Nosocomial infections (NI)

* Hospital aquired infection
* Healthcare-associated infections

Nosocomial infections

- Definition
- Predisposition
- Transmission
- Prevention
- Epidemiology

Definition of nosocomial infections

- infections which are a **result of treatment in a hospital or a healthcare service unit**, but secondary to the patient's original condition

- infections are considered nosocomial **if they first appear 48 hours or more after hospital admission or usually within 30 days after discharge**

- **etymology** - nosocomial comes from the Greek word **nosokomeion** meaning (*nosos* - **disease**, ***komeo*** **- to take care of**)

Predisposition to nosocomial infections

* patients **already in a poor state of health**, impairing their defense against bacteria – advanced age or premature birth along with **immunodeficiency** (due to drugs, illness, or irradiation) present a **general risk**, while other diseases can present **specific risks** - for instance chronic obstructive pulmonary disease

* **invasive devices**, for instance **intubation tubes, catheters, surgical drains and tracheostomy tubes** all **bypass the body's natural lines of defence** against pathogens and provide an **easy route for infection**. Patients already colonised on admission are instantly put at greater risk when they undergo an invasive procedure.

* **a patient's treatment itself can leave them vulnerable** to infection – immunosuppression and antacid treatment undermine the body's defences, while antimicrobial therapy (removing competitive flora and only leaving resistant organisms) and recurrent blood transfusions have also been identified as risk factors.

Transmission of nosocomial agents

- microorganisms are transmitted in hospitals **by several routes**
- the same microorganism **may be transmitted by more than one route**
- main routes of transmission:

- contact (direct, indirect)
- droplet
- airborne
- common vehicle
- vectorborne

Contact transmission

The **most important and frequent mode of transmission**

Direct-contact transmission

involves **a direct body surface-to-body surface contact** and physical transfer of microorganisms between a susceptible host and an infected or colonized person, such as occurs when a person turns a patient, gives a patient a bath, or performs other **patient-care activities** that require direct personal contact. Direct-contact transmission **also can occur between two patients**

Indirect-contact transmission

involves **contact of a susceptible host with a contaminated intermediate object**, usually inanimate, such as contaminated instruments, needles, or dressings, or contaminated gloves that are not changed between patients.

Other ways of trasmission

- **Droplet transmission** occurs **when droplets are generated** from the source person mainly during coughing, sneezing, and talking, and during the performance of certain procedures such as bronchoscopy
- **Airborne transmission** occurs by dissemination of **either airborne droplet nuclei** (small-particle residue {5 μm or smaller in size} of evaporated droplets containing microorganisms that remain suspended in the air for long periods of time) or **dust particles** containing the infectious agent, may become inhaled by a susceptible host (e.g. Legionella, Mycobacterium tuberculosis and the rubeola and varicella viruses)
- **Common vehicle transmission** applies to microorganisms transmitted to the host **by contaminated items** such as **food, water, medications, devices, and equipment**.
- **Vector borne transmission** occurs when **vectors** such as mosquitoes, flies, rats, and other vermin **transmit**

Categorization and prevention of NI

central line-associated bloodstream infections (CLABSIs)

before insertion – e.g. educated healthcare personel) insertion, care, maintenance)

at insertion – e.g. hand infection, sterile barrier preacutions, chlorhexidin-based antiseptic for skin preparation, all-inclusive catheter kit, avoid using the femoral vein for central acces in adults

after insertion - e.g. remove nonessential catheters, change catheters and gauze dressing permanently,

in the following days – e.g. bathe ICU patients older>2 months daily with chlorhexidine containing sponge, use

Categorization and prevention of NI

ventilator-associated pneumonia (VAP)

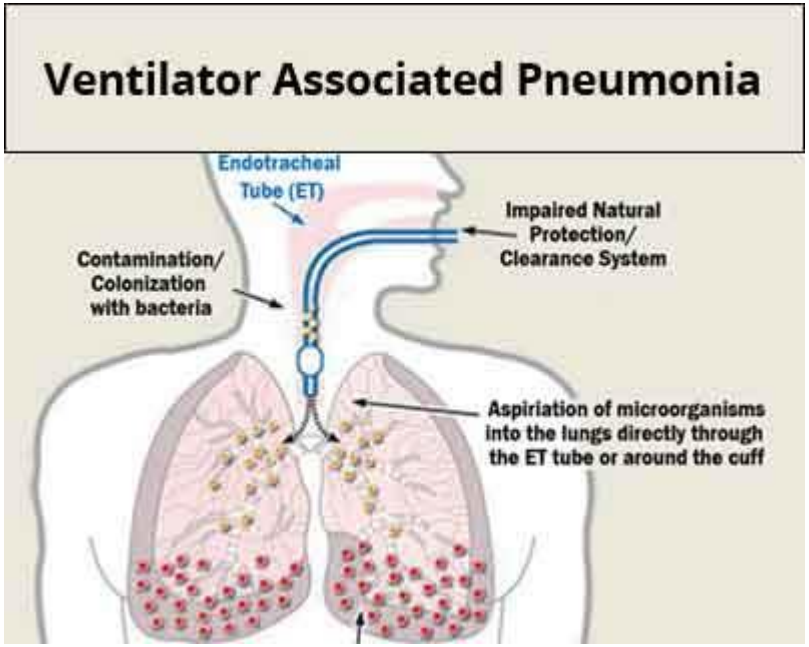
education – e.g. educate healtcare personnel (local epidemiology, risk factors)

