IFA
Institut für Arbeitsschutz der
Deutschen Gesetzlichen Unfallversicherung

BG RCI
Berufsgenossenschaft
Rohstoffe und chemische Industrie

Bundesministerium
für Arbeit und Soziales

Staphylococcus aureus subsp. aureus

General information | Occupational and health protection | Morphology and physiology | Occurrence/natural habitat | Pathogenicity/pathogenic properties | Disease | Epidemiology | Resistance/Tenacity | Legal basics | Links | References

GENERAL INFORMATION

Staphylococcus aureus subsp. aureus

For further information on the current nomenclature of the species see
List of Prokaryotic names with Standing in Nomenclature

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Category: Bacteria

Strain type: ATCC 12600, CCM 885, DSM 20231, NCDO 949, NCTC 8532

Further information:
BacDive - The Bacterial Diversity Metadatabase (DSMZ)

Risk group: **2**
Biological agents that can cause human disease and might be a hazard to employees; they are unlikely to spread to the comunity; there is usually effective prophylaxis or treatment available.

References:

Note ht:
Pathogenic for humans and vertebrates, but normally no transmission between the two host groups.

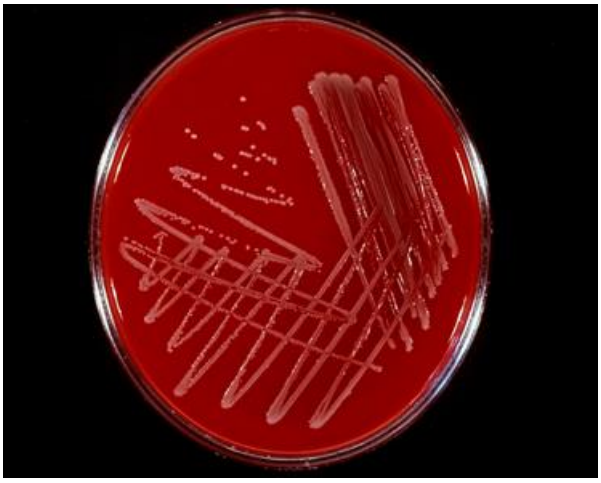
Note T:
Toxin production: prokaryotes capable of forming exotoxins. The "T" tag lays no claim to completeness, however, i.e. exotoxin-forming strains may also arise in types of prokaryote without this tag. The "T" tag adopted over from Annex III of Directive 2000/54/EC.

Footnote 17:
Recently, there have been reports of a zoonotic potential of S. aureus subsp. aureus, particularly for certain MRSA strains.

Consultant / Reference laboratory:

National Reference Centre for Staphylococci and Enterococci
[Nationales Referenzzentrum für Staphylokokken und Enterokokken]
at the Robert Koch Institute [Robert-Koch-Institut] (Section Wernigerode),
PD Dr. G. Werner / Dr. Layer
Burgstr. 37
38855 Wernigerode, Germany

For methicillin-resistant *Staphylococcus aureus* strains (MRSA):
National Reference Centre for Surveillance of Nosocomial Infections
[Nationales Referenzzentrum für Surveillance von nosokomialen Infektionen]
at the Institute of Hygiene and Environmental Medicine
[Institut für Hygiene und Umweltmedizin],
Charité – University Medicine Berlin
[Charité – Universitätsmedizin Berlin],
Prof. Dr. P. Gastmeier
Hindenburgdamm 27,
12203 Berlin, Germany



Culture of *Staphylococcus aureus* on sheep's blood agar; colonies are golden yellow (lat. Aureus = golden); Prof. Dr. K.P. Schaal, Institute of Medical Microbiology, Immunology and Parasitology [Inst. f. Med. Mikrobiolog., Immunologie und Parasitologie], University Hospital of Bonn [Universitätsklinikum Bonn].

Medical significance

Triggers disease in humans and other vertebrates (livestock, pets and wild animals). In humans, it causes purulent skin and wound infections (e.g. impetigo follicularis, mastitis, boils and abscesses) and postoperative or hospital infections (nosocomial infections); spreads into the bloodstream (sepsis) with involvement of practically all organs. Also causes Inflammation of the parotid gland (parotitis), bone marrow (osteomyelitis), lungs (pneumonia), heart valves and endocardial membrane (endocarditis), the meninges (meningitis); foreign body infections (e.g. vascular prosthesis infections); and toxin-related disorders (staphylococcal scalded skin syndrome = SSSS, toxic shock syndrome = TSS, staphylococcal enteritis or food poisoning).
In animals, the infection spectrum is wide, ranging from superficial skin and wound infections to infections of the inner organs and septicaemia with a severe course (sepsis), e.g. mastitis (inflammation of the mammary gland) in cattle and hogs, botryomycosis (wound infection) in ungulates (hooved animals), "bumble foot" in poultry, dermatitis (skin inflammation) and abscess formation in numerous animal species.
Recently, there have been indicators of a zoonotic potential of S. aureus subsp. aureus, particularly in certain methicillin resistant *S. aureus* (MRSA) strains (livestock-associated (LA) MRSA strains in hogs, poultry and cattle). These are transmitted by direct contact with animals or animal products and result in a high colonisation rate in accordingly exposed persons (e.g. farmers, slaughterers, butchers, veterinarians and animal owners and caretakers) and further spread in the direct environment (family members).
Human-adapted *S. aureus subsp. aureus* strains are also commonly transmitted to animals (anthropozoonosis).

Reference: 03009 03010 20430 20431 20432

Transmission routes

Transmission takes place by smear infection: exogenously in contact with (often asymptomatic) carriers of microbial agents (hand contact), exogenously from the person's own hand or mucous membrane flora, aerogenically via dust or droplet emission, and orally via consumption of contaminated foods.

