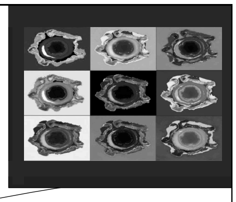
Innate Resistance to Sproicides and Potential Failure to Decontaminate
Prof. Jean-Yves Maillard, Cardiff University, Wales
A Webber Training Teleclass

Innate Resistance to Sporicides and Potential Failure to Decontaminate

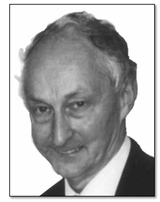


Dr Jean-Yves Maillard
Cardiff School of Pharmacy and Pharmaceutical Sciences
Cardiff University, Wales

Hosted by Prof. Syed A. Sattar
Centre for Research on Environmental Microbiology
University of Ottawa

www.webbertraining.com April 12, 2012

The A. Denver Russell Memorial Teleclass Lecture (2012)



Professor Allan Denver Russell
(1936-2004)

2

CONTENT

- Review the latest information on spore structures conferring resistance to sporicides
- Review microbicides with a sporicidal activity
- Review the conditions necessary to achieve sporicidal efficacy
- Reflect on conditions found in practice focussing notably on environmental surface in the healthcare environment and on the disinfection of medical devices
- Reflect on the use of wipes for the delivery of microbicides and their efficacy against bacterial endospores.
- Discuss the risks associated with sporicide failure

3

AD Russell Memorial Teleclass Lecture 2012

LIMITATIONS OF CURRENT SURFACE INTERVENTIONS

Levels of 'germicidal' action – Spaulding classification

High-level	- prions - bacterial spores
Intermediate-level	- protozoal oocysts - mycobacteria - naked viruses - protozoal cysts - vegetative Gram- negative - fungi
Low-level	- protozoa - vegetative Gram-positive - enveloped viruses

SPORICIDE

4

AD Russell Memorial Teleclass Lecture 2012

SPORICIDES

ALKYLATING AGENTS

- Ethylene oxide
- Glutaraldehyde
- Formaldehyde
- *ortho*-phthalaldehyde

OXIDISING AGENTS

- Hydrogen peroxide
- Peracetic acid
- Chlorine dioxide
- Ozone
- Sodium hypochlorite
- Sodium dichlororisocyanurate
- Chloramine-T
- Calcium hypochlorite

5

AD Russell Memorial Teleclass Lecture 2012

SPORICIDES

ALKYLATING AGENTS

- Ethylene oxide
- Glutaraldehyde
- Formaldehyde
- *ortho*-phthalaldehyde

OXIDISING AGENTS

- Hydrogen peroxide
- Peracetic acid
- Chlorine dioxide
- Ozone
- Sodium hypochlorite
- Sodium dichlororisocyanurate
- Chloramine-T
- Calcium hypochlorite

Highly reactive compounds

High-level disinfection

6

AD Russell Memorial Teleclass Lecture 2012

Hosted by Prof. Syed A. Sattar, University of Ottawa
www.webbertraining.com

SPORICIDES – alkylating agents

Spores		Concentration	Log reduction	Time (min)
Formaldehyde				
B. subtilis globigii		10%	6	60
B. subtilis globigii (10^9)		8%	0.8	30
B. anthracis		2%	5	60
B. cereus		2%	5	4 h
G. stearothermophilus		2%	5	24 h
Glutaraldehyde				
B. anthracis (10^8)		20000 ppm	4	15
B. subtilis globigii (2-7 X10^6)		20000 ppm	2.5	30
B. subtilis (10^9)	[Cidex Long-Life]	20000 ppm (4%)	>5	60
[Sporicidin + 7.05% phenol + 1.2% sodium phenate]		20000 ppm (1/8)	>6	8 h
C. difficile (~10^5)	[Wavicide-200]	20000 ppm	>4.1	30

7

SPORICIDES – alkylating agents

Spores		Concentration	Log reduction	Time (min)
Formaldehyde				
B. subtilis globigii		10%	6	60
B. subtilis globigii (10^9)		8%	0.8	30
B. anthracis		2%	5	60
B. cereus		2%	5	4 h
G. stearothermophilus		2%	5	24 h
Glutaraldehyde				
B. anthracis (10^8)		20000 ppm	4	15
B. subtilis globigii (2-7 X10^6)		20000 ppm	2.5	30
B. subtilis (10^9)	[Cidex Long-Life]	20000 ppm (4%)	>5	60
[Sporicidin + 7.05% phenol + 1.2% sodium phenate]		20000 ppm (1/8)	>6	8 h
C. difficile (~10^5)	[Wavicide-200]	20000 ppm	>4.1	30

8

SPORICIDES – alkylating agents

Spores		Concentration	Log reduction	Time (min)
Formaldehyde				
B. subtilis globigii		10%	6	60
B. subtilis globigii (10^9)		8%	0.8	30
B. anthracis		2%	5	60
B. cereus		2%	5	4 h
G. stearothermophilus		2%	5	24 h
Glutaraldehyde				
B. anthracis (10^8)		20000 ppm	4	15
B. subtilis globigii (2-7 X10^6)		20000 ppm	2.5	30
B. subtilis (10^9)	[Cidex Long-Life]	20000 ppm (4%)	>5	60
[Sporicidin + 7.05% phenol + 1.2% sodium phenate]		20000 ppm (1/8)	>6	8 h
C. difficile (~10^5)	[Wavicide-200]	20000 ppm	>4.1	30

