Gastrointestinal endoscopy: infection and disinfection

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SUMMARY The past decade has seen the development of an array of complex flexible fiberoptic instruments for gastrointestinal (GI) endoscopy, and an increasing use of these for diagnostic and therapeutic purposes.¹ It has been recognised more recently that the use of contaminated endoscopic equipment can lead to serious and occasionally fatal infections. Infection with a wide variety of micro-organisms has been reported following oesophago-gastroduodenoscopy (OGD) and endoscopic retrograde cholangio-pancreatography (ERCP).

Microbiological hazards in endoscopy arise in three ways. Organisms may be transmitted from patient to patient, the endoscope acting as the vehicle of transmission; opportunists such as *Pseudomonas* may colonise endoscopic equipment while in storage, and then be inoculated into a succession of patients or the endoscopic examination itself may give rise to autologous infection such as aspiration pneumonia. This paper will consider the first two mechanisms, both of which can be eliminated by thorough disinfection of fibre-endoscopes and their accessories. Any disinfection technique has to take account of the fragility and complexity of the instruments themselves, the short time available for disinfection during busy endoscopy lists, and the choice of an effective disinfectant which is safe for both staff and endoscopic equipment.

The dangers of patient to patient transfer of organisms will be considered first, the evidence for opportunistic infection second, and finally disinfection methods will be discussed in detail.

Patient to patient transfer

In one large questionnaire survey of American endoscopy centres,^{2,3} 17 infectious episodes were reported following 211 410 examinations. Although all micro-organisms contaminating fibre-endoscopes should be considered potential pathogens, *Salmonella* species are a particular danger.

SALMONELLA

Outbreaks of infection by *S. oslo*,⁴ *S. oranienburg*,⁵

S. agona,^{6,7} *S. typhi*,⁸ *S. typhimurium*⁹⁻¹¹ and *S. kedougou*¹² involving a total of 81 patients have been attributed to contaminated endoscopic equipment. Though there were no fatalities, five patients developed septicaemia.^{4,7,8,12} The endoscopic equipment which acted as the vehicle of transmission of infection in these outbreaks had been disinfected with hexachlorophene,^{8,9,10} cetrimide,^{7,12} chlorhexidine,¹¹ and a quaternary ammonium compound,⁵ disinfectants known to have relatively poor germicidal activity against Gram-negative bacteria.¹³ No new cases of Salmonellosis were reported and endoscope cultures became negative when the disinfectant was changed to povidone-iodine^{5,9,10} or 2% glutaraldehyde.^{7,12}

OTHER MICRO-ORGANISMS

In an outbreak of *Strongyloides* oesophagitis involving four patients,² circumstantial evidence strongly favoured cross-infection from a single endoscope. No further cases were noted after gas sterilisation of the instrument.

Though there are no reports of transmission of *Mycobacterium tuberculosis* by gastrointestinal endoscopy, cross-infection with this organism has occurred after bronchoscopy with a fibre-optic bronchoscope disinfected for 10 minutes before use with povidone-iodine.¹⁴ Disinfection of endoscopic equipment using an agent with effective anti-tubercular action¹⁵ such as alkaline glutaraldehyde should minimise the risk of endoscopic transmission of tuberculosis.

HEPATITIS

The transmission of viral hepatitis to patients or personnel is a potential risk of gastrointestinal endoscopy. With an estimated HBsAg carrier rate

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of 0.1–0.5%¹⁶ in Western countries, it is inevitable that unrecognised HBsAg-positive patients will, from time to time, undergo endoscopic procedures.^{17 18} Direct or indirect exposure to blood or blood products is generally accepted as the major and most efficient mode of transmission.¹⁹ Saliva is probably the main vehicle of infection in non-parenterally acquired Type B hepatitis²⁰ though other body fluids including bile²¹ have also been implicated. Endoscopic equipment invariably becomes contaminated with blood, saliva, and bile during routine use and HBsAg has been recovered from endoscopes used on HBsAg-positive patients.²²