Reference: 99999

For further information on transmission routes see chapter EPIDEMIOLOGY.

OCCUPATIONAL SAFETY AND HEALTH

Sector | Activity | Protective measures | Inactivation/Decontamination | Immediate measures/First aid | Occupational health care

SECTORS

- Health services
- Nursing services
- Pathology departments
- Room maintenance in sanitary facilities
- Laboratories
- Veterinary medicine
- Animal care
- Animal husbandry
- Slaghtering
- Meat processing

Reference: 10025 99999

ACTIVITIES

- Work involving contact with diseased persons
- Provision of medical care to persons needing it
- Contact with potentially infected body fluids, excretions and tissues
- Work involving contact with infected samples or specimens
- Work involving contact with contaminated objects or materials
- Wound care
- Performance of surgical procedures
- Performance of autopsies and dissection work
- Cleaning work in sanitary facilities with infected patients
- Work involving contact with infected animals
- Slaughter of animals with undetected infections
- Meat inspection

Reference: 10025 99999

PROTECTIVE MEASURES

General protective measures

In non-specific activities where contact with potentially infectious individuals / animals or their test specimens/excretions may occur, care must be taken to ensure strict compliance with protective measures and hygiene regulations. Special care should be taken to ensure use of disposable gloves and that hygienic hand disinfection is correctly performed. In skin irritations or smaller skin defects, direct (unprotected) contact with infected individuals/animals or contaminated objects should be avoided. For healthcare-related activities, also see MRSA management (www.rki.de).
In non-specific activities where large amounts of microbe-contaminated dust may be produced (for example, when cleaning pig and chicken barns), respiratory protection may be necessary depending on the risk assessment.

The following protective measures apply to specific activities in laboratories, the husbandry of laboratory animals and biotechnological activities. For further information see TRBA 100, TRBA 120, TRBA 500.

Technical measures

Where tasks intentionally involve biomaterials, their identity must be verified and documented routinely.
Areas in which the biomaterial is processed must be isolated from other areas and labelled with the 'Biohazard' warning symbol and protection level **2**.
The doors of the area within which the protection level applies must open in the direction of the escape route and be equipped with an inspection window.
Where a health hazard posed by bioaerosols cannot be eliminated, the relevant activities must be performed in a microbiological safety cabinet (MSC). For detailed information on activities in MSCs, see leaflet B 011 of the BG RCI (German Social Accident Insurance Institution for the raw materials and chemical industry).
Wash basins, disinfectant dispensers, disposable towels and hand detergents must be available.
Water faucets and disinfectant dispensers must be operable without the use of the hands.
Laboratories must offer suitable eyewash facilities.
All surfaces and areas that could come into contact with biological agents must be easy to clean, liquid-tight and resistant to detergents and disinfectants. A seamless wall-floor joint must be effected.
Windows and doors must be kept closed while work is in progress.
Work areas are to be maintained in a clean and tidy state. Only tools and devices that are actually needed may remain on the benches.
Pipettors must be provided and used. Mouth pipetting is not permitted.
If the use of pointed or sharp instruments cannot be avoided, they must be disposed of in suitable containers after use.
The release of biological agents must be minimised during the opening of technical equipment.
Catch basins must be in place to ensure that open sample containers are prevented from turning over during work operations.
The biomaterial must not be stored under conditions that favour its reproduction.
Clearly labelled, closed, rigid, liquid-tight and unbreakable vessels that can be disinfected from the outside must be provided and used for the in-house transport of biological agents.
Transport of biological agents outside the plant is subject to the regulations governing hazardous goods (class 6.2).
Suitable containers must be available for the collection of waste that constitutes biological agents.
In non-targeted activities in which *Staphylococcus aureus* (particularly MRSA strains) is expected (e.g. work carried out in hospitals, residential or nursing homes, physicians' and veterinary practices, animal-care and animal-breeding facilities, etc.), the respectively required protective measures must be specified and implemented based on the hazard assessment.
In particular, handling of MRSA-colonised or infected persons requires the precise implementation of specific measures (MRSA management) to avoid transmission or curb spread (RKI, Recommendation on the Prevention and Control of Methicillin-Resistant *Staphylococcus aureus* strains (MRSA) in Hospitals and Other Medical Facilities; www.rki.de).

Organisational measures

The number of staff must be limited to the actual requirements, and access to the area in which the protection level applies must be restricted to authorized persons.
An instruction manual must be prepared. Prior to beginning their activity and subsequently at least once a year, verbal and work-related instruction must be provided to staff members to familiarise them with the hazards and protective measures as laid down in the instruction manual. DGUV Informative Publication 213-016 (BGI/GUV-I 853) contains a prototype instruction manual on 'activities involving biological agents of Risk Group 2' in accordance with the German Ordinance on Biological Substances.
The instruction process must also include advice in occupational medicine and safety.
Restrictions of employment for expectant and nursing mothers must be observed in accordance with the German Maternity Protection Act.
Injuries must be reported immediately to the person in charge.
In non-specific activities in which exposure to *Staphylococcus aureus* (and particularly to MRSA strains) is expected, special organisational measures may apply to the affected facilities and personnel (prevention and control measures in clinical facilities, residential and nursing homes, outpatient nursing services, see RKI Advisory for Staphylococcal Diseases, Particularly Infections Due to MRSA; www.rki.de).

Personal protection - body protection

Suitable protective clothing must be worn (at least lab coats).
Durind the processing of infectious tissues, the protective clothing must be complemented by disposable aprons.
Remove protective clothing when leaving the area in which the protection level applies.
Keep protective clothing separate from normal clothing.