9

SPORICIDES – oxidising agents

Spores		Concentration	Log reduction	Time (min)
Liquid hydrogen peroxide - Surface test				
B. subtilis globigii (10^9)		100000 ppm (pH 4.2, 22ºC)	3	30
B. subtilis (10^6)	[Virox STF]	70000 ppm	≥ 6	15
B. anthracis, *B. subtilis*, *B. atrophaeus*, *B. licheniformis* (10^6)		70000 ppm	≥ 6	15
C. sporogenes (10^7)	[Virox STF]	70000 ppm	≥ 6	~5
C. difficile (10^7)	[Virox STF]	70000 ppm	≥ 6	5-10
Peracetic acid – surface test				
B. subtilis globigii spores (10^9)		300 ppm (pH 2.6)	2.2	30
B. anthracis, *B. subtilis*, *B. atrophaeus*, *B. licheniformis* (10^6)		3000 ppm	≥ 6 Log	10
B. anthracis		5000 ppm (30ºC)	>6	10
Liquid chlorine dioxide – surface test				
B. subtilis (10^6-10^7)		~630 ppm	≥ 6	~5
B. subtilis (10^6)		600 ppm	≥ 6	15
B. anthracis, *B. subtilis*, *B. atrophaeus* (10^6)		1000 ppm	5	20
B. licheniformis (10^6)		1000 ppm	4	20
C. sporogenes (~10^7)		600 ppm	≥ 6	10
C. difficile (6 x 10^7)		600 ppm	≥ 6	10
Liquid chlorine dioxide – suspension test				
B. subtilis		146 ppm	6	2.5
B. cereus		200 ppm (~pH11)	5.4	5
Peracetic acid				
B. atrophaeus (10^6 CFU)	[Perasafe®]	2600 ppm	<3	10
B. subtilis (10^9)	[Nu-Cidex]	3500 ppm (4%)	>5	2
C. difficile (~10^5)	[Perasafe®]	3500 ppm (3%)	>4	5
	[Perasafe®]	2600 ppm	6	10

10

SPORICIDES – oxidising agents

Spores		Concentration	Log reduction	Time (min)
Liquid hydrogen peroxide - Surface test				
B. subtilis globigii (10^9)		100000 ppm (pH 4.2, 22ºC)	3	30
B. subtilis (10^6)	[Virox STF]	70000 ppm	≥ 6	15
B. anthracis, *B. subtilis*, *B. atrophaeus*, *B. licheniformis* (10^6)		70000 ppm	≥ 6	15
C. sporogenes (10^7)	[Virox STF]	70000 ppm	≥ 6	~5
C. difficile (10^7)	[Virox STF]	70000 ppm	≥ 6	5-10
Peracetic acid – surface test				
B. subtilis globigii spores (10^9)		300 ppm (pH 2.6)	2.2	30
B. anthracis, *B. subtilis*, *B. atrophaeus*, *B. licheniformis* (10^6)		3000 ppm	≥ 6 Log	10
B. anthracis		5000 ppm (30ºC)	>6	10
Liquid chlorine dioxide – surface test				
B. subtilis (10^6-10^7)		~630 ppm	≥ 6	~5
B. subtilis (10^6)		600 ppm	≥ 6	15
B. anthracis, *B. subtilis*, *B. atrophaeus* (10^6)		1000 ppm	5	20
B. licheniformis (10^6)		1000 ppm	4	20
C. sporogenes (~10^7)		600 ppm	≥ 6	10
C. difficile (6 x 10^7)		600 ppm	≥ 6	10
Liquid chlorine dioxide – suspension test				
B. subtilis		146 ppm	6	2.5
B. cereus		200 ppm (~pH11)	5.4	5
Peracetic acid				
B. atrophaeus (10^6 CFU)	[Perasafe®]	2600 ppm	<3	10
B. subtilis (10^9)	[Nu-Cidex]	3500 ppm (4%)	>5	2
C. difficile (~10^5)	[Perasafe®]	3500 ppm (3%)	>4	5
	[Perasafe®]	2600 ppm	6	10

11

SPORICIDES – oxidising agents

Spores		Concentration	Log reduction	Time (min)
Liquid hydrogen peroxide - Surface test				
B. subtilis globigii (10^9)		100000 ppm (pH 4.2, 22ºC)	3	30
B. subtilis (10^6)	[Virox STF]	70000 ppm	≥ 6	15
B. anthracis, *B. subtilis*, *B. atrophaeus*, *B. licheniformis* (10^6)		70000 ppm	≥ 6	15
C. sporogenes (10^7)	[Virox STF]	70000 ppm	≥ 6	~5
C. difficile (10^7)	[Virox STF]	70000 ppm	≥ 6	5-10
Peracetic acid – surface test				
B. subtilis globigii spores (10^9)		300 ppm (pH 2.6)	2.2	30
B. anthracis, *B. subtilis*, *B. atrophaeus*, *B. licheniformis* (10^6)		3000 ppm	≥ 6 Log	10
B. anthracis		5000 ppm (30ºC)	>6	10
Liquid chlorine dioxide – surface test				
B. subtilis (10^6-10^7)		~630 ppm	≥ 6	~5
B. subtilis (10^6)		600 ppm	≥ 6	15
B. anthracis, *B. subtilis*, *B. atrophaeus* (10^6)		1000 ppm	5	20
B. licheniformis (10^6)		1000 ppm	4	20
C. sporogenes (~10^7)		600 ppm	≥ 6	10
C. difficile (6 x 10^7)		600 ppm	≥ 6	10
Liquid chlorine dioxide – suspension test				
B. subtilis		146 ppm	6	2.5
B. cereus		200 ppm (~pH11)	5.4	5
Peracetic acid				
B. atrophaeus (10^6 CFU)	[Perasafe®]	2600 ppm	<3	10
B. subtilis (10^9)	[Nu-Cidex]	3500 ppm (4%)	>5	2
C. difficile (~10^5)	[Perasafe®]	3500 ppm (3%)	>4	5
	[Perasafe®]	2600 ppm	6	10

12

SPORICIDES – oxidising agents

Spores	Concentration	Log reduction	Time (min)
Super-oxidized water			
B. subtilis (10^7) [Microcyn™]	50 ppm av.Cl + 4 ppm H_2O_2	5	3
B. anthracis (10^8)	400 ppm av.Cl (20ºC)	>7	30
C. difficile (10^6) [Sterilox® 2500]	?	>5	5

Sagripanti & Bonifacino. *Am J Infect Control* 1996; 24:364-71.
Perez *et al. AmJ Infect Control* 2005;33:320-5.
Majcher *et al. Appl Environ Microbiol* 2008; 74:676-81.
Beuchat *et al.J Food Prot* 2004; 67:1702-8.
Baldry. *J Appl Bacteriol* 1983; 54:417-23.

