautions' and included the isolation and management of *all* bodily substances. Protecting patients and personnel from infection risks, standard precautions promote the usage of personal protective equipment (PPE) and employers are legally bound to supply PPE as enforced by the *Personal Protective Equipment at Work Regulations* (HMSO 1992a). Inconsistent conformity to standard precautions increases occupational exposure, hence risk assessment by healthcare workers should be undertaken as should the adorning of gowns, gloves, hats, masks and eye protection to preserve an aseptic environment and thus counteract contamination (Osbourne 2003).

Assessing risk in relation to disposable masks could prove troublesome for theatre staff as a Cochrane review concluded that not enough evidence could prove whether wearing face masks in surgery caused more or less surgical infections (Lipp and Edwards 2002). Reviewing for the Cochrane Collaboration, Parkinson and Tanner (2005) established that double-gloving could reduce surgical cross-infection of blood-borne pathogens from patients to the surgical team and vice versa.

### Hand-washing and asepsis

Before applying gloves the surgical hand-washing procedure is performed in order to reduce contamination in the clinical, sterile

zone (Beesley and Pirie 2004). Damani recommends that the first surgical hand scrub of the day should be three to five minutes in duration and further disinfections should be three minutes between procedures utilizing nailbrushes and antiseptics such as chlorhexidine or povidone iodine (Damani 2003). Alcohol based hand-rubs are more effective than soaps and antimicrobial agents in routine washing of physically clean hands. Grasping an effective technique such as the six step approach will render the hands socially clean, free from transient microbes. Transient organisms, obtained through patient contact or the vicinity, are not representative of the normal flora of the hands and survive for a restricted period only. Resident organisms are deep seated in the skin and are not easily removed through routine handwashing.

Kumar (2005) writing on asepsis highlights six main principles of technique to minimize contamination of any surgical wound. All OT staff should maintain sterility of all instruments keeping sterile and non-sterile devices separate. Following correct sterile scrubbing, gowning and gloving processes are paramount. The surgical patient's skin ought to be prepared correctly as should draping. Unsterile individuals should face the sterile field and never lean over sterile trolleys or pass between trolleys and the operating table, with duty of care to the patient of uppermost importance.

### Waste disposal and sharps management

The *Health and Safety Act* (HMSO 1974), COSHH and the *Controlled Waste Regulations* (HMSO 1992b, 2002) for the disposal of clinical waste, are intrinsic to the prevention of harm to all and medical negligence - a result of failure in the duty of care (Ayliffe *et al* 2000). Clinical waste may be toxic, hazardous or cause infection to those in contact with it. It consists of human tissue, swabs, dressings, excretions, bodily fluids, syringes, needles or sharp instruments (Gilmour 2005). Gilmour also specifies that it is separated from household waste and costs acute hospitals in England and Wales £30 million per annum (between £180 and £320 per tonne). Trusts have adopted a nationally

recognized system for categorizing waste which also categorizes cost: yellow bags for clinical waste and black for household waste to be segregated at source. Any liquid clinical waste must be solidified with gel or powder to prevent spillage and further bacterial spread. Infected linen is also separated and placed in water-soluble bags. All categorized waste must have its origin labelled at source to ensure correct cost, handling, carriage and disposal in compliance with the *Environment Protection Act* (HMSO 1990) which protects individuals and the environment from harm.

Campbell (2004) stipulated that sharps be transferred safely, never recapped and disposed of immediately after use. Vitally, sharps must be discarded by the user into an approved container complying with *British Standard* BS3720 and UN3291. The address of the source must be visible on the container and it must be dispatched for incineration by an approved organization. The National Audit Office reported that needle-stick injuries represent one of the top four kinds of accidents occurring within the NHS (Watterson 2005). Carrying high risk of infection from Hepatitis B, C or HIV, needle-stick injuries not only spread infection but could prove fatal if infected (Damani 2003).

### Conclusion

Older patients living longer have greater susceptibility to infection by higher resistant strains than ever before, proving more difficult to control (Ayliffe and English 2003). For practitioners it is their duty to control infection with best practice thus minimizing risk, as stipulated by their codes of conduct (HPC 2004, NMC 2008). In minimising the risk of infection it is essential to understand the nature of microbiology in order to apply infection control effectively. Identification of transmission will not only assist the patient but also forewarn the practitioner of the precautions required to prevent spread (Keyworth 2000). Larger, better designed, randomized controlled trials are needed to aid evidence based practice and assist infection control (Lipp and Edwards 2002). Yet it is the consistent improvement of current practice, continual reviewing of one's own practice proactively and diligent adherence to current informed →

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legislation that will combine to minimize the spread of infection. To combat infection further some European standards may be best implemented if legalized, greater arming the practitioner and health trust in the battle against contamination, fulfilling their duty of care to the patient (Fullbrook 2007).

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