



©2005 Artofact Records

Hygiene in Biomedical Technology

Jan Liese, MD

**Hospital Hygiene and Infection Control
University Hospital Tübingen**

July 16, 2018

NATIONAL BRIEFING | PLAINS

Oklahoma: Dentist May Have Put Patients at Risk

By THE ASSOCIATED PRESS

Published: March 28, 2013

Health officials on Thursday urged an oral surgeon's patients to undergo [hepatitis](#) and [H.I.V.](#) testing, saying filthy conditions at his upscale practice posed a threat to his 7,000 clients and made him a "menace to the public health." The Oklahoma Board of Dentistry said inspectors went to Dr. W. Scott Harrington's office after a patient with no other known risk factors tested positive for both [hepatitis C](#) and the virus that causes AIDS. Inspectors found multiple problems, including cross-contamination of needles and other instruments and the use of a separate rusty set of instruments for patients who were known to carry [infectious diseases](#), according to a complaint. Dr. Harrington voluntarily closed his offices and faces a hearing April 19.

 FACEBOOK

 TWITTER

 GOOGLE+

 SAVE

 E-MAIL

 SHARE

 PRINT

 REPRINTS

Outline

- **Microbiology and Infection**
- **Disinfection**
- **Sterilization**
- **Legal Regulations**

MICROBIOLOGY AND INFECTION

Microbiology and Infection

- Every infectious disease is caused by a microorganism (= infectious agent = pathogen)
- Only a minority of all microorganisms has a pathogenic potential

Group	Size
Parasites	
Protozoa	
Fungi	
Bacteria	
Viruses	
Prions	

Microbiology and Infection

- Simple presence of a microorganism does not equal infection
- Colonization with bacteria is normal for many compartments of the human body (skin, upper respiratory tract, gut, vagina): „normal flora“
- Infection requires recognition by the immune system and initiation of a host immune response

Microbiology and Infection

- Opportunistic pathogens:
 - causes disease under certain circumstances (immunosuppression, age, underlying conditions etc.)
 - often part of the normal flora
- Nosocomial infection:
 - acquired in the hospital („healthcare-associated“)
 - ca. 500.000 cases/year in Germany (ca. 15.000 deaths)
 - 1/3 are avoidable
 - not necessarily transmitted in the hospital!

Microbiology and Infection



zur Startseite machen

Abo Shop TV-Programm **BEWEGER GESUCHT!**  Wetter | Anmelden Registrieren

Suchen... 

Home Politik Wirtschaft Geld Sport Wissen **Panorama** Kultur Reise Motor Regionales Meinung Videos Marktplatz

IN DEN NACHRICHTEN: Bayern München | SPD-Kompetenzteam | Thomas de Maizière | Dan Brown 28. Mai. 2013, 15:01

Home > Panorama > Weltgeschehen > Klebsiella – der Todes-Keim auf der Frühchenstation

03.11.11 | Bremer Klinik

Klebsiella – der Todes-Keim auf der Frühchenstation

Drei frühgeborene Babys sind schon auf einer Bremer Intensivstation an einem resistenten Klebsiella-Keim gestorben. Die Quelle der Infektion ist noch immer unbekannt. *Von Ullrich Exner*

ARTIKEL EMPFEHLEN

  7  1  0

Microbiology and Infection

Abnahme Eingang
13.03.2011 **13.03.2011**
07:00 10:45

Untersuchungsmaterial Blutkultur

Diagnose: Fieber in Aplasie

Blutkulturmedium (aerob) positiv
Blutkulturmedium (anaerob) negativ
Blutkulturmedium (Pilze) negativ

Kultureller Befund

K1 (aerobes Medium) *Pseudomonas aeruginosa*

Antibiogramm	K1					
Gentamicin	R					
Tobramycin	R					
Piperacillin	R					
Piperacillin/Tazobactam	R					
Ceftazidim	R					
Tetrazyklin	R					
Levofloxacin	R					
Ciprofloxacin	R					
Meropenem	R					
Cefepim	R					
Fosfomycin §	R					
Aztreonam	R					
Colistin §	S					
Amikacin	R					