SPORICIDES – halogens

Spores	Concentration	Log reduction	Time (min)
Sodium hypochlorite - Surface test			
B. subtilis globigii (10^9)	500 ppm, (22ºC)	2.2	30
B. anthracis, B. subtilis, B. atrophaeus, B. licheniformis (10^6)	5000 ppm	≥ 6	10
Sodium hypochlorite – Suspension test			
B. subtilis	100 ppm	4	5
	1000 ppm	5	0.5
Sodium dichloroisocyanurate – surface test			
B. atrophaeus (10^6)	1000 ppm	<2	10
C. difficile	1000 ppm	<1	10
Sodium dichloroisocyanurate – suspension test			
B. subtilis (10^9) [Haz-Tab]	5750 ppm	>5	5
[Presept]	3180 ppm	>5	60
[Titan -+ anionic, mild alkali]	1200 ppm	>5	180

SPORICIDES – halogens

Spores			Concentration	Log reduction	Time (min)
Bleach – surface test					
B. subtilis	(~10^6)	[acidified bleach]	5000 ppm	≥ 6	5
	(~10^7)	[regular bleach]	1000 ppm	≥ 6	~20
	(~10^6)	[regular bleach]	5000 ppm	≥ 6	~5
C. sporogenes	(10^7)	[acidified bleach]	5000 ppm	≥ 6	~1
	(10^6)	[regular bleach]	1000 ppm	≥ 6	15
	(10^6)	[regular bleach]	5000 ppm	≥ 6	5
C. difficile	(10^7)	[acidified bleach]	5000 ppm	≥ 6	3
	(10^7)	[regular bleach]	1000 ppm	≥ 6	~25
	(5 x 10^7)	[regular bleach]	5000 ppm	≥ 6	~10
Calcium hypochlorite – surface test					
B. anthracis spores (10^8 CFU)			50000 ppm, 20ºC	≥ 7	30

SPORICIDES – halogens

Spores			Concentration	Log reduction	Time (min)
Bleach – surface test					
B. subtilis	(~10^6)	[acidified bleach]	5000 ppm	≥ 6	5
	(~10^7)	[regular bleach]	1000 ppm	≥ 6	~20
	(~10^6)	[regular bleach]	5000 ppm	≥ 6	~5
C. sporogenes	(10^7)	[acidified bleach]	5000 ppm	≥ 6	~1
	(10^6)	[regular bleach]	1000 ppm	≥ 6	15
	(10^6)	[regular bleach]	5000 ppm	≥ 6	5
C. difficile	(10^7)	[acidified bleach]	5000 ppm	≥ 6	3
	(10^7)	[regular bleach]	1000 ppm	≥ 6	~25
	(5 x 10^7)	[regular bleach]	5000 ppm	≥ 6	~10
Calcium hypochlorite – surface test					
B. anthracis spores (10^8 CFU)			50000 ppm, 20ºC	≥ 7	30

SPORICIDES – halogens

Spores			Concentration	Log reduction	Time (min)
Bleach – surface test					
B. subtilis	(~10^6)	[acidified bleach]	5000 ppm	≥ 6	5
	(~10^7)	[regular bleach]	1000 ppm	≥ 6	~20
	(~10^6)	[regular bleach]	5000 ppm	≥ 6	~5
C. sporogenes	(10^7)	[acidified bleach]	5000 ppm	≥ 6	~1
	(10^6)	[regular bleach]	1000 ppm	≥ 6	15
	(10^6)	[regular bleach]	5000 ppm	≥ 6	5
C. difficile	(10^7)	[acidified bleach]	5000 ppm	≥ 6	3
	(10^7)	[regular bleach]	1000 ppm	≥ 6	~25
	(5 x 10^7)	[regular bleach]	5000 ppm	≥ 6	~10
Calcium hypochlorite – surface test					
B. anthracis spores (10^8 CFU)			50000 ppm, 20ºC	≥ 7	30

SPORICIDES – halogens

Spores			Concentration	Log reduction	Time (min)
Bleach – surface test					
B. subtilis	(~10^6)	[acidified bleach]	5000 ppm	≥ 6	5
	(~10^7)	[regular bleach]	1000 ppm	≥ 6	~20
	(~10^6)	[regular bleach]	5000 ppm	≥ 6	~5
C. sporogenes	(10^7)	[acidified bleach]	5000 ppm	≥ 6	~1
	(10^6)	[regular bleach]	1000 ppm	≥ 6	15
	(10^6)	[regular bleach]	5000 ppm	≥ 6	5
C. difficile	(10^7)	[acidified bleach]	5000 ppm	≥ 6	3
	(10^7)	[regular bleach]	1000 ppm	≥ 6	~25
	(5 x 10^7)	[regular bleach]	5000 ppm	≥ 6	~10
Calcium hypochlorite – surface test					
B. anthracis spores (10^8 CFU)			50000 ppm, 20ºC	≥ 7	30

SPORICIDES – vaporised oxidizers

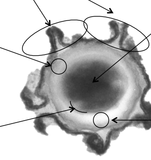
OXIDISING AGENTS

Spores	Concentration	Log reduction	Time (min)
Ozone			
B. cereus	9 ppm, 70% RH	2	360
B. megaterium, B. cereus	2.29 ppm	6?	5
Hydrogen peroxide vapour			
B. subtilis subsp. globigi, G. stearothermophilus (10^6)	Vaporizing a 30% solution of H_2O_2, 4°C	6	8
B. subtilis (10^8)	>1000 ppm within an air-tight glove box	≥6	120
G. stearothermophilus (10^8)	>1000 ppm within an air-tight glove box	2-6	120

19

AD Russell Memorial Teleclass Lecture 2012

RESISTANCE TO SPORICIDES



EXOSPORIUM Degradation ? Persistence on surfaces

SPORE CORE
Small Acid Soluble Proteins (SASPs)
Protection of nucleic acid

Low water content
Protection of proteins

SPORE COATS
Barrier to biocide

INNER MEMBRANE
Highly compressed
Barrier to biocide
Barrier to rehydration

CORTEX
Barrier to biocides
Physical pressure to inner membrane?

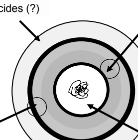
20

AD Russell Memorial Teleclass Lecture 2012

RESISTANCE TO SPORICIDES

EXOSPORIUM
- highly reactive biocides (?)

SPORE COATS
- lysozymes
- hypochlorites
- chlorine dioxide
- GTA
- iodine
- hydrogen peroxide
- chlorhexidine
- ethylene oxide (?)
- ozone



CORTEX
- alkali
- hypochlorites
- chlorine dioxide
- GTA(?)
- iodine
- chlorhexidine (?)
- ozone (?)

SPORE CORE
- dehydration
- SASPs (hydrogen peroxide)

21

AD Russell Memorial Teleclass Lecture 2012

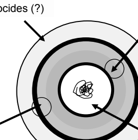
RESISTANCE TO SPORICIDES

DEGRADATION (superoxide dismutase)

INACCESSIBILITY OF TARGET SITES

EXOSPORIUM
- highly reactive biocides (?)