surveillance – e.g. active surveillance of VAP in units

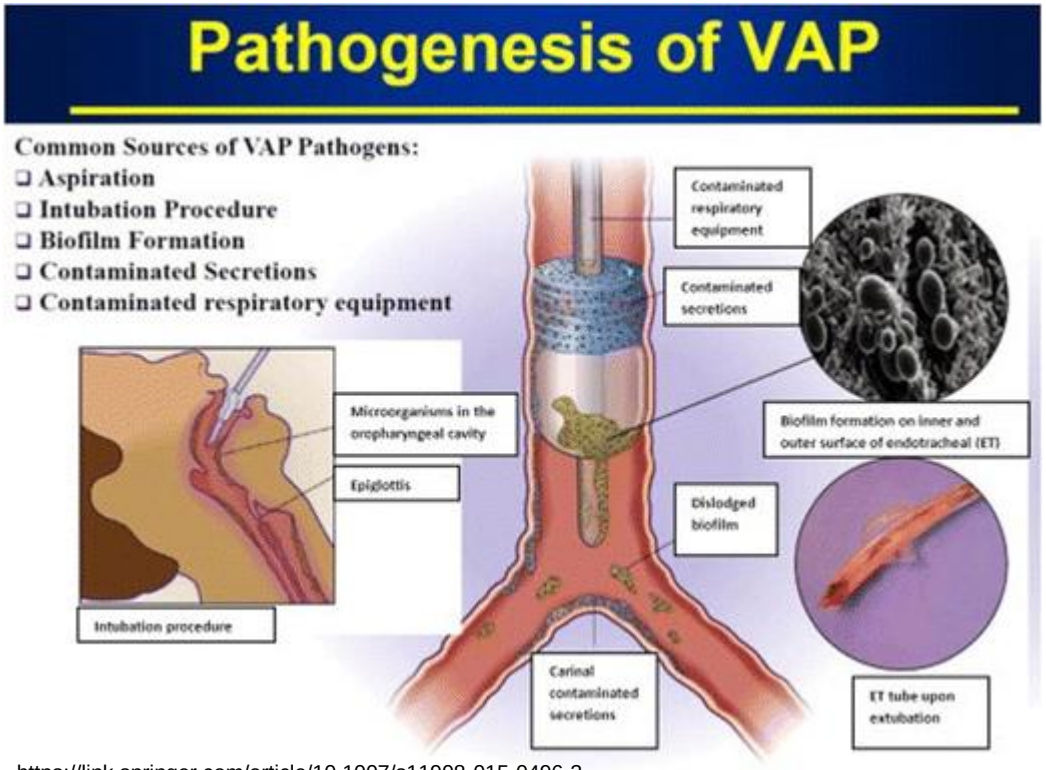
practice – e.g. implement policies and practices for disinfection, sterilization, and maintenance of respiratory equipment, patients must be maintained in a semirecumbet position, antiseptic oral care

other – e.g. use endotracheal tube with suction

Risk factors and pathogenesis of VAP



https://speciality.medicaldialogues.in/preventing-ventilator-associated-pneumonia-in-hospitals-goi-guidelines/



https://link.springer.com/article/10.1007/s11908-015-0496-3

Risk factors and pathogenesis of VAP

Traditionally, the clinical diagnosis of VAP has included a **combination of the following: clinical symptoms/signs, chest radiography, and microbiological data** [23].

Clinical symptoms and signs include **changes in sputum or tracheal secretions** in terms of purulence, colour and/or increasing production; cough**; temperature >38 or <36 °C**; rales or bronchial breath sounds on examination and worsening oxygenation.

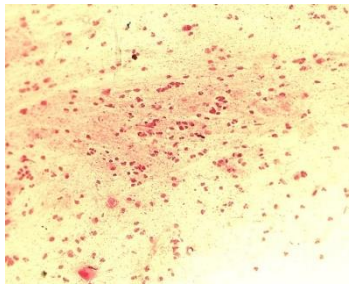
Laboratory findings include non-specific indicators of infection including leukocytosis (>12 × 10^9 WBC/L) or leukopenia (<4.0 × 10^9 WBC/L). Findings on **chest radiography (**CXR) include the development of new infiltrates or the presence of persistent and/or worsening infiltrates. Published case definitions for VAP have included a variety of combinations of these [24, 25].
There is no reference standard for the diagnosis of VAP, and clinical criteria plus microbiological sampling techniques lack specificity and sensitivity when compared to the demonstration of pneumonia on histological samples obtained by either biopsy or necropsy [26]. For example, **clinical criteria alone** have been reported to have a **sensitivity and specificity of 91 and 15 %** [26].

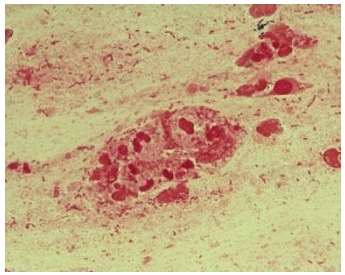
Respiratory tract sampling should be routinely conducted when there is a clinical suspicion of VAP. This can be done via **non-bronchoscopic** or **bronchoscopic techniques**. Bronchoscopic sampling includes **bronchoalveolar lavage** (BAL) or protected specimen brush (PSB), while non-bronchoscopic techniques include **endotracheal aspirates** and mini-BAL. Bacterial growth in semi-quantitative cultures is usually reported as heavy, moderate, light or no growth. Typically, **quantitative cultures** are done on BAL or PSB specimens, while semi-quantitative cultures are done on other samples such as endotracheal aspirates. If quantitative cultures are done, thresholds have been ascribed to the presence of infection as 10^4 colony forming units/mL (cfu/mL) for BAL and 10^3 cfu/mL for PSB. Although quantitative cultures are touted as being more specific for infection, a recent Cochrane analysis that included five randomized control trials (RCTs) (n = 1240 patients) found no change in mortality, days on mechanical ventilation, number of days in the ICU, or antibiotic utilization when compared to semi-quantitative cultures [31]. In the absence of demonstrated superiority of one technique over another, the relative invasiveness of bronchoscopy and its requirement for specialized expertise and equipment, endotracheal aspirates are the preferred method of respiratory tract sampling for microbiology. There may be other indications for bronchoscopy such tracheobronchial toileting, but there is little rationale for its routine utilization for the diagnosis of VAP.