Personal protection - hand protection

Depending on the results of the risk assessment, the use of protective gloves may be mandatory for certain activities.
The skin protection plan must be observed.
In non-targeted activities where contact with potentially infectious persons and animals or their examination materials (e.g. specimens) or excretions may occur, care must be taken to ensure that disposable gloves are worn.
Persons with skin irritations or smaller skin defects should avoid direct contact with infected persons or contaminated objects.

Personal protection – eye and face protection

Depending on the results of the risk assessment, protective goggles or face protection may be necessary.

Personal protection - respiratory protection

Depending on the results of the risk assessment, a respiratory protection device may be necessary.
Respiratory protection equipment must be worn for only a limited period of time. This period must be defined in the risk assessment.
A mask to cover the mouth and nose should be worn by persons in possible contact with infected human or animal wounds, body excretions or secretions to prevent colonisation of the nose, particularly with MRSA strains.
In non-targeted activities in which large amounts of dust which may contain the microbial agent are formed, e.g. when cleaning hog and chicken barns, respiratory equipment must be worn.

Occupational hygiene

The consumption and storage of food and alcohol/tobacco in the protection level area is forbidden.
The wearing of jewellery, watches and rings on the hands and the forearms is not permitted.
Fingernails are to be kept short.
Following completion of work and prior to leaving the work area, hands are to be disinfected, washed and remoisturised according to the skin protection plan.
Skin protection and skin care agents must be made available in contamination-proof containers.
Contaminated protective clothing and shoes are to be collected safely and decontaminated, cleaned and disposed of centrally.
Work clothing must not be cleaned at home.
The cleaning regulations for employees, equipment and workplaces must be defined in a hygiene plan.
Insects and pests in the working area must be regularly controlled.
In non-targeted activities in the health care sector (i.e. in clinical facilities and in residential and nursing homes), compliance with strict hygiene measures (MRSA management) must be ensured particularly when working with MRSA-colonised or MRSA-infected patients. In this context, particular emphasis must be placed on correctly performing hand disinfection before and after patient contact (before and after putting on disposable gloves) as well as wiping disinfection of patient contact surfaces, etc.) (see also the "Recommendation for the Prevention and Control of MRSA in Hospitals and Other Medical Facilities" – www.rki.de).
In non-targeted activities with potentially colonised or infected animals (veterinary practice, agriculture, animal husbandry - particularly hog and poultry raising): careful hand disinfection, changing of work clothes and shoes before and after leaving the work area, as well as cleaning and if applicable disinfection of work surfaces and animal barns ("Barn hygiene" and "Milking hygiene").

Vaccination

No licensed vaccine for humans is available.
Various vaccines for animals are known (based on attenuated *S. aureus* strains and *S. aureus* toxoid components); they are used to prevent the economically significant *S. aureus* mastitis in cattle and hog-breeding.

Reference: 00001 04049 20432 20435 20440 99999

INACTIVATION / DECONTAMINATION

Disinfection measures must be carried out by proven means and procedures. For detailed information see the following lists: DVG - Animal Husbandry (German Association for Veterinary Medicine, Accommodation and Husbandry of Animals), DVG - Food Area, VAH and RKI. Officially ordered disinfection measures (decontamination) required by the authorities may be carried out only with disinfection agents included in the RKI list.
Furthermore, the Industrie Association Hyhiene and Surface Protection (IHO) supplies lists of statements of companies on the efficacy of different products. The information in this register is based on statments of the respective companies.
A suitable autoclave must be available in the same building.
Externally contaminated test vessels must be disinfected before opening.
Work areas and working equipment must be decontaminated before the performance of maintenance measures. For further information see TRBA 100 ('Technical Rules for Biological Agents').
Contaminated solid wastes, liquid cultures and suspensions containing pathogens are to be collected in appropriate containers and deactivated.
In non-targeted activities, the amounts of any microbial agents which may be present are largely reduced by thoroughly cleaning and disinfecting of the workplace and work equipment (if required, several times daily).

Reference: 00001

IMMEDIATE MEASURES / FIRST AID / POST-EXPOSURE PROPHYLAXIS

Accidental release measures

Clear contaminated work areas; subsequently perform surface disinfection according to the hygiene plan immediately.
Absorb large amounts of liquids with a universal binding agent (e.g. silica gel or sand), autoclave the resulting mixture and then dispose of it as waste.
If small to medium amounts of contaminated liquids enter the sewage system, serious hazards to bodies of water are not a concern since biological sewage treatment plants reduce the microbial count sufficiently, and the microbial agent may be found in the environment regardless.

First aid: eyes and mucous membranes

Flush under running water or with an eye shower or ready-made rinse solution for 10 - 15 minutes with opened lids; consult the accident insurance consultant.

First aid: skin

Remove contaminated clothing, wet contaminated skin areas with a disposable cloth soaked in hand disinfectant and allow the disinfectant to act, then thoroughly wash the affected skin area.

First aid: respiratory tract

The hazard of infection by inhalation of infectious aerosols is low. In the event of massive ingestion, thoroughly rinse the mouth with water if necessary, spit out the water and do not swallow it!

First aid: swallowing

Rinse the mouth thoroughly with water without swallowing; consult the accident insurance consultant.

Information for physicians

If microbial agents have most likely been ingested (by swallowing), general preventive antibiotic treatment is not recommended.
If (nasal) MRSA colonisation is confirmed, treatment with muciprocin nasal ointment is the standard procedure.
Additional disinfectant oral rinses or whole body washing of intact skin, including hair, with antiseptic soaps and solutions of proven efficacy are recommended to eliminate colonisation of the pharynx or skin with MRSA.