Legende: S = sensibel I = intermediär R = resistent
P = positiv N = negativ NB = nicht
MHK in µg/ml bestimmbar

Transmission of pathogens

- **contact:**
 - direct: from person to person, e.g. hands
 - indirect: inanimate surfaces
- **air-borne:**
 - droplets: $>5\ \mu\text{m}$, sedimentation radius $<5\text{m}$
 - aerosol: $<5\ \mu\text{m}$, direct deposition in lower airways, no sedimentation (e.g. measles, chicken pox)
- **fecal-oral:**
 - contaminated food or water
- **parenteral:**
 - blood or other bodily fluids
- **vector:**
 - e.g. mosquitoes (malaria), ticks (borreliosis)

Infection control measures within the hospital

- **HAND HYGIENE!!!**
- **Adequate re-processing of instruments**
- **Aseptic procedures**
- **Working under hygienic conditions**
- **Cleaning and disinfection of inanimate areas**
- **Isolation in single-bed rooms**

Definitions

Sterilization		
Disinfection		
Antisepsis		

Definitions

Sterilization	Treat an object to achieve freedom of reproducible microorganisms.	
Disinfection		
Antisepsis		

Definitions

Sterilization	Treat an object to achieve freedom of reproducible microorganisms.	
Disinfection	Reduction of number of microorganisms on a surface or an object, which can then no longer serve as a source of infection.	
Antisepsis		

Definitions

Sterilization	Treat an object to achieve freedom of reproducible microorganisms.	
Disinfection	Reduction of number of microorganisms on a surface or an object, which can then no longer serve as a source of infection.	
Antisepsis	Use of antimicrobial agents at the (entrance) site of a potential or established infection (skin, mucosa, wounds).	

Definitions

Sterilization	Treat an object to achieve freedom of reproducible microorganisms.	Max. one (1) surviving organism in 10^6 sterilized units (SE)
Disinfection	Reduction of number of microorganisms on a surface or an object, which can then no longer serve as a source of infection.	Reduction of organisms by at least 5 decades under standardized conditions
Antisepsis	Use of antimicrobial agents at the (entrance) site of a potential or established infection (skin, mucosa, wounds).	Microbiological requirements not defined

Reprocessing („Aufbereitung“)

- **Re-utilization of medical devices:**
 - Preliminaries (coarse cleaning, disassembly etc.)
 - Cleaning, disinfection (if necessary) and water-flushing
 - Checking (cleanness, intactness)
 - Maintenance, checking of function
 - Labeling (if necessary)
 - Packaging and sterilization (if necessary)
 - Approval

When do I have to disinfect?

When do I have to sterilize?

Validation

Food and Drug Administration (FDA):

“Validation is the documented act of demonstrating that a procedure, process, and activity will consistently lead to the expected results.”

Classification of medical products

		in contact with	Requirements	Procedure

Classification of medical products

		in contact with	Requirements	Procedure
uncritical		intact skin		Cleaning (Disinfection)
semi-critical	A	mucosa or not intact skin	normal	Disinfection
	B		increased	