https://link.springer.com/article/10.1007/s11908-015-0496-3

Algorithm of VAP diagnosis

Small magnification (validity of sputum)





large magnification (bacterial morphology)

microscopy: Gram (G- rods and PMN)

sputum

culture: enriched culture media

Identification (MALDI)

antibiogram

\+
hemoculture

Specific treatment

Categorization and prevention of NI

catheter-associated urinary tract infections (CAUTIS)

infrastructure – e.g.written guidelines for use, insertion & maintenance (aseptic techniques, records –date…), trained personnel,

surveillance – e.g. ID groups of patients with high risk, dg UTI

education and training – e.g.procedures for insertion, management and removal

catheter insertion – e.g. only when necessary, as long as indication persist, hand hygiene before and after manipulation of the catheter

management of indwelling catheters – e.g. prevent movement after insertion, maintain asterile, continuosly closed drainage system, replacing by aseptic teqniques,

prevention – e.g. implement organization-wide program to identify and remove catheters that are no longer necesary, intermittent catheters…

Algorithm of nocomial UTI

? microscopy: Gram (PMN….), biochemistry

urine

culture: enriched culture media

Identification
(MALDI)

antibiogram

Specific treatment

\+
hemoculture

Categorization and prevention of NI

surgical site infections (SSIs)

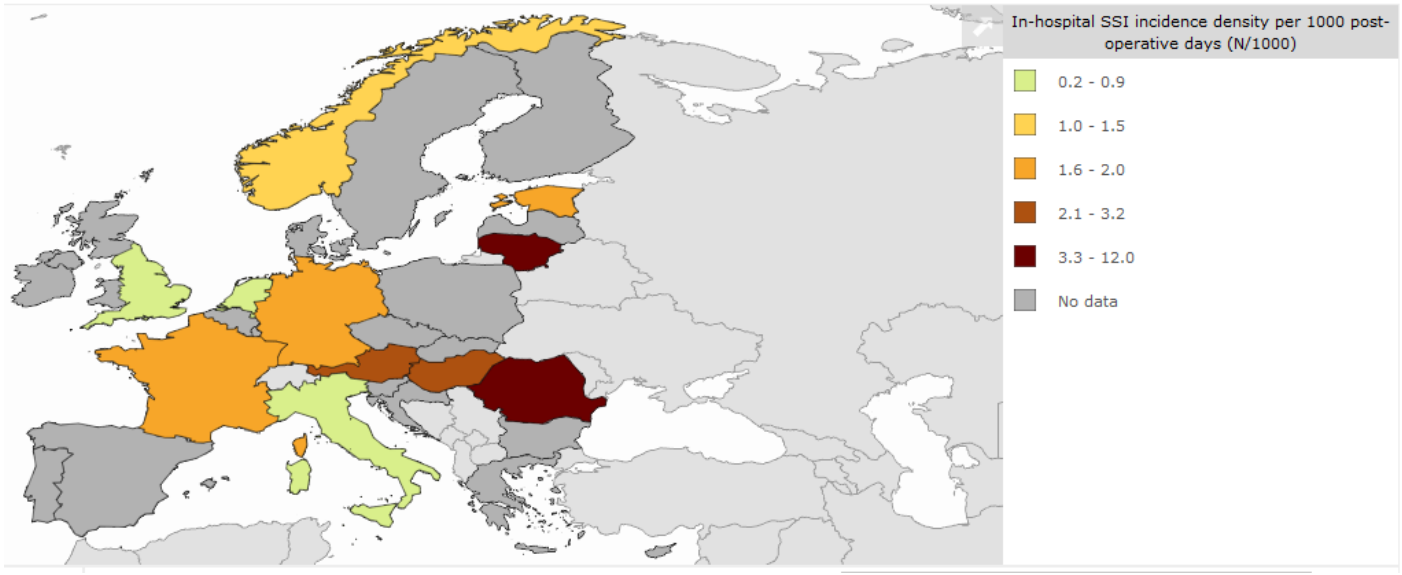
Diagnosis – swabs, aspiration – microscopy, culture, PCR

surveillance – e.g. feedback on surveillance measures

practice – e.g. antimicrobial prophylactis in accordance with standards and guidelines, dont remove hair from operative sites unless the hair will interfere with the operation

education – e.g. educate surgeons and patients about SSI prevention, dont routinely use vancomycin fro prophylaxis

Overview of HCAI agents and occurence (EU)