Reference: 04049 99999

OCCUPATIONAL HEALTH CARE according to ArbMedVV

Optional health care:

In the case of tasks specifically involving contact and tasks involving incidental contact with biological agents classed as Risk Group 2 under the Biological Agents Ordinance (Biostoffverordnung, BioStoffV) or which involve a comparable risk, the employer must offer an optional health care. This does not apply when on account of the risk assessment and on account of the protective measures taken it can be assumed that there is no risk of infection.
An optional health care must also be offered if as a result of the exposure to biological agents
- a serious infectious illness is to be expected and post-exposure prophylatic measures are possible, or
- an infection has resulted.

MORPHOLOGY AND PHYSIOLOGY

MORPHOLOGY

Cellular: Gram-positive cocci with a diameter of 0.5 - 1.5 µm occurring singly, in pairs, as tetrads, in short chains (consisting of 3 - 4 cells) or in irregular "grape clusters"; non-motile and non-sporulating; many *S. aureus* strains possess a polysaccharide capsule.
Cultural: round, shiny colonies with colours ranging from white to golden yellow, colony diameter 1 - 2 mm; on blood agar, a colony is surrounded by a haemolysis halo (beta-haemolysis) (*S. aureus* can form 4 different haemolysins: alpha-, beta-, gamma- and delta-haemolysin. These dissolve erythrocytes.
Characteristic diagnostic attributes and identification: undemanding, easily grown in cultures (usually blood agar) from pus, sputum, blood or swabs as starting materials; adding common salt (up to 10 %!) to the nutrient medium can suppress the growth of other flora (important particularly in food and faecal tests); detection of mannitol utilisation; confirmation of heat-stable DNAse formation; confirmation of plasma coagulase formation and the clumping factor (fibrinogen binding to the cell wall surface); protein A (serological antigen detection); phage typing (lysotype and genotyping); antibiotic resistance testing; enterotoxin detection (enterotoxins A - H) (important in food poisoning!), using specific antisera, or molecular biologically by toxin gene detection with PCR. Newer molecular biological methods (e.g. multiplex PCR methods) allow for simultaneous determination of species and antibiotic resistance, e.g. detection of methicillin-resistant *S. aureus* (MRSA) strains via mecA gene detection.

Reference: 03006 03009 03010 04049 20430

PHYSIOLOGY

Chemoorganoheterotrophic; facultatively anaerobic, mesophilic, optimal growth at 30 - 37 °C (temperature range between 10 - 45 °C), halotolerant (tolerance of up to 10 % NaCl in the medium) and catalase-positive.
Develops numerous virulence factors which are decisive for its pathogenicity. Cell bound virulence factors: Protein A, clumping factor and numerous adhesins. Extracellular virulence factors: hyaluronidase, haemolysins (alpha-, beta-, gamma- and delta-haemolysin), leukocidin (some strains produce highly toxic Panton-Valentine leukocidin, PVL), exotoxins (strain-specific formation of exfoliatin toxin, toxic shock syndrome toxin or enterotoxins).

Reference: 03006 03009 03010 20430 99999

INFORMATION ON MOLECULAR BIOLOGY

Genome

S. aureus N315 (methicillin-resistant): a circular chromosome (2,813,41 bp), G+C content of 32.8 %, 2,595 protein coding regions, numerous different insertion (IS) elements, transposons, pathogenicity islands (SCCmec), also a plasmid with various resistance genes (24.653 bp, G+C content of 28.7 %, 29 protein-coding regions).
DDBJ / Genbank / EMBL database Genom Accession Number: AP003129-AP003138 DDBJ / Genbank / EMBL database Plasmid Accession Number: AP003139
S. aureus Mu50 (vancomycin-resistant): a circular chromosome (2,878,084 bp), G+C content of 32.9 %, 2,697 protein coding regions, numerous different insertion (IS) elements, transposons, pathogenicity islands (SCCmec), also a plasmid with various resistance genes (25.107 bp, G+C content of 28.9 %, 34 protein-coding regions).
DDBJ / Genbank / EMBL database Genom Accession Number: AP003358-AP003366 DDBJ / Genbank / EMBL database Plasmid Accession Number: AP003367

Comments

Numerous complete genome sequencing procedures have already been completed on various *Staphylococcus aureus* strains.
The two *S. aureus* strains N315 and Mu50 are described here in greater detail as well documented examples. Both are clinically relevant strains; *S. aureus* N315 is a methicillin-resistant strain which was isolated from clinical material in 1982, while *S. aureus* Mu50 is a vancomycin-resistant strain which was isolated from clinical material in 1997.

Reference: 20430 20442 20443 99999

OCCURRENCE / NATURAL HABITAT

FREE-LIVING / HOST BOUND

This biological agent is host-dependent parasitical.

This biological agent is host dependent-commensalic.

Staphylococcus aureus lives as a commensal partner on skin and mucous membranes in humans and animals, where it is part of the normal physiological body flora.
In humans, it primarily colonises skin surfaces (axillae, inguinal regions and perineal regions), the mucous membranes of the nose (vestibule of the nose) and pharynx, the milk ducts of the mammary glands, head hair and (less commonly) the intestinal and genital regions.
Its pronounced environmental resistance (tenacity) results in long survival times on practically all organic and inorganic surfaces.

Reference: 03009 03010 10038 99999

HOSTS

Depending on the specific strain in humans and many other vertebrates (domestic animals, livestock and wild animals: cattle, sheep, goats, hogs, horses, rabbits, poultry).
S. aureus has so-called local varieties, i.e. specific *S. aureus* strains are specifically adapted to their respective hosts, and can be detected only in humans or only in animals.
Therefore, domesticated or feral animals are generally not reservoirs for the *S. aureus* strains which are significant in human medicine; however, transmission from animals (hogs and poultry) to humans was recently confirmed for certain methicillin-resistant *S. aureus* (MRSA) strains (= livestock-associated (LA) MRSA).
Human MRSA strains are found at higher rates both in hospital environments (patients and personnel) (= hospital-associated (HA) MRSA), and independently in the general population (= community-associated (CA) MRSA).