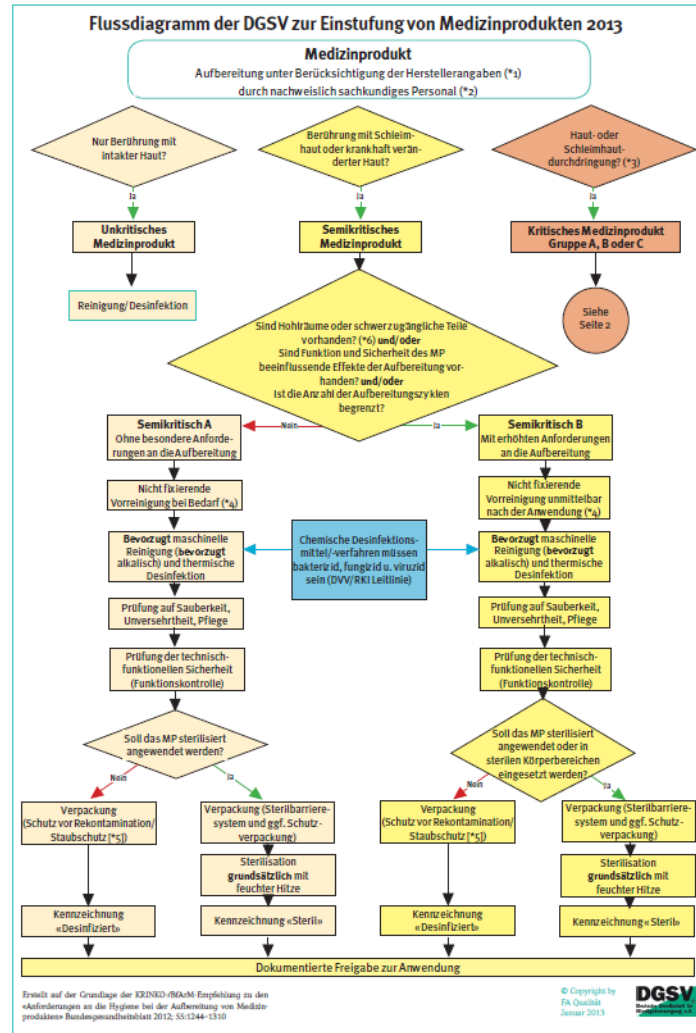
Classification of medical products

		in contact with	Requirements	Procedure
uncritical		intact skin		Cleaning (Disinfection)
semi-critical	A	mucosa or not intact skin	normal	Disinfection
	B		increased	
critical	A	sterile compartments (transection of skin/mucosa)	normal	Sterilization
	B		increased	
	C		increased+ thermolabile	

Classification of medical products

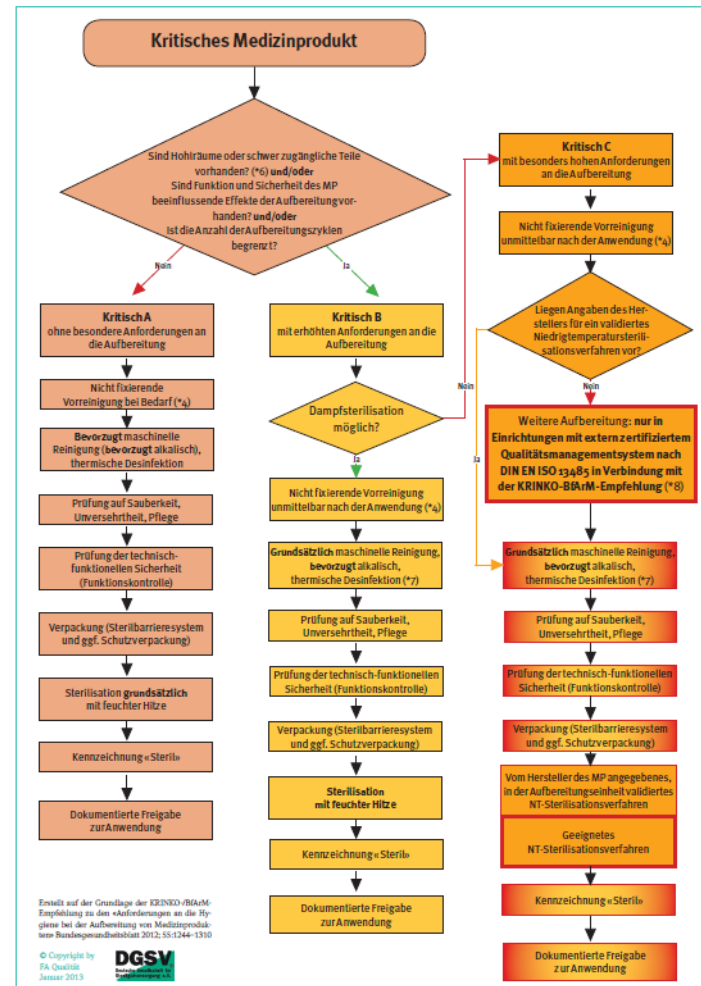
Zentralkontamination 1/2013

EMPFEHLUNGEN | 67



68 | EMPFEHLUNGEN

Zentralkontamination 1/2013



DISINFECTION

Physical procedures

- Boiling (ca. 100 °C, 15 min)
- **Washer-disinfectors (WD), „Dishwasher“ (80-95°C, e.g. 90°C/5 min holding time)**
- Ultraviolet rays (UV-C)