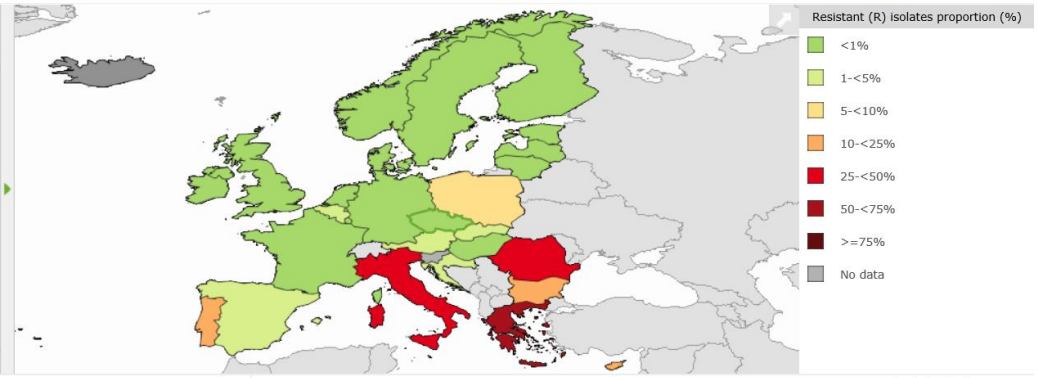
Example SSI – surgical site infections

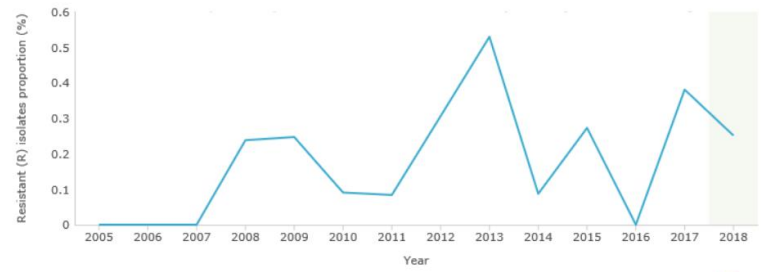
https://atlas.ecdc.europa.eu/public/index.aspx

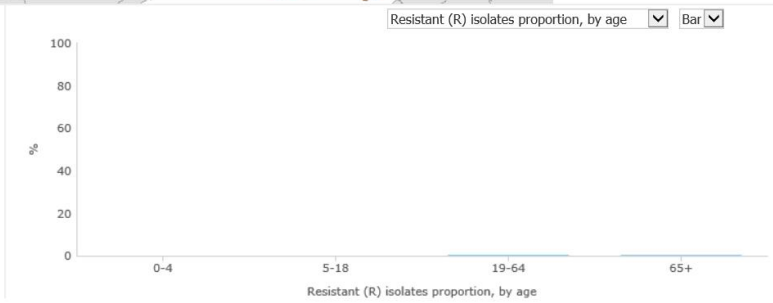
Surveillance Atlas of Infectious Diseases

Antimicrobial resistance | Klebsiella pneumoniae | Carbapenems | Resistant (R) isolates proportion | 2018

Region	Resistant (R) isolates proportion (%)
Austria	1.0
Belgium	1.4
Bulgaria	21.2
Croatia	2.2
Cyprus	21.8
Czech Republic	0.3
Denmark	0.5
Estonia	0.6
Finland	0.6
France	0.5
Germany	0.4
Greece	63.9
Hungary	0.2
Iceland	







Staphylococci

- the genus name is derived from Greek term *staphylé*, meaning a bunch of grapes
- Gram-positive spherical bacteria (about 1 μm in diameter)
- present on the skin and mucous membranes of humans and animals
- important pathogens in humans – wide spectrum of life-threating systemic diseases (e.g. infections of the skin, soft, tissues, bones, urinary tract and opportunistic infections)