SPORE COATS
- lysozymes
- hypochlorites
- chlorine dioxide
- GTA
- iodine
- hydrogen peroxide
- chlorhexidine
- ethylene oxide (?)
- ozone



CORTEX
- alkali
- hypochlorites
- chlorine dioxide
- GTA(?)
- iodine
- chlorhexidine (?)
- ozone (?)

SPORE CORE
- dehydration
- SASPs (hydrogen peroxide)

INACCESSIBILITY OF TARGET SITES

INACCESSIBILITY OF TARGET SITES

22

AD Russell Memorial Teleclass Lecture 2012

SPORICIDES - usage

PREVENT THE TRANSMISSION OF SPORES FROM THE ENVIRONMENT

From patients to patients
From health care workers to patients — Hand hygiene
From visitors to patients
From the environment to hands

PREVENT THE TRANSMISSION OF SPORES FROM MEDICAL DEVICES

Single use items
Altering usage (e.g. Thermometer)
Endoscope
Others (e.g. blood pressure cuffs)

23

AD Russell Memorial Teleclass Lecture 2012

SPORICIDES - usage

PREVENT THE TRANSMISSION OF SPORES FROM THE ENVIRONMENT

From patients to patients
From health care workers to patients — Hand hygiene
From visitors to patients
From the environment to hands

REMOVED BUT NOT KILLED

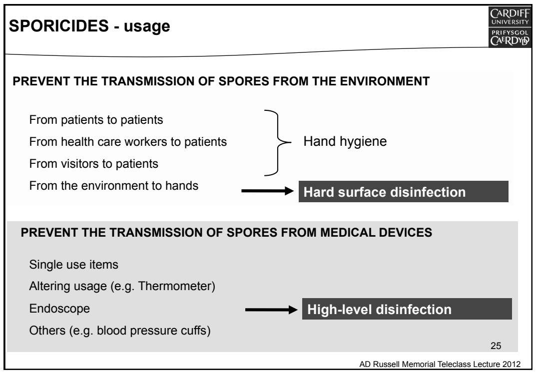
PREVENT THE TRANSMISSION OF SPORES FROM MEDICAL DEVICES

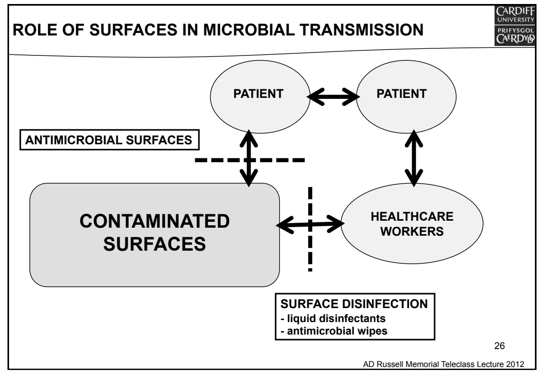
Single use items
Altering usage (e.g. Thermometer)
Endoscope
Others (e.g. blood pressure cuffs)

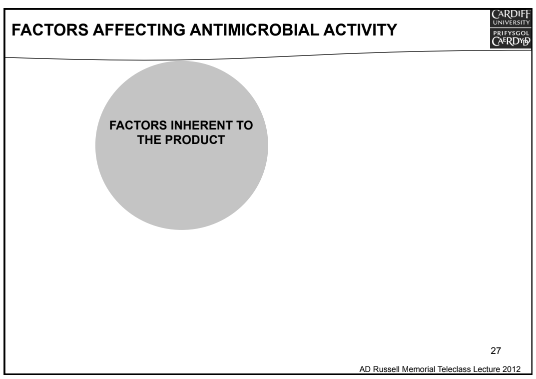
REMOVED BUT NOT KILLED

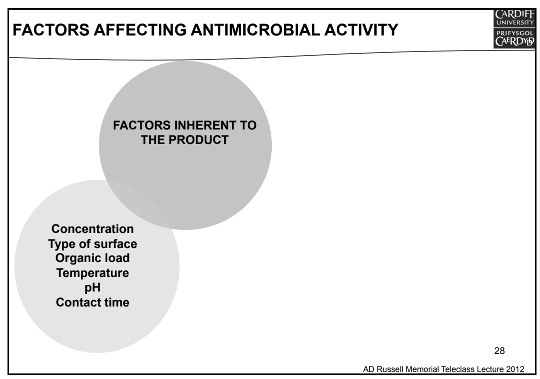
24

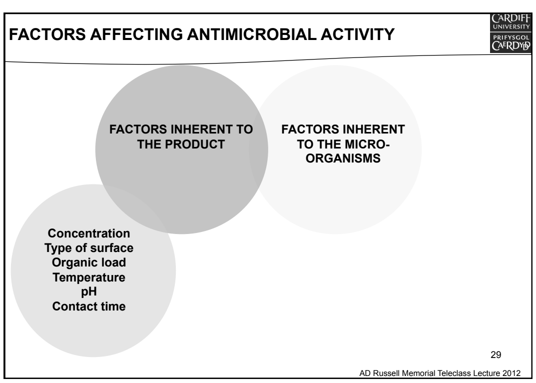
AD Russell Memorial Teleclass Lecture 2012

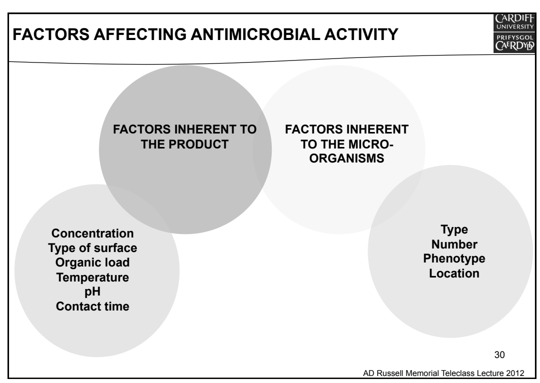

SPORICIDES - usage
PREVENT THE TRANSMISSION OF SPORES FROM THE ENVIRONMENT
From patients to patients
From health care workers to patients
From visitors to patients
Hand hygiene
From the environment to hands
Hard surface disinfection
PREVENT THE TRANSMISSION OF SPORES FROM MEDICAL DEVICES
Single use items
Altering usage (e.g. Thermometer)
Endoscope
High-level disinfection
Others (e.g. blood pressure cuffs)
25
AD Russell Memorial Teleclass Lecture 2012