Chemical procedures

Chemical compounds for wiping, spraying, or submerging

Chemical-thermal procedures

- Washer-disinfectors (WD) (40-65 °C + chem. disinfectant)

1. Microbiological Activity

- broad spectrum
- short residence time
- irreversible action
- reliable activity also with contaminants (blood, dirt)

2. Properties during usage

- compatibility with materials (e.g. corrosion)
- security (flashpoint)
- dosage adjustment
- acceptance (e.g. smell, feel on skin etc.)

3. Toxicology

- compatibility on skin and mucous membranes
- low acute oral toxicity
- low dermal toxicity

4. Environmental safety

- biodegradable
- low toxicity in wastewater

Disinfection: Spectrum of activity

1. Low to intermediate resistance:

enveloped viruses, vegetative bacteria

characteristic organisms: *E. faecium*, *S. aureus*, *P. aeruginosa*

fungi incl. fungal spores

characteristic organism: *Aspergillus niger*

2. Intermediate to high resistance:

mycobacteria, Hepatitis B-Virus, hydrophile viruses

characteristic organisms: polio virus, *Mycobacterium terrae*

3. High to very high resistance:

bacterial spores

prions

-> commonly not covered by disinfection

Chemical Disinfectants (1)

Group Grade of activity	Important compounds	Application	Problems
Alcohols A (B)	Ethanol, Isopropanol, n-Propanol	skin, hands, (small) surfaces and instruments	Flammability, Embrittlement of plastic
Aldehydes A B C	Formaldehyde, Glutardialdehyde	intruments, surfaces	skin-irritating, allergenic
Phenolics A (B)	o-Phenylphenol, Cresol,	surfaces, excrements	activity (viruses, mycobacteria), toxicity, low degradability
Tensides (Surfactants) A (B)	Benzalkoniumchloride, Chlorhexidine, Octenidine	skin, hands, mucosa, surfaces	activity (viruses, mycobacteria)

Chemical Disinfectants (2)

Group Grade of activity	Important compounds	Application	Problems
Oxidating substances A B C (D)	Ozone, Hydrogenperoxide, Peracetic acid	water, water- bearing systems	smell, corrosion
Halogens A B C	Chlorine (Hypochlorite, Chloramine) Iodine (povidone- iodine)	water skin, mucosa, wounds	smell, corrosion, protein error
Metal salts A	Silver, Copper, Mercury	water, mucosa, wounds	static activity, toxicity (Hg is obsolete!)

A: vegetative bacteria B: viruses (B): only enveloped viruses
C: spores with low resistance D: spores with higher resistance (*C. difficile*)

Disinfection: sources of error

dosage

↓: loss of action
↑: smell

temperatur

evaporation

soap error

flocculation when mixing with soap

protein error

consumption by proteins

insufficient
moistening

e.g. inclusions of air or skin creases

insufficient
residence time

STERILIZATION

Requirements for sterilizing procedures

1. Comprehensive and fast mode of action
2. Penetration (packaging, porous material, cavities)
3. Toxicological and environmental harmlessness
4. Compatibility with material
5. Possibility of validation and documentation

Sterilization is one step of reprocessing

Re-processing of a critical medical device always comprises:

Cleaning
Disinfection
Sterilization

**One can clean without sterilizing,
but one can never sterilize without previous cleaning!**

Sterilizing procedures I

1. Physical procedures

- 1.1 Humid heat (steam sterilization)
saturated steam
e.g. 121°C/15 min or 134°C/3 min holding time
- 1.2 Dry heat
circulating hot air, 180°C/30min residence time
- 1.3 Ionizing Radiation
Gamma-rays (Co^{60}), electron beam processing

Sterilizing procedures II

2. Physical-chemical procedures („low temperature procedures“)

2.1 Ethylene oxide

2.2 Formaldehyd-Wasserdampf

2.3 Hydrogen peroxide plasma sterilization

Other procedures (infrequently used in Germany)