Nosocomial strains of MRSA

situation in the world
&
in the Czech Republic

Typing of staphylococcal isolates & epidemiology of the infections

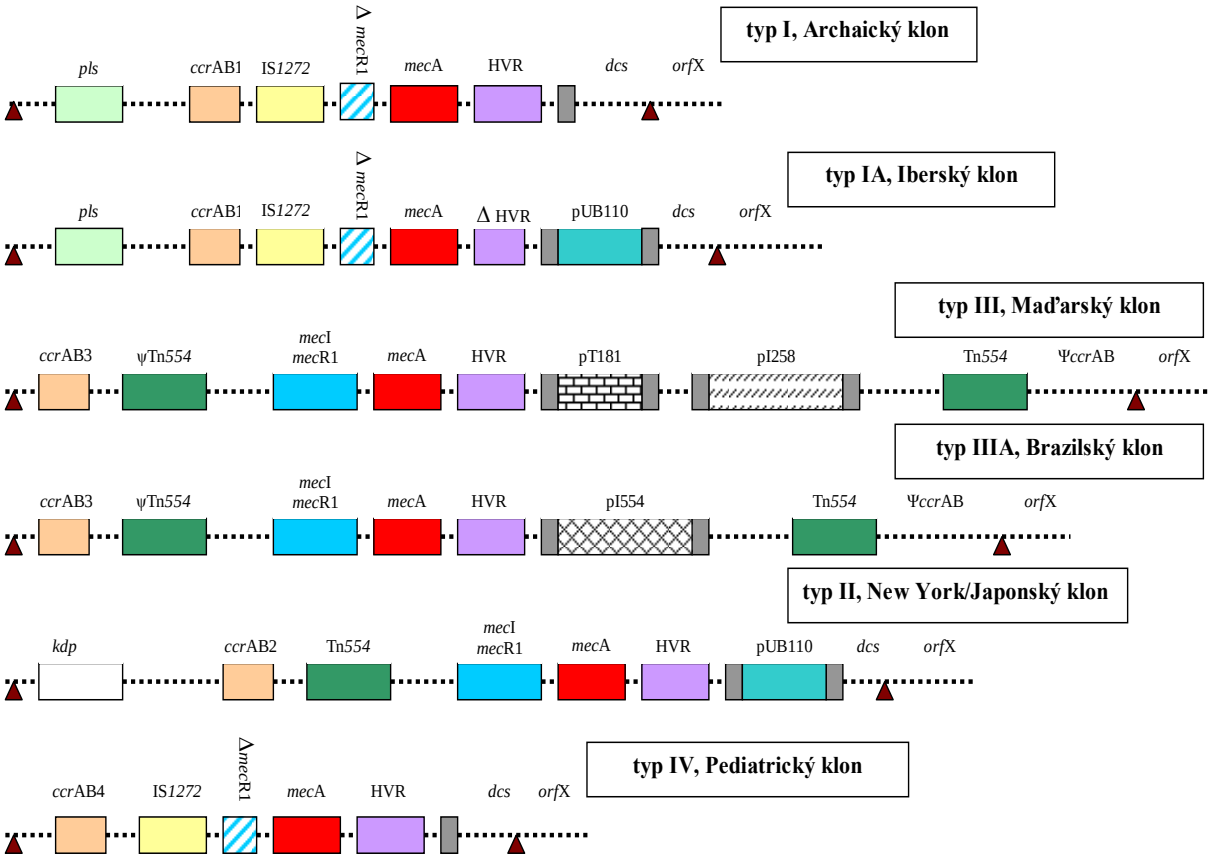
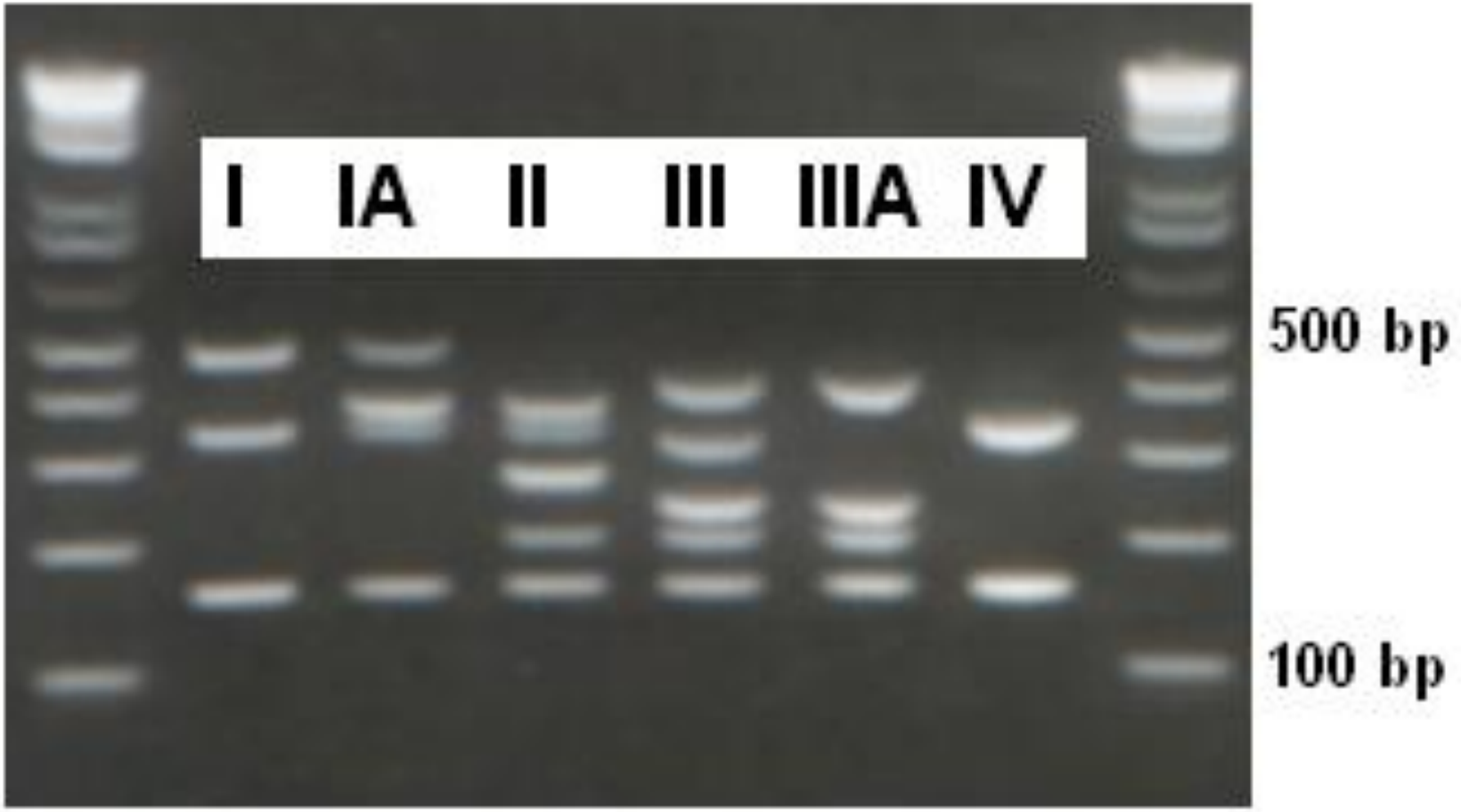


fig. MRSA pandemic clones and their chromosome cassetes (SCC)