Existing data suggest that the risk of transmission of hepatitis B virus (HBV) at endoscopy is small. In nine prospective studies,^{17 23–30} none of 230 patients inadvertently examined with an endoscope previously used on HBsAg-positive patients, two of whom were 'e' antigen positive, developed overt hepatitis and only one became HBsAg-positive (Table 1). Recently, one case of type B viral hepatitis almost certainly acquired at endoscopy has been reported and it may be that endoscopic transmission of HBV has not been detected because the subsequent attack of hepatitis B has been subclinical.³¹ It is now clear that the possibility of hepatitis B transfer by the endoscope exists^{19 22 23 31} and adequate preventive measures are needed. General preventive measures should include:^{19 32} the education of endoscopy staff regarding the possible transmission mechanisms of hepatitis B, frequent handwashing and the use of disposable gloves, prompt disposal of spilled blood or other body fluids or tissues and watertight dressings for any abrasions or other breaks in the skin.

The evaluation of the hepatovirucidal activity of chemical disinfectants has been hampered by the lack of firm evidence about the intrinsic resistance of HBV,¹⁹ the different inactivation kinetics of the

infective particle and the associated surface antigen,³³ and the inability to culture the virus.¹⁹ It is likely that the HBsAg is much more resistant to physical and chemical stresses than is the infective viral particle.¹⁹ The virus may be inactivated by a disinfectant but the antigen associated with subviral or defective viral particles, may remain immunologically reactive.²⁴ It has been estimated that the resistance level of HBV to chemical disinfectants lies somewhere between that of the tubercle bacillus and bacterial spores.¹⁹

The following disinfectants have been recommended for decontaminating fibre-endoscopes exposed to HBV: ethylene oxide gas, 2% alkalised glutaraldehyde, 5% succine dialdehyde,³⁴ and iodophors with 5000 ppm available iodine. The following disinfectants cannot be relied upon to inactivate HBV: quaternary ammonium compounds, phenolics, and alcohols.^{19 22} Meticulous physical cleaning of the endoscope should precede disinfection after each patient procedure with any one of the recommended agents. It is difficult to recommend precise immersion times in disinfectants from existing data though it has been shown that endoscopes remained HBsAg-positive despite short immersion times¹⁷ in glutaraldehyde. Spring-like endoscopic accessories such as biopsy forceps and cytology brushes deserve special attention as HBsAg has been recovered from their coiled outer cover after routine disinfection.^{22 26} Sufficient numbers of these accessories should be available to allow prolonged (30 minutes) immersion in disinfectant between patient procedures. If endoscopy is essential for a patient known to be HBsAg-positive, thorough cleaning and disinfection (2 hours immersion) after the procedure should minimise the risk of hepatitis B transmission; the practice of reserving one endoscope for exclusive use on HBsAg-positive patients is probably unnecessary.^{22 25}

Table 1 Gastrointestinal endoscopy – the risk of hepatitis transmission

Reference and year	Index patients*	Patients inadvertently endoscoped	Outcome	Mode of disinfection
Morris <i>et al</i> , 1975 ²³	1	65	1 patient HBsAg Pos.	Chlorhexidine/cetrimide
McDonald and Silverstein, 1976 ²⁴	1†	4	HBsAg Neg.	7% Isopropyl alcohol
Hepatitis Surveillance Report, 1977 ²⁵	3	15	HBsAg Neg.	Iodophor
McClelland <i>et al</i> , 1978 ²⁶	1	38	HBsAg Neg.	Chlorhexidine/cetrimide
Morgan <i>et al</i> , 1978 ²⁷	1	28	HBsAg Neg.	Chlorhexidine/cetrimide
Moncada <i>et al</i> , 1978 ²⁸	2‡	10	HBsAg Neg.	Iodophor/isopropyl alcohol
Koretz and Camacho, 1979 ²⁹	2	9	HBsAg Neg.	Not stated
Carr-Locke, 1980 (personal communication)	2	not stated	HBsAg Neg.	Glutaraldehyde
Ayoola, 1981 ³⁰	not stated	61	HBsAg Neg.	Chlorhexidine/cetrimide

* = Serum HBsAg+ † = Saliva HBsAg+ ‡ = 'e' Antigen+

For the future, the use of objective test systems such as morphological alteration and disintegration of Dane particles⁵⁴ coupled with increasing utilisation of animal models should define more accurately the hepatovirucidal capacity of disinfectants and the role of non-parenteral routes in the transmission of hepatitis.^{19 20}

OPPORTUNISTIC INFECTION

Opportunists multiply in warm damp environments, thus the endoscope, the water bottle and other water-containing pieces of apparatus in the endoscopy room quickly become contaminated. *Pseudomonas* is the commonest contaminant. It is sometimes resistant to antibiotics and can give rise to serious illness.