Ozone

Vaporized hydrogen peroxide

Chlorine dioxide

Peracetic acid

Not approved: Bead sterilizer, UV-sterilizer

Steam sterilization

1. Conditioning phase:

Heating

Air removal and steam generation

Equilibration (= reach temperature in all parts of sterilizing good)

2. Sterilization phase:

Holding time (Sterilization time) =

Killing time + Safety margin

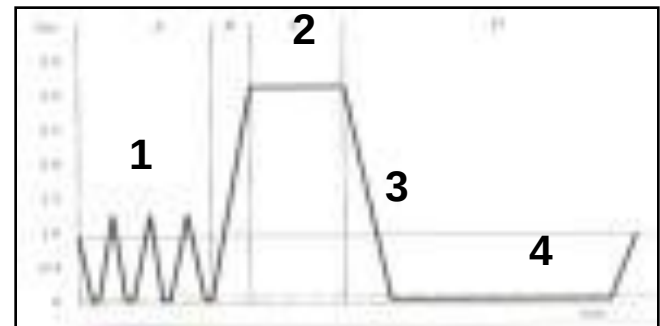
3. Decompression phase:

Pressure removal

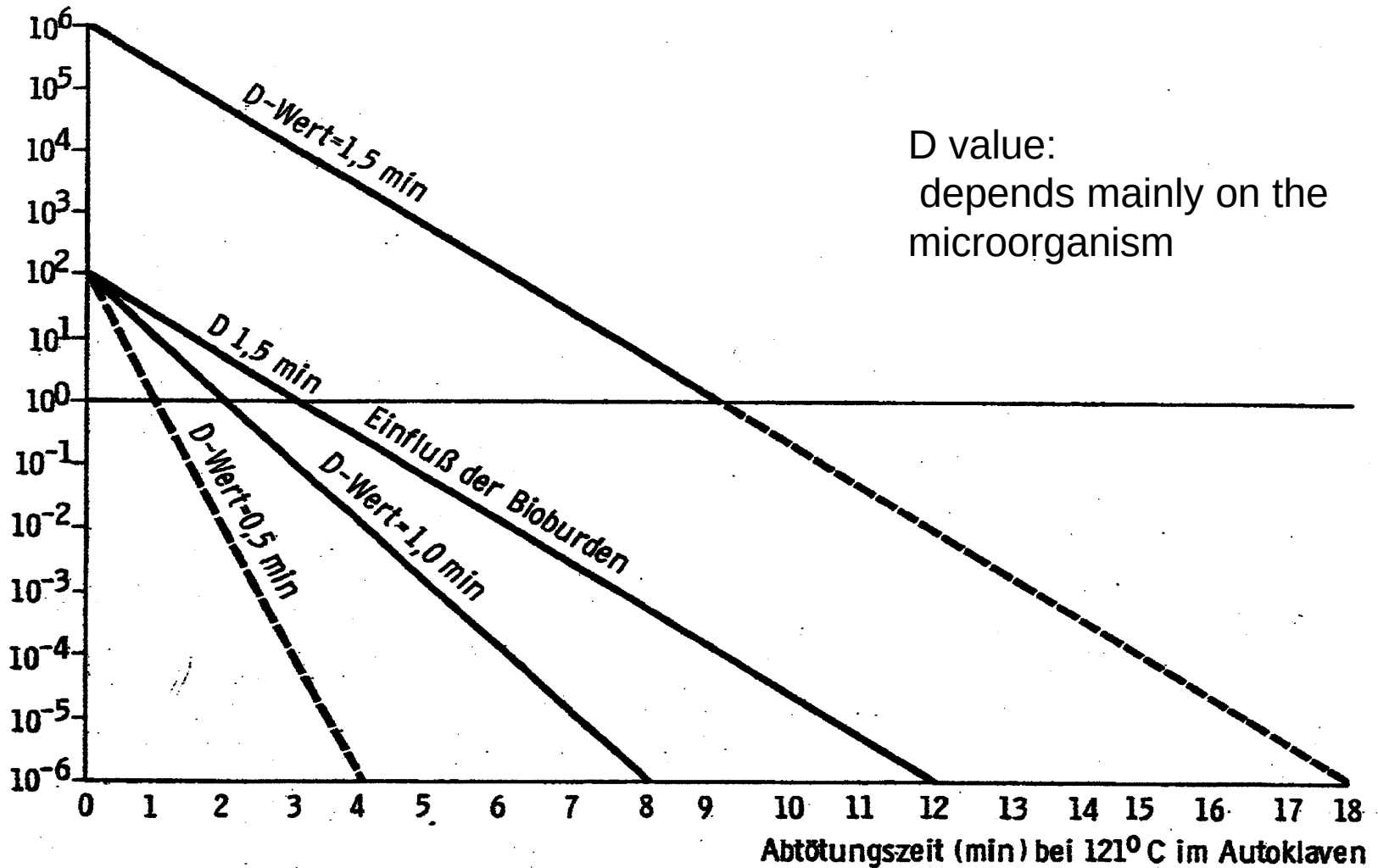
4. Cooling phase:

Drying in vacuum

Pressure equilibration



Influence of microbial burden on kinetic of steam sterilization



Steam sterilizers (autoclave)



**First autoclave
(1888)**



**Small sterilizer
(< 1 StU)**



Lab sterilizer



**High throughput
sterilizer**



Application of steam sterilization

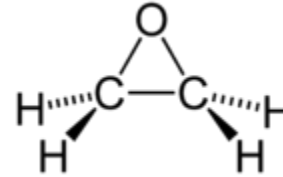
Suitable:

- metal objects (corrosion)
- glas, ceramics
- aqueous solutions
- cotton, linen
- rubber
- thermostable polymeres (plastic)

Not suitable:

- electric and electronic objects
- water-free oils, grease, wax
- powder and granulate

Ethylene oxide (EO)-sterilization



EO-sterilization:

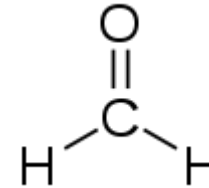
Pure EO (negative pressure) or EO-CO₂-mix (high pressure),
Temperature ca. 40 – 55°C, fully automated process

EO is a biohazard! (carcinogen, mutagenic, teratogenic, caustic), therefore
extensive safety measures

Increased absorption in plastic ⇒
controlled desorption phase before use of sterilized goods

use only for thermo-labile goods
(e.g. cameras, optical fiber, cables)

Formaldehyde (FA)-steam sterilization



FA-sterilization:

Formaldehyde-steam mixture with negative pressure,
Temperature up to 65°C, fully automated process

FA is a biohazard (potential carcinogen, caustic),
but less problematic than EO, therefore less stringent safety measures

Low penetration in hollow parts, low absorption in plastic

area of application similar to EO

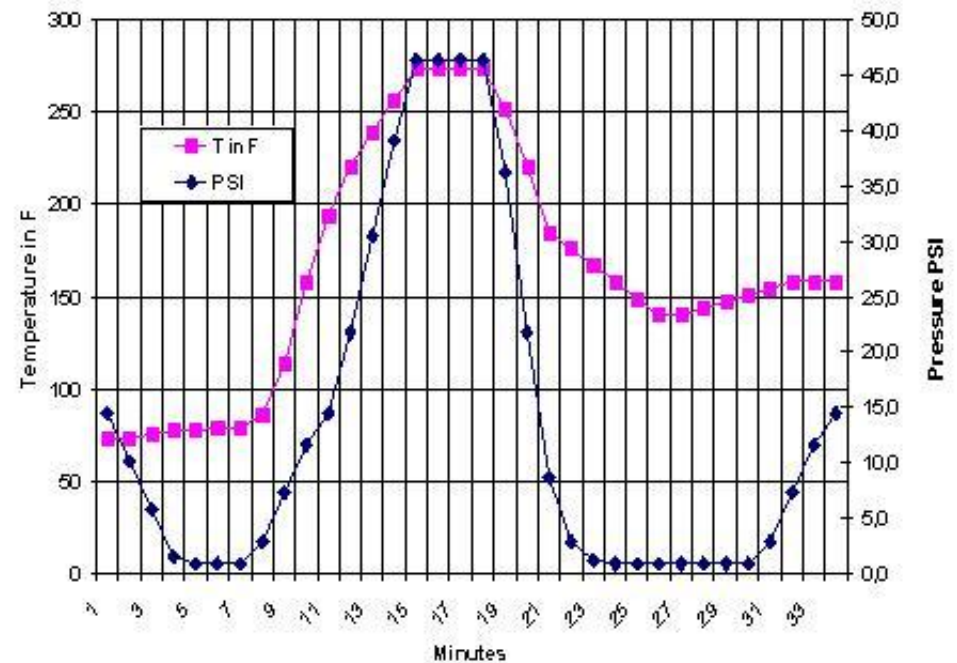
Verifying of sterilization processes (1)