fig. PCR amplicons (*scc*) of MRSA



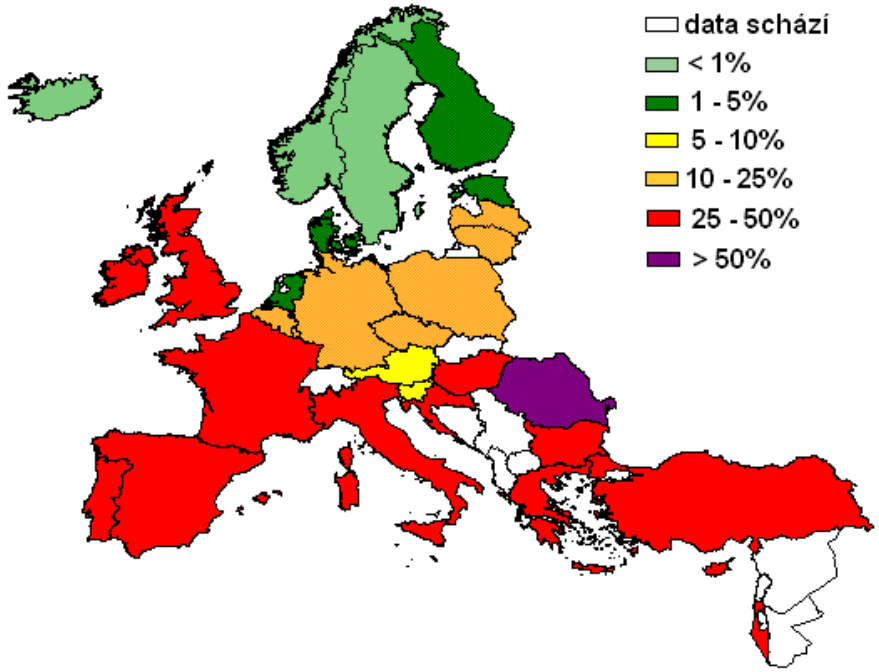
Recent classification of MRSA clones

clonal complex	clone	allelic profile	previous names of MRSA clones
5	ST5-MRSA-I	1-4-1-4-12-1-10	*UK EMRSA-3*
	ST5-MRSA-II	1-4-1-4-12-1-10	*New York/Japanese*
	ST228-MRSA-I	1-4-1-4-12-24-29	*Southern German*
8	ST8-MRSA-II	3-3-1-1-4-4-3	*Irish-1*
	ST8-MRSA-IV	3-3-1-1-4-4-3	*UK EMRSA-2,-6*
	ST239-MRSA-III	2-3-1-1-4-4-3	*UK EMRSA-1,-4,-11, Portuguese, Brazilian, Viennese*
	ST247-MRSA-I	3-3-1-12-4-4-16	*UK EMRSA-5,-17, Iberian*
	ST250-MRSA-I	3-3-1-1-4-4-16	*First MRSA*
22	ST22-MRSA-IV	7-6-1-5-8-8-6	*UK EMRSA-15, Barnim*
30	ST36-MRSA-II	2-2-2-2-3-3-2	*UK EMRSA-16*
45	ST45-MRSA-IV	10-14-8-6-10-3-2	*Berlin*

Současná klasifikace klonů MRSA a jejich příslušnost do klonálního komplexů (Enright,03)

Klasifikace se provádí na základě sekvenčního typu (ST), citlivosti nebo rezistence k meticilinu (MSSA/MRSA) a typu SCC*mec* oblasti (I-V). Klony, které mají pět identických genových alel patří do stejného klonálního komplexu. Kmeny MRSA na celém světě patří pouze do 5 klonálních komplexů z čeho vyplývá, že kmeny MRSA se téměř výhradně šíří vertikální tzn. klonální cestou. V praxi to znamená že tato infekce se přenáší pouze kontaktem s kolonizovaným nebo infikovaným člověkem nebo výjimečně zvířetem.