PSEUDOMONAS

Fatal *Pseudomonas* septicaemia has complicated oesophagoscopy in two severely granulocytopenic patients who were examined with an endoscope disinfected by soaking in benzalkonium chloride (Zephiran),³⁵ a solution in which *Pseudomonas* spp can readily survive.³⁶⁻³⁹ *Pseudomonas* sepsis acquired from an endoscope inadequately disinfected with a chlorhexidine-cetrimide solution (Savlon) has contributed to the death of three other patients,⁴⁰ and in another report of endoscopy related infection, identical strains of *Ps aeruginosa* were cultured from material obtained from nine affected patients and from the endoscopic equipment used.⁴¹ Contamination of aqueous solutions of cetrimide and cetrimide-chlorhexidine by *Pseudomonas* spp is well recognised.^{38 42} In addition to isolation from fibre-endoscopes disinfected with hexachlorophene⁴³ and cetrimide-chlorhexidine solution,⁴⁴ *Pseudomonas* spp have also been cultured from endoscopic equipment disinfected with 70% alcohol⁴⁵ and 5% succine dialdehyde.⁴⁶ Ancillary equipment, especially water bottles and their connecting tubes,⁴⁷ may be readily colonised by *Pseudomonas* spp^{40 45 48} and act as an important reservoir of contamination.⁴⁵

ERCP

Endoscopic retrograde cholangio-pancreatography (ERCP) has now a firmly established place in the management of patients with pancreatico-biliary disease. There is an overall complication rate of 2.2-5%⁴⁹⁻⁵² with a mortality of 0.1-0.2%,⁵³ compared with an overall complication rate for oesophago-gastroduodenoscopy of 0.1%.³ Complication rates for ERCP lessen considerably with greater experience, in one report, from 15% for inexperienced workers (<25 studies) to 3.5% for those more experienced (>200 studies).⁵² Leaving

aside medication reactions and complications inherent in all upper gastrointestinal endoscopic procedures,³ the major complications of ERCP are cholangitis/septicaemia,⁵²⁻⁶⁴ pancreatitis^{52 60 65-67} and pancreatic sepsis/pseudocyst abscess.^{52 53 68-73} Fatalities have been reported with each of these complications.^{58 60 68 70 72 73}

CHOLANGITIS/SEPTICAEMIA

Cholangitis is the commonest cause of death following ERCP⁵² and is the second most common complication of the procedure with a reported incidence of 0.8-6%.^{52 55} The incidence of cholangitis increased to 15% for endoscopic retrograde cholangiography in patients with extra-hepatic biliary obstruction in one series.⁵⁵ Over 90% of reported instances of cholangitis following ERCP and all fatal cases have occurred in patients with obstructed bile ducts.^{52 58 62} A fatal outcome may be more likely in patients with malignant obstruction of the biliary tract.⁵² The onset of cholangitis may be as early as 12 hours after the procedure⁵⁶ or may be delayed for up to three days.⁵⁸ The source of infection remains controversial. Is infection introduced into the biliary tract from contaminated cannulae and endoscopes, or does instrumentation simply facilitate bacterial dissemination from already contaminated bile? Fibre-endoscopes and cannulae disinfected with 70% alcohol have been incriminated as the source of infection in some cases of cholangitis following ERCP when identical micro-organisms, including *Pseudomonas aeruginosa*, *Enterobacter aerogenes* and *Staph epidermidis*, were isolated from blood cultures and from endoscopic equipment.^{57 59} Similarly, multiple episodes of bacteraemia following ERCP and the repeated isolation of *Ps aeruginosa* from pancreaticobiliary aspirates were caused by strains of *Pseudomonas* found resident in the endoscopic channels; isolation of these strains ceased after more rigorous cleaning and disinfection of the endoscope.^{61 63} In contrast, fluid aspirated from the papilla of Vater before contrast injection at ERCP grew *E coli* which were later isolated from blood cultures drawn during cholangitis which complicated the procedure.⁵⁹ Clearly biliary stasis is an important aetiological factor^{55 58} though cholangitis may rarely occur following ERCP in patients without biliary tract obstruction.⁵⁷ Measures recommended by different operators to prevent cholangitis include proper disinfection of equipment,^{59 63 74} surgery within 24 hours of cannulation in all patients found to have common bile duct obstruction at ERCP,⁵⁵ endoscopic sphincterotomy with endoscopic per-nasal drainage,⁷⁵⁻⁷⁷ prophylactic antibiotics and the use of antibiotic-containing contrast