Reference: 03009 04048 10025 99999

VECTORS

Not known.

Reference: 10038 99999

GEOGRAPHIC DISTRIBUTION

Worldwide.

Reference: 10038 99999

PATHOGENICITY / PATHOGENIC PROPERTIES

CHARACTERISTIC OF PATHOGENICITY

Facultative human-pathogenic (it does not necessarily cause diseases in humans).
Facultative animal-pathogenic (it does not necessarily cause diseases in animals).

Humans and animals are often asymptomatic carriers of host-specific adapted *S. aureus* strains. Some 20 - 50 % of the healthy general population are permanently colonised by *S. aureus* without becoming ill. In animal hosts, *S. aureus* colonisation amounts to 90% in chickens, 42 % in hogs, 29 % in sheep and 14 - 23 % in cattle.
The degree of pathogenicity of *S. aureus* is strain-specific and depends on the existence of various virulence factors (e.g. toxin formation), the infection site (local superficial skin-wound infections or deep systemic infections), but also on the immune status of the particular host (predisposing factors include, for example, skin irritation or wounds, weak immune defences due to underlying disorders such as diabetes, HIV, liver or heart disease, or certain infections e.g. with influenza A viruses).

Reference: 03009 03010 04049 10038 20432

MINIMUM INFECTIOUS DOSE (MID)

Humans: variable, approx. 103 - 108 cells
Animals: very low (fewer than 100 cells) in mammary gland infection (mastitis) of cattle (the entry point is the very sensitive teat canal of the udder!).

Reference: 10038 20432 20433

CARCINOGENICITY / MUTAGENICITY / REPRODUCTIVE TOXICITY

Carcinogenicity: not known.
Mutagenicity: not known.
Reproductive toxicity: Teratogenic effects are known in connection with infections in pregnant women; in rare cases teratogenic effects have also occurred in the foetus during 4th - 9th month of gestation. These include infection of the umbilical stump (omphalitis) and sepsis, which are relatively common in new-borns as a result of the transmission of *S. aureus* during birth (peripartum); conjunctival infection (conjunctivitis); inflammation of the umbilical stump (omphalitis); necrotising soft-tissue infections; neonatal or premature-infant sepsis (early- and late-onset neonatal sepsis); and inflammations of the bone marrow (osteomyelitis).

Reference: 01012

ALLERGENICITY / SENSITISING EFFECT

An allergic / sensitising potential is not known.

Reference: 99999

TOXIGENICITY / TOXIN FORMATION

Strain-specific formation of exotoxins: exfoliatin toxins (exfoliatin A and B), toxic shock syndrome toxin (TSST-1), enterotoxins A-H.
Also forms numerous extracellular proteins and enzymes which have toxic effects on tissues: leukocidins (granulocyte and macrophage toxicity), haemolysins (alpha-, beta-, gamma- and delta-haemolysin) (haemolysins of erythrocytes or platelets). Some *S. aureus* strains (usually methicillin-resistant *S. aureus* strains) form a bacteriophage-coding leukocidin (Panton-Valentine (PV) leukocidin) with strongly toxic, tissue-necrotising effects.

Reference: 03006 03009 04049

DISEASE

DESCRIPTION

Humans
Local superficial infections: purulent skin and wound infections with abscess formation, particularly affecting the hair follicles and sebaceous and sweat glands; impetigo follicularis, mastitis, boils and carbuncles (when several boils merge).
Deep-seated, invasive infections which affect practically all internal organs (often postoperative or nosocomial): purulent parotitis, osteomyelitis, pneumonia, endocarditis, tropical pyomyositis (infection of the skeletal muscle) and necrotising pneumonia caused by Panton-Valentine-leukocidin (PVL)-producing *S. aureus* strains; foreign body infections (e.g. vascular prosthesis infections); toxin-related illnesses: staphylococcal scalded skin syndrome (SSSS), toxic shock syndrome (TSS), and staphylococcal enteritis or food poisoning.
Animal
Superficial skin and wound infections and internal organ infections, in some cases with severe courses (septicaemias or sepsis): mastitis (inflammation of the mammary glands) in cattle, sheep, goats and hogs; botryomycosis (wound infection) in ungulates (hooved animals), pododermatitis (bumble foot, claw disease; and wound infection of the foot pad) in poultry and wild birds (e. g. birds of prey), dermatitis (skin inflammation) and development of abscesses.

Reference: 03006 03009 04049 20432

ZOONOSIS

Zoonosis (transmission between animals and humans): Yes

Transmission from animals to humans has been well documented since some time now for specific, methicillin-resistant *S. aureus* strains. This particularly applies to the MRSA strain ST (sequence type) 398, which commensally colonises primarily hogs, poultry and to a lesser extent, cattle. In recent times, further MRSA strains have appeared in these domestic animal stocks; they are collectively referred to as livestock-associated (LA) MRSA strains. These are transmitted by direct contact to the animal or animal product and result in a high colonisation rate in accordingly exposed persons (e.g. farmers, slaughterers, butchers, veterinarians and animal owners and caretakers) and wide spread in the direct environment (family members).
There are numerous known cases of human illness (wound infections, pneumonia and endocarditis) due to LA-MRSA.

Reference: 04048 10025 20434 20435 20436 99999

INFECTIOUS STAGES

The bacteria can always have infectious effects.
Patients (even asymptomatic carriers) can also always have infectious effects. Particular infectious stages of the bacteria are not known.