Occurence of MRSA strains – European study, EARSS, 2006

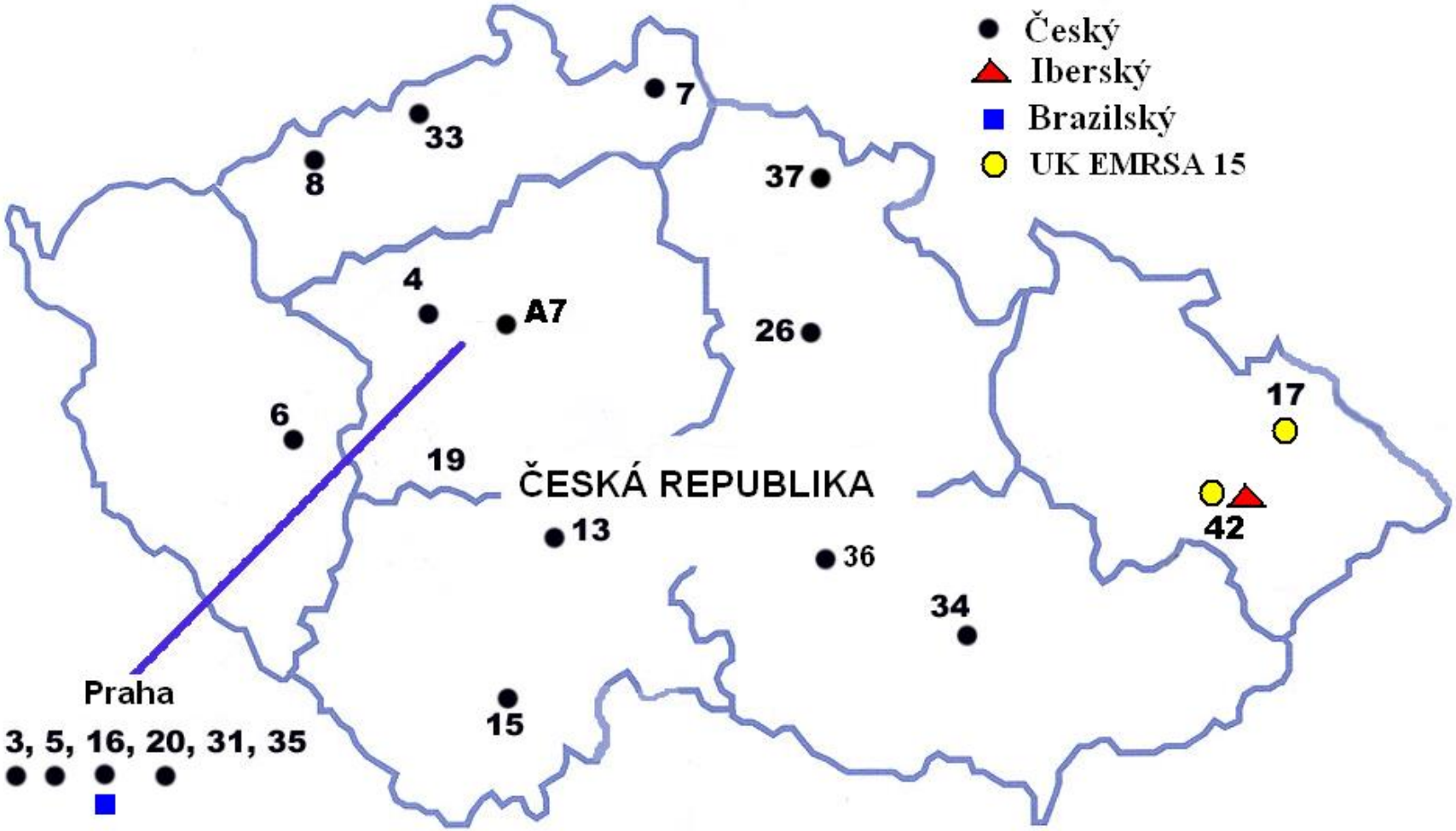


Výskyt kmenů MRSA z evropské studie EARSS v roce 2006 (www.earss.cz)

V evropské studii EARSS (*European Antimicrobial Resistance Surveillance System*) pro sledování rezistence baktérií k antibiotikům bylo vyšetřeno 29552 kmenů *S. aureus* v 31 státech. Z toho čtvrtina z nich byla rezistentní k meticilinu (**www.earss.cz**). V polovině států byla proporce MRSA vyšší než 25%.

MRSA clones in the Czech Republic

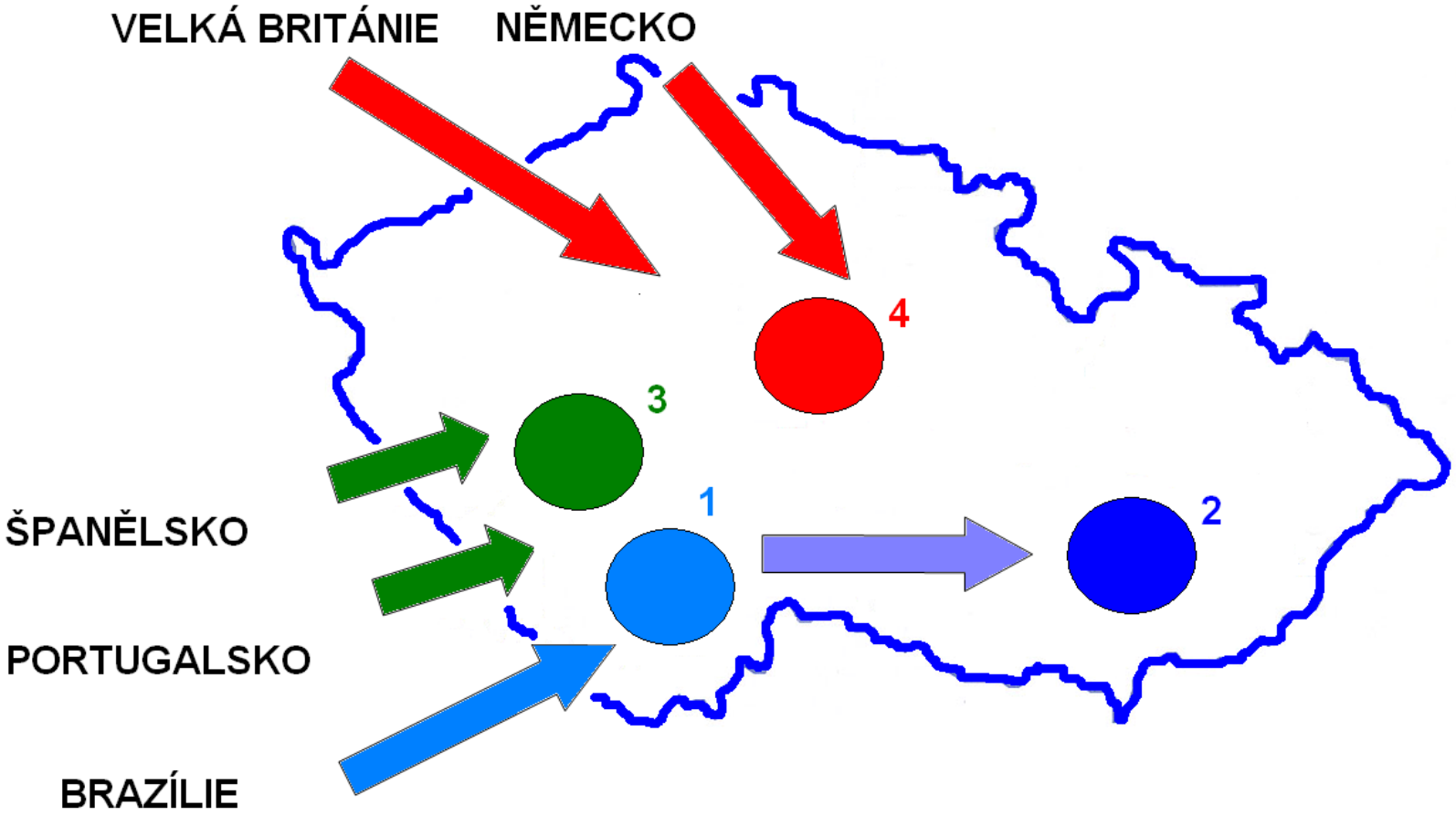
(2000-2002), analyzed 100 nosocomial MRSA strains



Klony MRSA v ČR (studie 2000-2002)(Melter,2003)

Výsledky na základě analýzy 100 kmenů MRSA. Nemocnice jsou označeny číslem.