1. Physical methods

- Parametric controls: Temperature/pressure/time-relation (Proof of holding time and steam saturation); Documentation of sterilization cycle by recording devices
- Thermologgers in different positions within the chamber or the sterilizing good (process validation)
- gas concentration (EO), relative moisture (EO, FA)

Verifying of sterilization processes (1)

1. Physical methods



Verifying of sterilization processes (2)

2. **Chemical indicators**

indicate compliance with several parameters.
Different types as defined by standards:

- e.g. sterilizing tapes
- indicators in combination with test bodies („process challenge device“ PCD) for penetration of steam into hollow parts

Chemical indicators do not allow
conclusion with respect to sterility!

indicator tapes



Verifying of sterilization processes (2)



Test body (PCD) with
chemical indicator
for batch control

Verifying of sterilization processes (3)

3. **Biological processes (bioindicators)**

- Bioindicators

contain bacterial spores with standardized density with defined D-value;
dependent on sterilization method

Requirements for test organism:

- **not pathogenic**
- **D-value higher than most resistant pathogenic microorganism**



Examples:

Steam sterilization

EO-sterilization

Radiosterilization

Geobacillus stearothermophilus

Bacillus atrophaeus

Bacillus pumilus

Packaging of medical products

- for shipping
- for storage

Packaging of sterilized goods

- Maintaining sterility
- Physical protection (from damage)
- Easy handling
- Labeling (content, sterilization procedure, expiration date)

Packaging of sterilized goods

Rigid containers

with filter or valve



pro: re-usable, robust, stackable

contra: weight, fixed volume, expensive

Soft wrapping

sterilizing paper, transparent bags

cotton is not allowed (no tight barrier)



pro: flexible, light, cheap

contra: easily damaged, not space-saving, constant costs, waste

Storage of sterilized goods

protected storage (storage time adapted to occasion of use):
clean, closed, dry, 20-25°C, protected from dust and light

industrial sterilized material in storage packaging: expiration date given
by the manufacturer (normally 5 years)

Legal regulations/references

- Infektionsschutzgesetz (IfSG) 2011
- Medizinhygieneverordnungen (MedHygV) der Länder (BW 2012)
- KRINKO-Empfehlungen (RKI)
 - Kommission für Krankenhaushygiene und Infektionsprävention
 - „Anforderungen an die Hygiene bei der Aufbereitung von Medizinprodukten“ (2012)
- Medizinproduktegesetz (MPG)
- Medizinprodukte-Betreiberverordnung (MPBetreibV)
- Technische Regeln für biologische Arbeitsstoffe (TRBA)
- Empfehlungen der Deutschen Gesellschaft für Sterilgutversorgung (DGSV)

Legal regulations/references

- Normen:
 - DIN EN ISO 15883:
 - Reinigungs-Desinfektionsgeräte (Validierung und Betrieb)
 - DIN EN ISO 14971 und 13485:
 - Medizinprodukte: Anwendung des Risikomanagements, Anforderungen für regulatorische Zwecke (Zertifizierung)
 - DIN EN ISO 17644:
 - Sterilisation von MP: Herstellerangaben
 - DIN EN ISO 17665-1:
 - Dampfsterilisation: Entwicklung, Validierung, Überwachung
 - DIN 58953:
 - Sterilgutversorgung (Logistik)



Thank you!

Contact:

Dr. med. Jan Liese

Institut für Med. Mikrobiologie und Hygiene

Universitätsklinikum Tübingen

Elfriede-Aulhorn-Str. 6

72076 Tübingen

jan.liese@med.uni-tuebingen.de