ROLE OF SURFACES IN MICROBIAL TRANSMISSION
PATIENT
PATIENT
ANTIMICROBIAL SURFACES
CONTAMINATED SURFACES
HEALTHCARE WORKERS
SURFACE DISINFECTION
- liquid disinfectants
- antimicrobial wipes
26
AD Russell Memorial Teleclass Lecture 2012

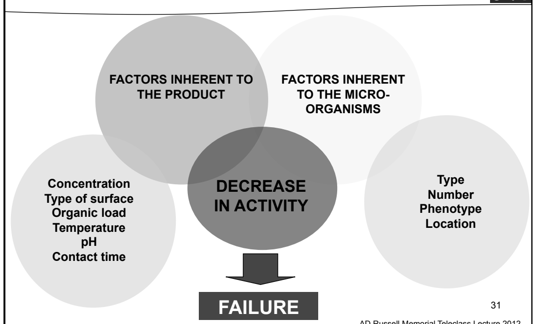

FACTORS AFFECTING ANTIMICROBIAL ACTIVITY
FACTORS INHERENT TO THE PRODUCT
27
AD Russell Memorial Teleclass Lecture 2012


FACTORS AFFECTING ANTIMICROBIAL ACTIVITY
FACTORS INHERENT TO THE PRODUCT
Concentration
Type of surface
Organic load
Temperature
pH
Contact time
28
AD Russell Memorial Teleclass Lecture 2012


FACTORS AFFECTING ANTIMICROBIAL ACTIVITY
FACTORS INHERENT TO THE PRODUCT
FACTORS INHERENT TO THE MICRO-ORGANISMS
Concentration
Type of surface
Organic load
Temperature
pH
Contact time
29
AD Russell Memorial Teleclass Lecture 2012


FACTORS AFFECTING ANTIMICROBIAL ACTIVITY
FACTORS INHERENT TO THE PRODUCT
FACTORS INHERENT TO THE MICRO-ORGANISMS
Concentration
Type of surface
Organic load
Temperature
pH
Contact time
Type
Number
Phenotype
Location
30
AD Russell Memorial Teleclass Lecture 2012

FACTORS AFFECTING ANTIMICROBIAL ACTIVITY



31

AD Russell Memorial Teleclass Lecture 2012

FACTORS AFFECTING ANTIMICROBIAL ACTIVITY

FACTORS	IMPORTANCE FOR EFFICACY	PREDICTABILITY
Concentration	+++	Concentration exponent (η)
Type of surface	+++	Roughness Hydrophobicity Charge
Organic load	+++	Chemical nature of active Soiling (blood, faeces, etc.)
Temperature	+++	Q_{10}
pH	++	Chemical nature of active
Contact time	+++	Continuous release (reservoir)
Relative humidity	+++	Gaseous biocides

32

AD Russell Memorial Teleclass Lecture 2012

FACTORS AFFECTING ANTIMICROBIAL ACTIVITY

FACTORS	IMPORTANCE FOR EFFICACY	PREDICTABILITY
Type	+++	Various susceptibility
Number	++	Difficult to predict
Phenotype	+++	Microbial growth (low metabolism) Environmental conditions Biofilm growth
Location	+++	Tissue surrounding implant : reservoir of pathogens

33

AD Russell Memorial Teleclass Lecture 2012

FACTORS AFFECTING ANTIMICROBIAL ACTIVITY

CONTROL OF ENVIRONMENTAL PARAMETERS

- Temperature
- Relative humidity
- Soiling/fomites

1. **Dried surfaces**
2. **Liquid is enhancing biocide interactions with the target microorganisms**

ENVIRONMENTAL SURFACES
- Door handles
- Bed rails
- Bed frame
- Side cupboards
- Trolley
- Wall panels
- Light switches
- Chairs
- Keyboards
- Equipment casing (plastic)

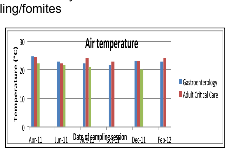
34

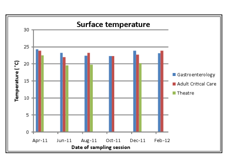
AD Russell Memorial Teleclass Lecture 2012

FACTORS AFFECTING ANTIMICROBIAL ACTIVITY

CONTROL OF ENVIRONMENTAL PARAMETERS

- Temperature
- Relative humidity
- Soiling/fomites





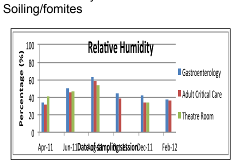
35

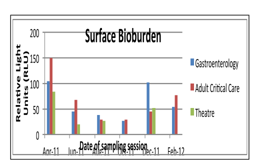
AD Russell Memorial Teleclass Lecture 2012

FACTORS AFFECTING ANTIMICROBIAL ACTIVITY

CONTROL OF ENVIRONMENTAL PARAMETERS

- Temperature
- Relative humidity
- Soiling/fomites





36

AD Russell Memorial Teleclass Lecture 2012

SPORICIDES – factors affecting activity

Spores		Soiling	Log reduction	Time (min)
Sodium dichloroisocyanurate				
B. subtilis (10^9)	[Haz-Tab – 5750 ppm av.Cl]	No organic material	>5	5
		2% blood	>5	30
		4% blood	>5	45
	[Presept -3180 ppm av.Cl]	No organic material	>5	60
		2% blood	>5	120
OXIDISING AGENTS		4% blood	0	180
	[Titan -1200 ppm av.Cl]	No organic material	>5	180
		2% blood	0	180

37

AD Russell Memorial Teleclass Lecture 2012

SPORICIDES – factors affecting activity

Spores	Surfaces	Log reduction	Time
Hydrogen peroxide vapour			
B. subtilis (10^8)	porous surfaces	1.6-2.2	120
	non-porous surfaces	>6	120
G. stearothermophilus spores (1 X10^8)	porous surfaces	0.81-4.1	120
	non-porous surfaces	2-6	120
Super-oxidized water			
B. subtilis (10^8)	porous surfaces	1.6-2.2	120
OXIDISING AGENTS	non-porous surfaces	>6	120
Sodium dichloroisocyanurate – 1000 ppm			
B. atrophaeus (10^6)	Stainless steel	<3	10
	PVC	5	10
C. difficile	Stainless steel	<1	10
	PVC	1	10
Peracetic acid [perasafe®]			
B. atrophaeus (10^6)	Stainless steel	<3	10
	PVC	>5	10

SPORICIDES – factors affecting activity

Spores	Growth media	Log reduction	Time (min)
Liquid chlorine dioxide – 600 ppm			
C. difficile (6 x 10^7)	BHI growth	≥ 6	30
C. difficile (1 x 10^7)	CB growth	≥ 6	10

39

AD Russell Memorial Teleclass Lecture 2012

SPORICIDES AND SURFACE DISINFECTION *IN SITU*

- **Important infection control measure**
- **Interruption of spore transmission to vulnerable patients from the environment**

PREVALENCE OF *Clostridium difficile*

Foors, commodes, toilets, bed pans, bed frames
Vonberg *et al. Clin Microbiol Infect* 2008; 14: 2-20.