Hypothesis of emergence and spread of MRSA clones



Hypotéza o šíření klonů MRSA na území ČR

1.Brazilský klon, 2.Český klon , 3. Iberský klon,4. UK EMRSA-15

Resistant genotype & phenotype of the clones

(Czech Republic, 2000-2002)

CLONE	RESISTANT GENES	ANTIBIOGRAM	TOXINS
Brazilian	*aacA-aphD*, *aphA3*, *ermA, ermC*	ERY, KLI, GEN, CIP, TET, RIF, SXT	0
Iberian	*aacA-aphD*, *aadC, ermA*	ERY, KLI, GEN, CIP, TET, RIF	enterotoxin A
Czech	*aacA-aphD*, , *ermA, ermC*	ERY, KLI, GEN, CIP, TET, RIF	enterotoxin A
UK EMRSA-15	*ermC*	ERY, KLI, CIP	enterotoxin A

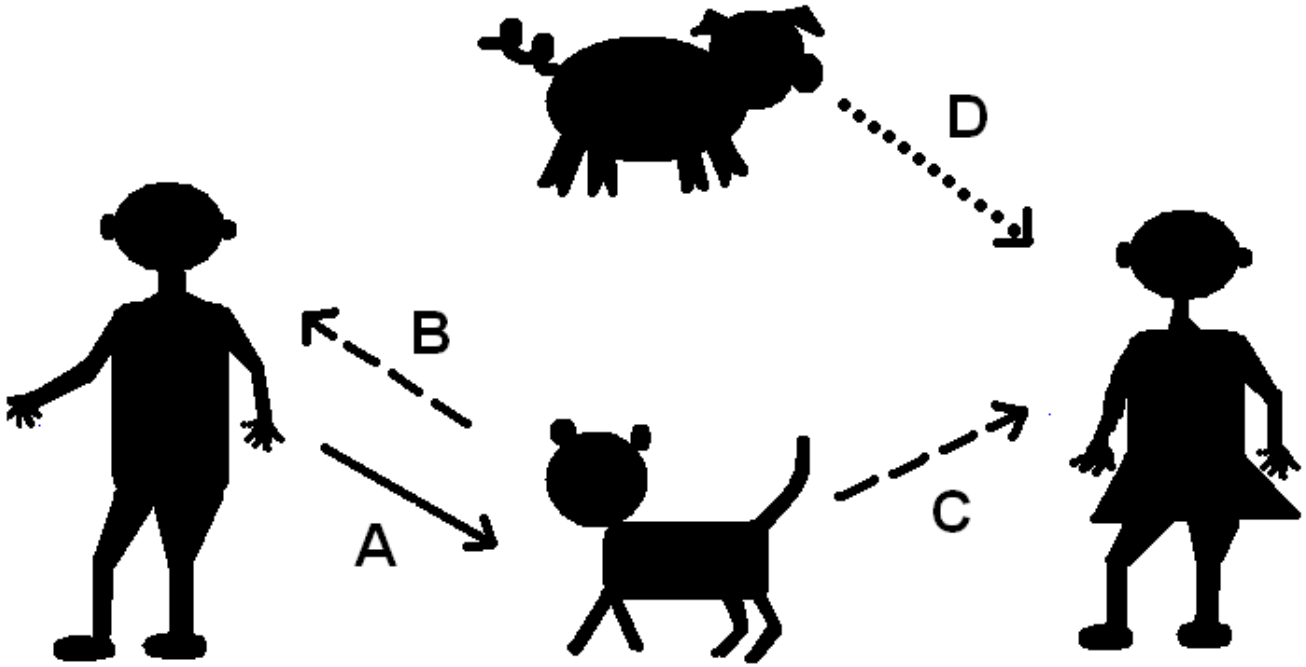
Geny rezistence, citlivost k antibiotikům a produkce toxinů

Profil antibiotické rezistence pro více než 50% kmenů určitého klonu.

Testována byla citlivost k těmto antibiotikům: ciprofloxacin (CIP), erytromycin (ERY), klindamycin (KLI), gentamicin (GEN), tetracyklin (TET), kotrimoxazol (SXT), chloramfenikol, mupirocin, rifampicin (RIF) a fusidová kyselina

Testovaná přítomnost genů rezistence pro MLS_B (makrolidy –linkosamidy-spektinomycin B)(Lina) antibiotika: *ermA, ermB, ermC* a *msrA* a pro aminoglykosidy (Vanhoof): *aacA-aphD, aphA3, aadC.*

Epidemiology of MRSA infections could cover also animal infections



Epidemiologie zvířecích infekcí MRSA

Zvíře (nejčastěji zvířecí společník – pes, kočka) se primárně infikuje kmenem MRSA od člověka – reverzní zoonóza (A). Takto infikované zvíře může reinfikovat člověka (B), nejčastěji svého majitele, který byl např. opakovaně léčený antibiotiky a zbaven infekce nebo může infikovat jiného člověka a zvíře (C). Ojediněle může být infekce MRSA klasifikovaná jako zoonóza (D) a to v případě kdy člověk je infikován autochtónním zvířecím kmenem MRSA, který pochází většinou od hospodářských zvířat (např. prase). Infekce se přenáší mezi člověkem a zvířaty přímým kontaktem, možný je pravděpodobně též přenos přes potravinový řetězec(Lee,6489).