Reference: 99999

INCUBATION PERIOD

In food poisoning due *to S. aureus* enterotoxins (orally via contaminated foods): 30 minutes to 8 hours after food was ingested.
In acute infections: 4 - 10 days
In persons with (permanent) colonisation, an infection may also occur months or years after the initial colonisation with *S. aureus*.

Reference: 04049 10025 10038

SYMPTOMS AND COURSE OF DISEASE

Acute and superficial purulent infections as well as deep invasive infections: purulent skin changes with and without abscess formation and inflammation of the skin appendages (e.g. hair follicles and sebaceous glands); purulent inflammation of the bone (osteomyelitis), the lungs (pneumonia) or spread into other organ systems with abscess formation, empyema in body cavities (empyema of the pleural, pericardial, peritoneal, joint or sinus cavities); with spread via the bloodstream (sepsis), practically all organs may become affected, and may also result in endocarditis with a rapid and severe course. Infections with methicillin-resistant *S. aureus* strains (MRSA) may result in major therapeutic difficulties, particularly insofar as sepsis is concerned. Specific *S. aureus* strains demonstrate a special ability to spread, due to forming a strongly toxic, tissue-necrotising leukocidin (Panton-Valentine leukocidin = PVL), and are associated both with the so-called tropical pyomyositis (infection of the skeletal muscles; primarily in tropical regions) and with formation of deep abscesses and boils, ranging to necrotising pneumonia or necrotising fasciitis and myositis.
Toxin-related disorders: in staphylococcal scalded skin syndrome (SSSS), abrupt onset of illness with generalized erythema and fever; after a few hours, superficial epidermolysis over large areas with formation of blisters ("scalded skin", dermatitis exfoliativa) over the entire body.
Toxic shock syndrome (TSS): sudden onset of illness with shock symptoms: high fever (over 39 °C), hypotension and exanthema (especially on the extremities), diarrhoea with vomiting, cardiovascular and disturbances of consciousness. TSS is associated with multiorgan failure (affecting the gastrointestinal tract, kidneys, liver and central nervous system); chronic renal failure and gangrene of the extremities (skin scaling and necrosis) occur as consequential disorders, particularly on the palms and soles.
Food poisoning (enterotoxin-related gastroenteritis): abrupt onset of illness with nausea, massive vomiting, cramping abdominal pain, individual episodes of diarrhoea, in some cases with fever and general sensation of illness. In most cases the illness is self-limiting and ends after 8 - 24 hours; in severe cases, high fluid loss may result in a blood pressure drop (hypotension) or blood volume deficiency (hypovolaemia).

Reference: 03009 04049 10038

LETHALITY

Relatively high fatality rate in patients with deep-seated invasive *S. aureus* infection (pneumonia and endocarditis) taking a severe course, particularly in the presence of weakened immune defences and a methicillin-resistant strain of the microbial agent (MRSA). In septic courses, the fatality rate is still as high as 15 %, even if the *S. aureus* strain is sensitive to antibiotics! Panton-Valentine-leukocidin (PVL) forming *S. aureus* strains have fatality rates of 75 % in healthy (immunocompetent), usually younger persons.
Very high in staphylococcal scalded skin syndrome (SSSS): very high (approx. 50 %) in persons with weakened immune systems (immunosuppression).
In severe cases of toxic shock syndrome (TSS), the fatality rate is approx. 5 - 8%.

Reference: 03009 04049 20437

THERAPY

Surgical measures to treat empyema and abscesses; systemic antibiotic treatment of severe local or generalised infections. An antibiogram should absolutely be performed in infections with methicillin-resistant *S. aureus* strains. ß-lactam antibiotics should basically not be used in patients with these and all other severe *S. aureus* infections (resistances!). Combinations of glycopeptides with rifampicin, clindamycin or gentamycin (depending on the antibiogram) are indicated here. Combination therapy with rifampicin and cotrimoxazole can also be used to treat skin and soft tissue infections; recently, tigecyclin and daptomycin have also become available (see the recommendations of the Robert Koch Institute).
In toxic shock syndrome (TSS): symptomatic therapy (fluid and electrolyte replacement, treatment of shock); possibly also clindamycin. The early administration of single high doses of corticosteroids is recommended for patients with severe TSS courses.
In patients with food poisoning: symptomatic treatment with fluid and electrolyte replacement therapy.
In the event of nasal colonisation by methicillin-resistant *S. aureus* (MRSA) strains: treatment with mupirocin nasal ointment.
In animals: the use of *Lactococcus lactis* live cultures (lantibiotic production) to replace common antibiotic therapy for the economically significant mastitis (mammary gland inflammation) occurring in dairy cows or hogs is being investigated in order to avoid higher losses of milk containing antibiotic residues.

Reference: 03009 04049 20432 20438

PROPHYLAXIS

Strict compliance with hygiene measures, particularly for medical and nursing personnel, but also for personnel in large-scale kitchens and in the foods-processing industry.
In hospitals: Screening at or better before hospital admission, isolation of MRSA patients in the hospital, and compliance with consistent, systematic hygiene management [MRSA management; see the Robert Koch Institute (RKI, Robert-Koch-Institut): Recommendation for the prevention and control of MRSA in hospitals and other medical facilities; www.rki.de], such as wearing a mask, hand disinfection before and after every patient contact). Carriers of the microbial agent (personnel known to be colonised with methicillin-resistant *S. aureus* (MRSA) strains should not treat or care for patients until confirmed decontamination (muciprocin treatment) has taken place.
When working with animals or animal products (particularly in commercial hog or poultry growing operations): Wear personal protective equipment (gloves and mask) and carefully change any contaminated work clothing before leaving the particular work area to prevent further spread of livestock-associated (LA) MRSA strains; hygiene measures (hand disinfection) when working with potentially infected animals or animal products, e.g. when milking cows, cleaning out barns ("barn hygiene" and "milking hygiene") or when cutting meat (butchering).
Various vaccines (see above) against *S. aureus* infections are known for animals (particularly in hog and cattle raising) and are used. Colonized or infected animals should be separated and treated in time, or removed from the animal herd.