C. difficile spores persistence on surfaces : 5 months
Kramer *et al. BMC Infect Dis* 2006; 6:130-8.

C. difficile incidence data correlated with the prevalence of environmental spores in 1 out of 2 wards.
Fawley *et al. Epidemiol Infect* 2001; 126: 343-50.

40

AD Russell Memorial Teleclass Lecture 2012

SPORICIDES AND SURFACE DISINFECTION *IN SITU*

HYPOCHLORITE EFFICACY FOR FLOOR DISINFECTION
Wilcox *et al. J Hops Infect* 2003; 54: 109-14.

•Two elderly medicine wards

•Alternative hypochlorite disinfection (1000ppm) and neutral detergent

•1128 environmental samples analysed; 35% positive for *C. difficile*

- No difference in environmental prevalence of *C. difficile* following detergent or hypochlorite usage
- In 1 ward significant decrease of CDI from 8.9 to 5.3 cases/ 100 admissions
- Differences between 2 wards explained by additional confounding factors?
  - cleaning efficiency
  - patients' type
  - prescribing
  - *hand hygiene*

41

AD Russell Memorial Teleclass Lecture 2012

SPORICIDES AND SURFACE DISINFECTION *IN SITU*

PERSISTENCE OF *C. difficile* AFTER HYPOCHLORITE INTERVENTION

•Hypochlorite (1000 ppm) – reduce CDI case in 1 ward – **SURVIVAL**
Wilcox *et al. J Hops Infect* 2003; 54: 109-14

•Unbuffered hypochlorite (500 ppm): decrease surface contamination by 21% from initial level

•Phosphate buffered hypochlorite (1600 ppm): 98% decrease in surface contamination
Kaatz *et al. Am J Epidemiol* 1988; 127; 1289-94

•Hypochlorite (5000 ppm): 8.6 - 3.3/10000 patients day reduction
Mayfield *et al. Clin Infect Dis* 2000; 31:995-1000.

42

AD Russell Memorial Teleclass Lecture 2012

SPORICIDES AND SURFACE DISINFECTION *IN SITU*

ENDOSCOPY

- No report of *C. difficile* of endoscope transmission
- Contamination of endoscope with *C. difficile* occur

Hughes *et al. Gastrointest Endosc* 1986; 32:7-9.

43

AD Russell Memorial Teleclass Lecture 2012

SPORICIDES AND SURFACE DISINFECTION *IN SITU*

ALCOHOL-BASED HAND RUBS

Hsu *et al. Am J Gastroenterol* 2010;105:2327-2339

TRIAL	STUDY DESIGN	POPULATION	RESULTS	
			Pre-intervention	Post-intervention
Gopal Rao *et al. J Hosp Infect* 2002; 50:42-7	Interventional before-after non randomized historical control	Patients hospital wide (ages not specified)	11.5 cases per 1000 admissions	9.5 cases per 1000 admissions (P=0.02)
Gordin *et al. Infect Control hosp Epidemiol* 2005; 26:650-3	Interventional before-after non randomized historical control	Adult patients hospital wide	3.24 cases per 10000 patient care days	3.38 cases per 10000 patient care days (P=0.78)

44

AD Russell Memorial Teleclass Lecture 2012

SPORICIDES AND SURFACE DISINFECTION *IN SITU*

HYPOCHLORITE DISINFECTANTS

Hsu et al. *Am J Gastroenterol* 2010;105:2327-2339

TRIAL	STUDY DESIGN	POPULATION	RESULTS	
			Pre-intervention	Post-intervention
Mayfield *et al. Clin Infect Dis* 2000; 31:995-1000	Interventional before-after; historical control	Adult patients in the bone marrow transplant unit, the neurosurgical intensive care unit and a general medicine unit	8.6 cases per 1000 patient days	3.3 cases per 1000 patient days
Wilcox *et al. J Hosp Infect* 2003:54:109-14	Non randomized cross-over control	Elderly patients on two elected medicine wards	8.9 cases per 100 admissions	5.3 cases per 100 admissions (P<0.05) (decline only in one unit)
McMullen *et al. Infect Control Hosp Epidemiol* 2007; 28:205-7	Interventional before-after; Outbreak	Medical and surgical intensive care units	MICU: 16.6 cases per 1000 patient days SICU: 10.4 cases per 1000 patient days	MICU: 3.7 cases per 1000 patient days SICU: 3.9 cases per 1000 patient days

45

AD Russell Memorial Teleclass Lecture 2012

SPORICIDES AND SURFACE DISINFECTION *IN SITU*

HYDROGEN PEROXIDE VAPOUR

Hsu *et al. Am J Gastroenterol* 2010;105:2327-2339

TRIAL	STUDY DESIGN	POPULATION	RESULTS	
			Pre-intervention	Post-intervention
Boyce *et al. Infect Control Hosp Epidemiol* 2008; 29:723-9	Prospective interventional before-after	Five inpatient units	2.28 cases per 1000 patient days	1.28 cases per 1000 patient days (P=0.047)
		All room vacated by patients	1.89 cases per 1000 patient days	0.88 cases per 1000 patient days (P=0.047)

46

AD Russell Memorial Teleclass Lecture 2012

SPORICIDAL WIPES ACTIVITY

ANTIMICROBIAL WIPE USAGE

Williams *et al. J Hosp Infect* 2007; 67: 329-35

Wipe Number	Surface initially wiped	Time applied (seconds)	Number of consecutive surfaces wiped (other surfaces)
1	Bed Rail	4	5 (bedside table, monitor X2, monitor stand)
2	Steel Trolley	6	2 (both shelves on the trolley wiped)
1	Monitor	4	5 (monitors, two keypads, monitor stand)
2	Bed rail	7	4 (table, monitor, keypad)
3	Bedside table	10	4 (folder, two bed rails)

47

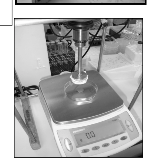
AD Russell Memorial Teleclass Lecture 2012

SPORICIDAL WIPES ACTIVITY

QUANTITATIVE 3-STAGE PROTOCOL

Williams *et al. J Hosp Infect* 2007;67:329-35

Observations of usage in practice –cleaning staff in ITUs
- use of wipes – surface area
- contact
- rotation



Stage 1 – bacterial removal

How good are the wipes in removing microbial contaminants? (not killing effect)

Stage 2 – bacterial transfer "adpression tests"

Can the wipes transfer survivors to other surfaces (i.e. cross-contaminate)?