material.^{49 52 78 79} In the only controlled trial of prophylactic antibiotics reported to date, the rate of bacterial complications after ERCP was not reduced by oral prophylaxis with broad spectrum tetracycline;⁵¹ over 50% of bacteria isolated from bile sampled at operation⁸⁰ or ERCP⁶⁴ are tetracycline-resistant. Further prospective controlled trials are now needed to establish the place of parenteral antibiotic regimes, namely, ampicillin plus gentamicin,^{64 81} or cefuroxime^{82 83} in the prevention of cholangitis.

PANCREATITIS

With a reported incidence of 1–8%,^{53 65 66} acute pancreatitis is the commonest complication of ERCP.^{52 65} Fortunately, most attacks of pancreatitis following ERCP are mild, uncomplicated, and short-lived⁷⁴ though progression to fatal pancreatic sepsis may occur in patients with pancreatic duct obstruction.^{49 67} Pancreatitis occurs almost exclusively with successful cannulation and pancreatic duct injection, and is more frequent in patients with known pancreatic disease.^{50 52 74} There is a correlation between acinar filling at ERCP and subsequent pancreatitis.⁶⁷

The endoscopic skill and experience of the operator and the number, speed, pressure and volume of pancreatic duct injections are probably the major determinants of the rate of acute pancreatitis following ERCP.^{49 52 53 74} Bile, duodenal juice and infection introduced into the pancreatic duct at ERCP may play some role in the subsequent development of pancreatitis though no controlled data are presently available for analysis from published studies.⁶⁰ The suggested value of prophylactic oral broad-spectrum tetracycline in reducing the rate of pancreatitis after ERCP⁸⁴ has not been confirmed in a recent controlled trial.⁵¹ It seems likely that infection alone probably plays only a minor role in the pathogenesis of acute pancreatitis after ERCP.

PANCREATIC SEPSIS/PSEUDOCYST ABSCESS

Pancreatic sepsis and pseudocyst abscess are rare but serious complications of ERCP which carry a high mortality and result in extensive morbidity.⁵² It is likely that both complications are caused by the introduction of contaminated material into a stagnant duct system from the endoscope, cannula or contrast.^{52 56 74 79} though there are no data available at present to indicate the exact source of infection.

In the detection and delineation of pancreatic pseudocysts ultrasonography and computed tomography are now the investigations of choice – ERCP should not be necessary.^{85–87} In the presence

of a known pseudocyst, ERCP is rarely indicated except for immediate preoperative mapping.^{53 65} When pancreatic duct obstruction is detected at ERCP, the smallest amount of contrast agent consistent with a diagnostic study should be injected.^{52 74} Both prophylactic broad-spectrum antibiotics and early decompression surgery have been recommended by different groups when a poorly draining pseudocyst or obstructed pancreatic duct is shown.^{50 56 70 72 74} although operation may not always be appropriate, especially when ERCP reveals pathology for which there is no suitable surgical therapy. Thorough disinfection of endoscopic equipment remains the most important precaution to take in order to eliminate the source of infection.

Colonoscopy

In contrast to OGD and ERCP, there are very few reports of transmission of infection at colonoscopy⁸⁸ and there is an impression that as the colon is a 'dirty' area less attention need be paid to thorough disinfection. Colonoscopes and accessories (snare, biopsy forceps, cytology brushes) become contaminated during routine use with faecal flora and pathogenic micro-organisms^{89 90} and the possibility of disease transmission exists; it may be that in the past such transmission has either gone unreported or undiagnosed. It is known that the endoscopist's hands and endoscopy room become contaminated with colonic flora during colonoscopy and inadequate disinfection is achieved with cresol, benzethonium chloride or chlorhexidine.⁸⁹ Thorough mechanical cleaning followed by disinfection with 2% alkaline glutaraldehyde (5 minute contact time)⁸⁸ or ethylene oxide gas⁸⁹ adequately decontaminates colonoscopes. Our recommendations regarding disinfectants, methods of disinfection, and storage apply equally to fibre-endoscopes and accessories used for upper and lower gastrointestinal procedures.