Reference: 03009 04049 20432 20439 20440

EPIDEMIOLOGY

TRANSMISSION ROUTES / PORTALS OF ENTRY

Transmission takes place percutaneously (through the skin).

Transmission takes place via inhalation (by breathe).
Transmission takes place orally (by ingestion).

Staphylococcus aureus is most commonly transmitted by smear infection from human to human (hand contact). Usually slight skin wounds or abrasions serve as portals of entry for the pathogen (percutaneous route). However, an infection can also originate in a person's own skin or mucous membrane flora; this person often remains asymptomatic for long periods.
Since *S. aureus* is highly resistant to dehydration, transmission may also take place aerogenically by inhalation of dust or aerosols bearing a high microbial burden, particularly from the surroundings of infected animals.
Humans infect themselves orally by ingestion of contaminated animal foods (e.g. meat).
Specific methicillin-resistant *S. aureus* (MRSA) strains are transmitted from humans to animals and vice versa.

Reference: 03009 10025 99999

PATHOGEN RESERVOIR

Strain-specific in humans and many other vertebrates (domesticated animals, livestock and wild animals): cattle, sheep, goats, hogs, horses, rabbits and poultry).
Some 20 - 50 % of the healthy normal population are permanently colonised with *S. aureus*; in animal hosts, *S. aureus* colonisation amounts to 90 % in chickens, 42 % in hogs, 29 % in sheep and 14 - 23 % in cattle. These are host-bound local variants.
Specific methicillin-resistant *S. aureus* (MRSA) strains are not host-bound in various host species (hogs, cattle and poultry) and were also detected as pathogenic agents in humans (so-called livestock-associated (LA) MRSA).
Human methicillin-resistant *S. aureus* (MRSA) strains occur at higher rates both in hospital environments (patients and personnel) (= hospital-associated (HA) MRSA) and independently in the normal population (= community-associated (CA) MRSA).

Reference: 04048 10025 20432 99999

INCIDENCE

Staphylococcus aureus causes 70 - 80% of all wound infections, 50 - 60 % of all bone-marrow inflammations (osteomyelitides), 15 - 40 % of all vascular prosthesis infections, up to 30% of all cases of sepsis and endocarditis, and 10 % of all cases of pneumonia. It is one of the most common causative agents of both community-acquired and noscomial infections.
Occurs in clusters ranging to epidemics, particularly due to methicillin-resistant *S. aureus* strains, the share of which has been relatively stable at about 20 % of all *S. aureus* isolates in hospitals, in the outpatient sector and in nursing homes (hospital-associated (HA) MRSA) in Germany in recent years during the period from 2007 onward.
A total of 4,456 infections, due to methicillin-resistant *S. aureus* strains (HA-MRSA), which took a severe invasive course were reported for the year 2012. In this context respiratory tract infections (including pneumonia) were most common at 35 %, followed by infections originating from central venous catheters or other types of invasive accesses (30.5 %) and infections of the skin and soft tissues (20.2%).
The incidence for the 4,456 reported cases in Germany amounted to 5.4 / 100,000 residents in 2012 (compared with 5.2 / 100,000 residents in 2011).
Infections with methicillin-resistant *S. aureus* strains in the normal population outside hospitals (community-associated (CA) MRSA) tend to be rare in Germany (about 2 % of all MRSA cases), but should receive attention due to the often lengthy and relapsing severe courses of illness with high fatality rates. They often occur in familial clusters (shared household) or endemically in countries with insufficiently hygienic living conditions. Places where people live in close quarters are generally problematic (e.g. barracks, prisons and households); this also applies to sports with a tendency to cause skin abrasions (e.g. football and rugby) or where hygiene articles are shared (e.g. towels). Travel in high-prevalence regions (USA, Mediterranean countries, East Asia, Oceania, Africa and the Middle East) is also a risk factor for acquiring CA-MRSA infections.
The number of human infections caused by methicillin-resistant *S. aureus* strains from livestock (livestock-associated (LA) MRSA) is also low. In this context, the share of the predominant *S. aureus* strain LA-MRSA CC398 amounted to 5.2 % out of all MRSA isolates from Germany in 2012. The share of human infections due to this strain was 1.5 % (out of all MRSA cases), whereby deeper skin and soft tissue infections were predominant. Regional clusters in the occurrence and spread of LA-MRSA are found in regions with a high density of commercial livestock facilities (in Germany: Lower Saxony and Westphalia), where direct contact to animals (particularly in commercial hog and poultry-raising operations) represents the most important risk factor for nasal colonisation by LA-MRSA. Some 86 % of hog farmers in Germany display nasal colonisation with LA-MRSA, as well as 12 - 45 % of veterinarians and no less than 4 % of family members of occupationally exposed persons who did not have any direct animal contact themselves.
Food infections caused by methicillin-resistant *S. aureus* strains are extremely rare and limited to individual cases.

Reference: 03010 04048 04050 20440 20441

RESISTANCE / TENACITY

SPORULATION

Does not form spores.

Reference: 99999

CONIDIA FORMATION

Does not form conidia.