Stage 3 – Antimicrobial activity

Can the wipes kill the bacteria they remove?

48

AD Russell Memorial Teleclass Lecture 2012

SPORICIDAL WIPES ACTIVITY

SPORICIDAL EFFICACY – efficacy testing against *C. difficile* NCTC12727

Siani *et al. AJIC* 2011; 39: 212-8.

Wipes	Ingredient disclosed in label and claim	Claim on label
WIPE A	Inorganic peroxygen generator, tetra acetyl ethylenediamine, surfactants	Sporicidal
WIPE B	<1% polymeric biguanide hypochloride, alkyl di-methyl benzyl ammonium chloride, didecyl dimethyl ammonium chloride	Sporicidal
WIPE C	QAC, PHMB and bronopol	Bactericidal claim and claim against *Clostridium difficile* on label
WIPE D	Didecyl dimethyl ammonium chloride 0.45%	Sporicidal
WIPE E	Composition not disclosed; "effective against *C. difficile* spores under 30 seconds with mechanical action of cleaning"	Sporicidal
WIPE F	Didecyl ammonium chloride, laurakonium chloride, polyaminoporopyl biguanide, 2-bromo-2-nitro-para1-3-diol	Sporicidal
WIPE G	"impregnated with low-level biocides" 5% cationic surfactant, amphoteric surfactant and EDTA	Sporicidal
WIPE H	Composition not disclosed	Sporicidal
WIPE J	<1% cationic and non-ionic surfactants	No sporicidal claim on label

49

AD Russell Memorial Teleclass Lecture 2012

SPORICIDAL WIPES ACTIVITY

SPORICIDAL EFFICACY – efficacy testing against *C. difficile* NCTC12727

Siani *et al. AJIC* 2011; 39: 212-8.

Wipes	Claim on label	Sporicidal effect (log_{10} reduction ±SD)	
		10 s contact time	5 min contact time
WIPE A	Sporicidal	0.11 (± 0.15)	1.54 (± 0.84)
WIPE B	Sporicidal	0.04 (± 0.05)	+0.84 (± 0.03)
WIPE C	Bactericidal claim and claim against *Clostridium difficile* on label	1.41 (± 0.14)	+0.92 (± 0.15)
WIPE D	Sporicidal	1.77 (± 0.27)	0.01 (± 0.44)
WIPE E	Sporicidal	0.99 (± 0.14)	+0.70 (± 0.15)
WIPE F	Sporicidal	1.96 (± 0.09)	+0.66 (± 0.13)
WIPE G	Sporicidal	0.37 (± 0.23)	+0.50 (± 0.19)
WIPE H	Sporicidal	0.41 (± 0.10)	+0.66 (± 0.10)
WIPE J	No sporicidal claim on label	0.31 (± 0.15)	+0.82 (± 0.14)
Hypochlorite soaked wipe	5000 ppm	+ 0.14 (± 0.49)	5.39 (± 0.00)

50

AD Russell Memorial Teleclass Lecture 2012

SPORICIDAL WIPES ACTIVITY

SPORICIDAL EFFICACY – efficacy testing against *C. difficile* NCTC12727

Siani *et al. AJIC* 2011; 39: 212-8.

Wipes	Claim on label	Sporicidal effect (log_{10} reduction ±SD)	
		10 s contact time	5 min contact time
WIPE A	Sporicidal	0.11 (± 0.15)	1.54 (± 0.84)
WIPE B	Sporicidal	0.04 (± 0.05)	+0.84 (± 0.03)
WIPE C	Bactericidal claim and claim against *Clostridium difficile* on label	1.41 (± 0.14)	+0.92 (± 0.15)
WIPE D	Sporicidal	1.77 (± 0.27)	0.01 (± 0.44)
WIPE E	Sporicidal	0.99 (± 0.14)	+0.70 (± 0.15)
WIPE F	Sporicidal	1.96 (± 0.09)	+0.66 (± 0.13)
WIPE G	Sporicidal	0.37 (± 0.23)	+0.50 (± 0.19)
WIPE H	Sporicidal	0.41 (± 0.10)	+0.66 (± 0.10)
WIPE J	No sporicidal claim on label	0.31 (± 0.15)	+0.82 (± 0.14)
Hypochlorite soaked wipe	5000 ppm	+ 0.14 (± 0.49)	5.39 (± 0.00)

Sporistatic (arrows pointing to WIPE C, D and F 10 s values)

51

AD Russell Memorial Teleclass Lecture 2012

SPORICIDAL WIPES ACTIVITY

SPORICIDAL EFFICACY – efficacy testing against *C. difficile* NCTC12727

Siani *et al. AJIC* 2011; 39: 212-8.

Wipes	Bacterial Removal (log_{10} cfu/disk ± SD) 500 g surface pressure	Bacterial transfer following 10 s wiping time at 500 g surface pressure
Negative control	1.13 (± 0.36)	5 consecutive transfers. TNTC
Hypochlorite soaked wipe	2.02 (± 0.21)	5 consecutive transfers. TNTC
WIPE A	4.09 (± 0.79)	No spore transferred
WIPE B	0.22 (± 0.07)	**5 consecutive transfers. From 0 to TNTC**
WIPE C	1.30 (± 0.33)	**5 consecutive transfers. From 0 to TNTC**
WIPE D	0.57 (± 0.07)	**5 consecutive transfers. From 1 to TNTC**
WIPE E	+0.08 (± 0.08)	5 consecutive transfers. TNTC
WIPE F	1.14 (± 0.65)	5 consecutive transfers. From 83 to TNTC
WIPE G	0.67 (± 0.11)	5 consecutive transfers of ≤43 bacteria
WIPE H	0.88 (± 0.13)	5 consecutive transfers. From 2 to TNTC
WIPE J	0.84 (± 0.66)	5 consecutive transfers. From 40 to TNTC

52

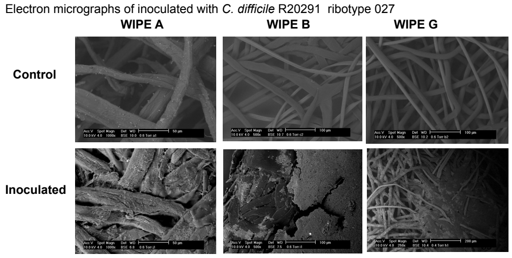
AD Russell Memorial Teleclass Lecture 2012

SPORICIDAL WIPES ACTIVITY

SPORICIDAL EFFICACY – efficacy testing against *C. difficile* NCTC12727

Siani *et al. AJIC* 2011; 39: 212-8.