HOSPITAL CROSS INFECTION

Though endoscopy-related sepsis primarily concerns the risk of infection to individual patients, it must also be considered in the broader context of hospital-acquired infection. The gastrointestinal tract is a 'jungle of dangerous micro-organisms'⁹¹ which can be the source of serious nosocomial outbreaks of infection involving multiply-resistant Gram-negative organisms.^{92–94} It is known that the selection of such multiply-resistant strains and the transfer of drug resistance occurs in the gastrointestinal tract of patients receiving antibiotics.^{91 93} Contamination of endoscopy room and personnel

with enteric flora occurs during endoscopic procedures³⁵ and in two outbreaks of endoscopy-related *Salmonella* infection^{4, 12} seven of the 25 patients (28%) affected were cross-infected through close contact with those examined by the contaminated endoscope. Any such risk of cross infection is eliminated by fastidious disinfection of fibre-endoscopes and their accessories.

Disinfectants and disinfection

A sterilisation process guarantees destruction of all microbial life including bacterial spores.^{13 91} Gastrointestinal fibre-endoscopes need not be sterile when used as they do not penetrate deep tissues or sterile body cavities, but they do need to be free of all vegetative pathogens, including tubercle bacilli and viruses – this is termed disinfection.^{13 95} The time available for disinfection between patient procedures on a busy endoscopy list is limited and a rapid acting, high level liquid disinfectant is needed.¹³ The delicate and thermolabile nature of endoscopic equipment further limits the range of disinfectants to the comparatively few compounds which are both germicidal and non-damaging.⁹⁶ The intricate design of the instruments and their ancillaries hampers penetration and rinsing of liquid disinfectants and therefore solutions of low surface tension which do not coagulate blood or protein are required.⁹⁷ The disinfectant used must also be non-toxic and non-allergenic for endoscopy staff repeatedly exposed to it during disinfection procedures. There are no disinfectant solutions available which fulfil all these requirements (Table 2).

Thorough physical cleaning of the endoscope and ancillary equipment is an essential prerequisite to any effective disinfection procedure. An endoscope after routine use retains proteinaceous material comprising blood, mucus, and saliva which entraps contaminating micro-organisms and inactivates and resists penetration by germicidal molecules.^{11 13 91}

Thus, the number of contaminating micro-organisms to be destroyed chemically depends to a large extent on the thoroughness of the precleaning procedure before immersion in disinfectant.¹³ Application of a mild detergent or soap solution combined with brushing of the suction/biopsy channel will adequately remove adherent tissue, blood and mucus. This should be followed by a warm water rinse to remove any residual detergent or soap. Meticulous attention must also be paid to cleaning and disinfection of endoscopic accessories including water bottles and their connecting tubes, cytology brushes, biopsy forceps, cannulae, and mouth guards; all of which are potential reservoirs of opportunist infection at endoscopy.^{22 40 45–47} Ultrasonic cleaning before disinfection may be an acceptable alternative to physical cleaning, especially for ancillary items, and has been shown to augment the bactericidal action of germicides including glutaraldehyde.^{98–101}

Aqueous 2% alkaline glutaraldehyde is at present the liquid disinfectant of choice for fibre-endoscopes.^{96 102} Glutaraldehyde provides rapid high level germicidal activity, even in the presence of organic soil, with a non-flammable, non-corrosive solution of low surface tension which allows adequate penetration and easy rinsing of endoscopic channels.^{103–108} In-use studies have shown that two minutes with alkaline glutaraldehyde adequately decontaminates fibre-endoscopes between patient procedures^{44 109 110} though some workers would advocate 10–30 minutes immersion^{46 111} in view of the risk of hepatitis B transmission²² and the disputed tuberculocidal efficacy of the solution.^{15 105} The most important disadvantage of glutaraldehyde is its propensity for causing serious sensitivity problems among endoscopy staff repeatedly exposed to it. A recent survey found a 37% incidence of sensitivity reactions, including dermatitis, conjunctivitis, and sinusitis in British endoscopy centres using glutaraldehyde.¹¹² Indeed, all aldehyde disinfectants should be regarded as