Reference: 99999

RESISTANCES

High resistance to desiccation, high salt content (tolerance up to 15 % w/v NaCl concentration), heat, UV rays and to some disinfectants.
Staphylococcus aureus therefore has long survival times outside hosts: e.g. up to 42 days on cadavers, up to 7 days on surfaces, 46 hours on glass, 17 hours in sunlight, 7 hours in UV light, 60 days on meat, up to 7 days on coins, and 30 minutes to 38 days on skin surfaces.
Dry heat (1 hour at 160 - 170 °C) destroys the otherwise heat-resistant *S. aureus* enterotoxins.
Effective disinfectants include: 70 % ethanol, chlorhexidine, 1 % sodium hypochlorite, 2 % glutaraldehyde, 0.25 % benzalkonium chloride and formaldehyde.
Antibiotic resistance: approx. 80 % of *S. aureus* strains are resistant to beta-lactam antibiotics due to forming penicillinase; spread of methicillin-resistant *S. aureus* strains (MRSA) which often show additional resistance to, for example, ciprofloxacin, moxifloxacin, erythromycin or clindamycin. Like resistance to glycopeptides (vancomycin, teicoplanin), resistances to reserve antibiotics (tigecyclin, linezolid and daptomycin) tend to be rare.
In recent years, increased resistance to mupirocin has been reported.

Reference: 03010 04048 10038

LEGAL PRINCIPLES / REGULATIONS

LAWS AND ORDINANCES

Ordinance on Safety and Health Protection at Workplaces Involving Biological Agents (Biological Agents Ordinance - BioStoffV)

Law for the regulation of genetic engineering (Genetic Engineering Act -GenTG) and associated regulations (only in German).

Public notice of the list risk-rated donor organisms and recipient organisms for genetic engineering of 5. July 2013

Law on the prevention and control of infectious diseases in humans (Infection Protection Act -IfSG) (only in German)

Ordinance on Occupational Health Care (ArbMedVV)

Law for the protection of working mothers (MuSchG)
(only in German)

Animal health law (TierGesG) and associated regulations (only in German)

Rules for transportation of dangerous goods:
- European Convention on the carriage of dangerous goods by road (ADR)
- Order concerning the International Carriage of Dangerous Goods by Rail (RID)
- International Air Transport Association (IATA), dangerous goods regulation, 54th edition 2013
- the law on the transport of dangerous goods (Gefahrgutbeförderungsgesetz". -GGBefG)
- Regulation on the national and international transport of dangerous goods by road, rail and inland waterway services (Dangerous Goods Regulations, road, rail and inland waterways - GGVSEB)
- Regulation on the International Maritime Dangerous Goods (Dangerous Goods Regulations lake - GGVSee)
- Regulation on the order of advisor and the training of the persons in businesses and enterprises (Dangerous Goods Advisor Ordinance - GBV) (only in German)

TECHNICAL RULES AND OTHER REGULATIONS

TRBA 100
Protective measures for activities involving biological agents in laboratories

TRBA 230
Protective measures for activities involving biological agents in agriculture and forestry and comparable activities

TRBA 250
Biological agents in health care and welfare facilities

TRBA 400
Guideline for risk assessment and for the instruction of employees in relation to activities with biological agents

TRBA 450
Criteria for the classification of biological agents

TRBA 466
Classification of prokaryotes (bacteria and archaea) into risk groups (only in German)

TRBA 468
List of cell lines and activities with cell cultures (only in German)

TRBA 500
Basic measures to be taken for activities involving biological agents

LINKS

Robert Koch Institute (RKI)
Information provided by the Robert Koch Institute for this pathogen

Public Health Agency of Canada (PHAC)
Information provided by the Public Health Agency of Canada for this pathogen

Centers for Disease Control and Prevention (CDC)
Information provided by the Centers for Disease Control and Prevention for this pathogen
Information provided by the Centers for Disease Control and Prevention for this pathogen

German Federal Institute for Occupational Safety and Health (BAuA)
Epidemiology of work-related infectious diseases (only in German)

European Association of Zoo and Wildlife Veterinarians (EAZWV)
Information provided by the EAZWV (European Association of Zoo and Wildlife Veterinarians) for this pathogen

Further Links:
Information provided by the Bundeszentrale für gesundheitliche Aufklärung - BZgA (Federal Center for Health Clarification) for MRSA (only in German)
Compendium of Measures to Prevent Disease Associated with Animals in Public Settings
National Research Platform for Zoonoses - Pathogen profile zoonotic methicillin-resistant Staphylococcus aureus (MRSA)

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General information | Occupational and health protection | Morphology and physiology | Occurrence/natural habitat | Pathogenicity/pathogenic properties | Disease | Epidemiology | Resistance/Tenacity | Legal basics | Links | References

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Information from the technical rules for biological substances, in particular from:
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Schutzmaßnahmen für Tätigkeiten mit biologischen Arbeitsstoffen in Laboratorien; Ausgabe: Oktober 2013, geändert 2014
Protective measures for activities involving biological agents in laboratories; Edition: October 2013, amended 2014
- TRBA 120
Versuchstierhaltung; Ausgabe: Juli 2012, geändert 2017
Experimental animal husbandry; Edition July 2012, amended 2017
- TRBA 500
Grundlegende Maßnahmen bei Tätigkeiten mit biologischen Arbeitsstoffen; Ausgabe: April 2012
Basic measures to be taken for activities involving biological agents; Edition April 2012

Quelle: 01012
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Quelle: 01466
TRBA 466
Einstufung von Prokaryonten (Bacteria und Archaea) in Risikogruppen; Ausgabe: August 2015, zuletzt geändert: GMBl. Nr. 25-31 vom 14. August 2019, S. 478
Classification of prokaryotes (bacteria and archaea) in risk groups; Edition August 2015, last amended August 2019

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Angabe des Bearbeiters
Indication of the author

General information | Occupational and health protection | Morphology and physiology | Occurrence/natural habitat | Pathogenicity/pathogenic properties | Disease | Epidemiology | Resistance/Tenacity | Legal basics | Links | References