Electron micrographs of inoculated with *C. difficile* R20291 ribotype 027



AD Russell Memorial Teleclass Lecture 2012

SPORICIDAL WIPES ACTIVITY *IN SITU*

Carter & Barry. Nursing Time 2011, 107

Study between 2006-2010; in 2008 chlorine based cleaning regimens and products changed to non-chlorine based sporicidal wipe

Average *C. difficile* rate per 1000 patients			
Financial year	Number of weeks	Mean C. difficile rate	Median C. difficile rate
2006-07	51	6.27	5.54
2007-08	52	6.99	5.95
Introduction of changes			
2008-09	51	2.05	1.74
2009-10	23	1.66	1.59

- Changes included staff training on wipe usage
- Daily environmental cleaning (including surfaces at risks)
- Weekly ward visit to ensure good practice (e.g. supply of wipes)
- Weekly multidisciplinary ward round to monitor infection prevention and control measures
- Increase awareness campaign

54

AD Russell Memorial Teleclass Lecture 2012

ACTIVITY AGAINST *C. difficile*

UNDERSTANDING *Clostridium difficile*

By ATS Labs on March 9, 2011

"Because the dormant spore form found in the health care environment causes concern for the infection control process, the EPA requires that all disinfectant products registered for use against *C. difficile* must be effective against the spore form of the organism, not the vegetative form.

However, testing is difficult because these strains don't readily sporulate to high populations (>10^8 spores/mL) using standard propagation methods and growth media."

55

AD Russell Memorial Teleclass Lecture 2012

ACTIVITY AGAINST *C. difficile*

PRODUCT C

"Product C achieved a 100% kill of vegetative cells of *Clostridium difficile* ATCC 9689 (1.1 x 10^7) dried out on a 12 inch square stainless steel test surface. (Wipe time: 30 seconds)"

Validation of Product C efficacy against *Clostridium difficile* ATCC 9689 – surface test

"The test organism was inoculated into 9ml of cooked meat medium (Biomerieux) and incubated at 37^{o}C for 48 hours to obtain a culture containing approximately 10^8 cells/ml (actual count = 1.1 x 10^8/ml). A 12 inch square test surface was marked out on a stainless steel plate and one ml of inoculum was spread over the test surface and allowed to dry for 30 minutes. The Product C was wiped systematically over the test surface for 30 seconds. Suspensions were taken from the surface of the test site and from the wipe itself, plated out on HBA plates and incubated in an anaerobic jar for five days at 37^{o}C ."

NO MENTION THAT THE TEST WAS CONDUCTED ANAEROBICALLY!!

56

AD Russell Memorial Teleclass Lecture 2012

SPORICIDE FAILURE AND INCIDENCE

SURVIVING SPORICIDAL INTERVENTION

HIGH CONCENTRATION
LONG CONTACT TIME

MEDICAL DEVICES ✓

No report of spore resistance

Failure of high-level disinfection documented

SURFACE DISINFECTION ✗

Ineffective use of sporicide
- lower concentration
- shorter contact times

Failure of high-level disinfection
- survival of spores
- persistence of spores

57

AD Russell Memorial Teleclass Lecture 2012

SPORICIDE FAILURE AND INCIDENCE

RISKS ASSOCIATED WITH SPORICIDE FAILURE

SEVERITY	LIKELIHOOD		RISK
HIGH	Surface	HIGH	HIGH
	Medical devices	LOW	LOW

Treatment costs
Hospital stay
Death

58

AD Russell Memorial Teleclass Lecture 2012

SPORICIDE FAILURE AND INCIDENCE

RISKS ASSOCIATED WITH SPORICIDE FAILURE

SEVERITY	LIKELIHOOD		RISK
HIGH	Surface	HIGH	HIGH
	Medical devices	LOW	LOW

Treatment costs
Hospital stay
Death

ADDITIONAL INTERVENTIONS

INCREASE HYGIENE
- protective barrir
- hand hygiene

ISOLATION ROOM

DEEP CLEAN

ANTIBIOTIC CHEMOTHERAPY

59

AD Russell Memorial Teleclass Lecture 2012

SPORICIDE FAILURE AND INCIDENCE

ENSURING EFFICACY OF SPORICIDES

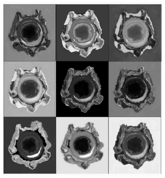
EFFICACY
- Clear understanding of the product limitations
- Clear understanding of the factors affecting activity
- Clear understanding of product application
- Clear manufacturer's instructions – including limitations of the products
- Ease of use (e.g. avoiding dilution / appropriate dispenser)

KNOWLEDGE
- Efficacy test protocols
- Matching product and application

60

AD Russell Memorial Teleclass Lecture 2012

CARDIFF UNIVERSITY PRIFYSGOL CAERDYD



Lovleen Joshi

Professor Allan Denver Russell
(1936-2004)

61

AD Russell Memorial Teleclass Lecture 2012

Coming Soon

17 April — *(FREE WHO Teleclass – North America)* **Implementing Change: The Technical & Socio-Adaptive Aspects of Preventing Catheter-Associated Urinary Tract Infection**
Speaker: Prof. Sanjay Saint, University of Michigan
Sponsor: World Health Organization First Global Patient Safety Challenge

18 April — **Central Line Associated Infection in the ICU**
Speaker: Prof. M. L. McLaws, University of New South Wales, Australia

24 April — **Managing Urinary Catheters and CAUTIs**
Speaker: Sharon Eustice, ARC Health Care Management Consultants, UK

26 April — ***Clostridium difficile*** **Infection: Lessons From the Quebec Experience**
Speaker: Prof. Yves Longtin, University of Laval, Quebec City
Sponsored by Vernacare (www.vernacare.com)

03 May — **Meet the Press – Tips and Techniques for Dealing With the Media**

www.webbertraining.com/schedulep1.php