Table 2 Disinfectants recommended for fibre-endoscopes

Disinfectant	Activity against				Inactivated by	Disadvantages
	Bacteria	TB	Viruses	Fungi		
Glutaraldehyde, 2% alkaline	*†	*	*	*		Staff sensitivity reactions. Toxic vapours.
Ethylene oxide	*	*	*	*		Toxic. Mutagenic. Endoscope damage. Expensive. Time-consuming
Iodophors	*	*	*	*	Organic soil. Hard water.	Reports of <i>Pseudomonas</i> contamination. Cause staining.

* = active against † = in 2 minutes.

potentially toxic⁴⁶ and glutaraldehyde should be handled with the same precautions as for the safe use of formaldehyde.¹¹³ The use of a 'closed-system' disinfecting apparatus and disposable gloves minimises direct and indirect exposure to glutaraldehyde during disinfection procedures.¹¹⁰ Another disadvantage of alkaline glutaraldehyde is the progressive decrease of germicidal capacity after activation due to chemical loss of active aldehyde groups which limits the effective use life of the disinfectant to 14 days.^{103 105 107} In practice, unavoidable dilution with water during disinfection procedures often necessitates more frequent change of the disinfectant solution.¹⁰⁷ Despite these disadvantages, alkaline glutaraldehyde is the disinfectant that at present comes closest to fulfilling the criteria for the ideal endoscopic disinfectant.

Disinfection of fibre endoscopes with ethylene oxide gas is microbiologically effective,^{13 45 89 91 109 114} but has many disadvantages which make it impractical for routine use during a busy endoscopy list. The process is expensive and time-consuming with at least 30 minutes exposure to ethylene oxide needed for effective disinfection¹¹⁴ followed by a prolonged period of aeration (up to 24 hours) to elute any retained disinfectant.^{89 96 109 114} Ethylene oxide is toxic causing severe burns on contact with skin and has an inhalation toxicity similar to ammonia gas.¹¹⁵ Ethylene oxide has also a mutagenic potential similar to radiation, has suspected carcinogenicity,^{96 115} and exposure in early pregnancy may increase the risk of spontaneous abortion.¹¹⁶ Repeated treatment with ethylene oxide may damage endoscopes with fogging of the lens and fluid staining of the eye-piece unit and image guide fibre bundle.^{96 109 117} Ethylene oxide has therefore no practical role in the routine disinfection of endoscopes between patient procedures, but it remains the best available treatment for endoscopes used on patients known to have infectious diseases including hepatitis B, tuberculosis, and typhoid fever.¹⁰⁹

The iodophor solution, povidone-iodine is an effective disinfectant for endoscopic equipment, but suffers the disadvantages of rapid inactivation by organic soil and hard water and causes staining of materials.¹³ Povidone-iodine has been shown to adequately decontaminate fibre-endoscopes with two to four minutes disinfection between patient procedures without causing yellowing of lenses.^{109 117} There have been more recent reports of outbreaks of pseudobacteraemia caused by povidone-iodine solutions contaminated during manufacture with *Ps cepacia*, an organism with a known propensity for contaminating hospital

solutions and disinfectants.^{118 119} The authors contend that, despite these findings, properly manufactured povidone-iodine solution with biologic assays to ensure sterility should still be considered effective.¹¹⁹

Other endoscopic disinfectants which deserve consideration are succine dialdehyde and buffered hypochlorite solutions. Ten per cent succine dialdehyde adequately disinfects fibre-endoscopes in 30 minutes with no evidence of endoscope damage,^{46 120-122} and is rapidly hepatovirucidal as evaluated by the morphological alteration and disintegration of Dane particles.³⁴ This valuable hepatovirucidal property of the solution has been confirmed in a recent prospective study where disinfection with a 10% solution prevented transmission of hepatitis B virus by the endoscope from HBsAg – and Dane particle – positive patients.¹²³ As with other aldehyde solutions, succine dialdehyde loses germicidal activity after activation and must be regarded as potentially toxic for endoscopy staff. Buffered hypochlorite solutions are rapidly germicidal¹²² and hepatovirucidal¹⁹ but are inactivated by organic soil, unstable at low concentration and cause damage to endoscope components.^{117 122}

The following solutions do not reliably disinfect fibre-endoscopes: quaternary ammonium compounds (quats), chlorhexidine, chlorhexidine-cetrimide mixtures, ethyl or isopropyl alcohol, hexachlorophene and cresol. Quaternary ammonium solutions, chlorhexidine-cetrimide and hexachlorophene show a low level of activity against *Pseudomonas*^{13 35-40 42 44} and *Salmonella* spp;^{5 7-11} lack tuberculocidal^{13 15} and picornavirucidal activity^{13 108} and quats in addition are rapidly inactivated by organic soil.⁹¹ In-use studies have shown persisting bacterial contamination after disinfection of fibre-endoscopes with 70% alcohol^{45 46} and cresol.⁸⁹ The alcohols are further limited as disinfectants by their volatility, flammability, lack of hepatovirucidal effect^{19 34} and their tendency to irritate tissue and coagulate protein.⁹⁶

After disinfection, endoscopic equipment must be rinsed free of residual germicide and dried. A tap water rinse for 30 seconds effectively removes glutaraldehyde from disinfected equipment,¹⁰⁵ though some workers would recommend rinsing with sterile water^{13 63 111} to ensure against possible recontamination from municipal water supplies. Regular bacteriological monitoring of tap water used in rinsing is recommended.¹³ After rinsing, the channels of the endoscope should be thoroughly air-dried, especially before storage. Endoscopes are best stored by hanging them vertically in air as this helps to prevent contamination and proliferation of

organisms in the instruments between sessions.⁴⁰

Disinfecting machines

An effective disinfecting apparatus for fibre-endoscopes can add to the microbiological efficiency, safety and speed of disinfection procedures.¹¹⁰ The ideal apparatus must rapidly and thoroughly disinfect with a simple technique which protects endoscopy staff from contact with potentially toxic disinfectants and be safe for the endoscope themselves. The disinfection systems commercially available vary from simple trough containers to sophisticated fully automatic machines.¹¹⁷ Open-trough systems are potentially hazardous for endoscopy personnel as they allow manual contact with disinfectant and splashing during disinfection procedures. Fully automated machines disinfect all the endoscope channels, incorporate timed pre-clean, disinfection and rinse cycles but are expensive and endoscopes have been damaged by some models.^{109 117 124} The Leeds Disinfector¹¹⁰ is a closed-system apparatus which has been shown to provide effective rapid disinfection with a simple technique protecting endoscopy staff from contact with glutaraldehyde and fibre-endoscopes from material damage. The provision of effective and safe disinfection systems has not kept pace with the rapid development of other endoscopic equipment and is an area deserving more attention.

Conclusion

Though hundreds of thousands of endoscopic examinations are now performed worldwide each year with very few reports of resulting infection, the use of inadequately disinfected fibre-endoscopes exposes patients to an unnecessary risk of infection which can be eliminated by thorough disinfection of endoscopic equipment.¹²⁵ The problem of infection with gastrointestinal endoscopy and the need for disinfection has been recently reiterated by statements from both the British and American endoscopy societies urging the adoption of thorough cleaning and disinfection protocols for fibre-endoscopes and their ancillaries.¹²⁶ An effective disinfection protocol incorporating thorough mechanical cleaning and the use of a safe rapidly germicidal disinfectant should be routine before and after each endoscopy session and between patient procedures. With properly trained endoscopy assistants and an efficient disinfecting apparatus, adequate disinfection procedures can easily be incorporated into the work of a busy endoscopy list. Priorities for the future should include the development of alternative compounds and solutions which

fulfil the stringent criteria for fibre-endoscope disinfectants, the manufacture of the fibre-endoscopes with heat and chemical resistant materials, the education and training of endoscopy assistants in thorough disinfection techniques and regular microbiological control of disinfection procedures.

As gastrointestinal endoscopy services continue to expand and diversify into new and more invasive procedures, it is important that endoscopy personnel are aware of the dangers of infection and that firm guidelines regarding adequate disinfection are laid down for endoscopy units.

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