Einsatz von Antibiotika in der Pferdemedizin, Möglichkeiten und Grenzen: ein Update

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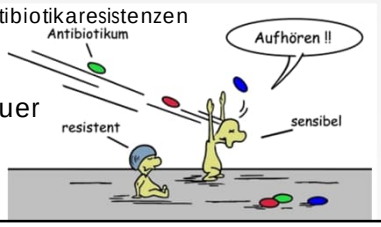
Antibiotic Stewardship

- Resistenzen = Problem sowohl in der Human-, als auch Veterinärmedizin → gesundheitliche Auswirkungen

- Klinische Szenarien die vermutlich zum Entstehen beitragen:
  - Gebrauch bei nicht bakteriell bedingten Erkrankungen
  - Unterdosierung
    - Subtherapeutische Konzentrationen → ↑ Antibiotikaresistenzen (längere/wiederholte Exposition)
    - In 30% der Fälle in einer australischer Studie
  - Unnötige verlängerte Behandlungsdauer



Antibiotic Stewardship

Resistenzprobleme deutlich häufiger bei stationären Pferden mit multiresistenten Keimen → ESKAPE-E Erreger

- *Enterococcus faecium*
- *Staphylococcus Aureus*
- *Klebsiella pneumoniae*
- *Acinetobacter Baumanii*
- *Pseudomonas aeroginosa*
- *Enterobacter spp.*
- *Escherichia coli*

Antibiotic stewardship

↑ Bewusstsein in den letzten 10 Jahren

Education

EDITORIAL

Antimicrobial resistance in horses, a call to action

Audit of antimicrobial use in eleven equine practices over a five-year period (2014–2018)

T. S. Mair[†,*] *and T. D. Parkin*[‡]

Antibiotic usage in 14 equine practices over a 10-year period (2012–2021)

Rose E. Tallon[1] | Brian Whitt[2] | Bruce M. Bladon[1]

Antimicrobial prescribing and antimicrobial resistance surveillance in equine practice

Amie Wilson[1] | Tim Mair[2] | Nicola Williams[1] | Catherine McGowan[1] | Gina Pinchbeck[1]

Outpacing the resistance *tsunami*: Antimicrobial stewardship in equine medicine, an overview

*J. F. Prescott**

Ceftiofur use and antimicrobial stewardship in the horse

Clare A. Ryan[1] | Christina D. McNeal[1] | Brenton C. Credille[2]

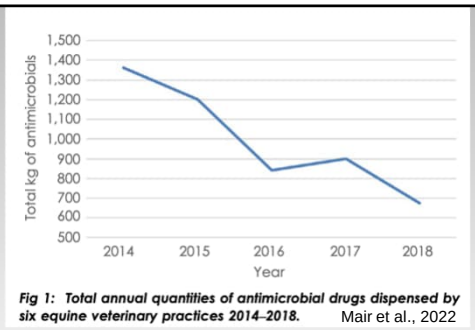


Fig 1: Total annual quantities of antimicrobial drugs dispensed by six equine veterinary practices 2014–2018. Mair et al., 2022

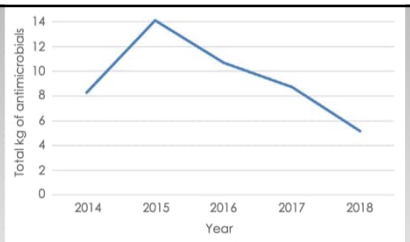


Fig 2: Total annual quantities of enrofloxacin dispensed by six equine veterinary practices 2014–2018.

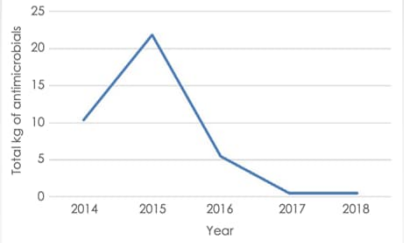


Fig 3: Total annual quantities of ceftiofur dispensed by six equine veterinary practices 2014–2018.

Mair et al., 2022

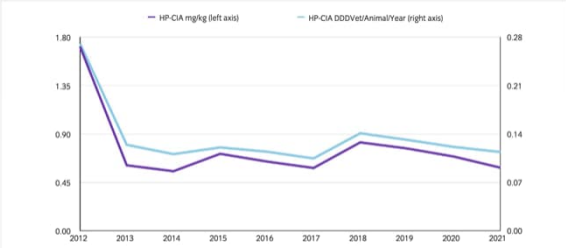
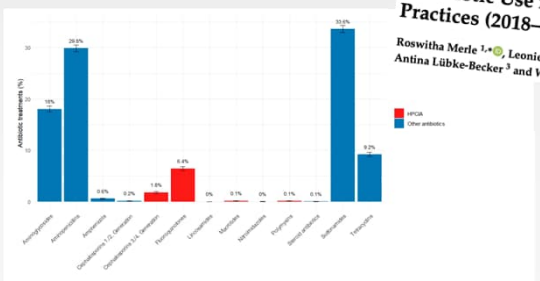


FIGURE 2 Graph showing annual usage of highest priority critically important antibiotics in mg/kg on the left axis and defined daily dose per animal per year on the right axis.

Tallon et al., 2023

Situation Deutschland

- → 57 Praxen/Kliniken
- → 7% der Konsultationen → Antibiotika verabreicht = < andere Studien
- → Sulfonamide und Trimethoprim > Aminopenicilline
- → 8.5% der Behandlungen mit HPCIA



Antibiotic Use in Horses: Analysis of 57 German Veterinary Practices (2018–2023)

Roswitha Merle [1,*], Leonie Feuer [2], Katharina Frenzer [1], Jan-Lukas Plenio [1], Astrid Bethe [3,4], Nunzio Sarnino [1], Antina Lübke-Becker [3] and Wolfgang Bäumer [2]

Figure 4. Percentage including 95% confidence intervals of consultations with antibiotic treatment per substance class in horses (17,633 applications or deliveries from 57 German horse practices from 2018 to 2023). Highlighted are substance groups that belong to the highest-priority critically important antibiotics.

→ Ophthalmologie
→ 10% der Rezepte für humane Präparate

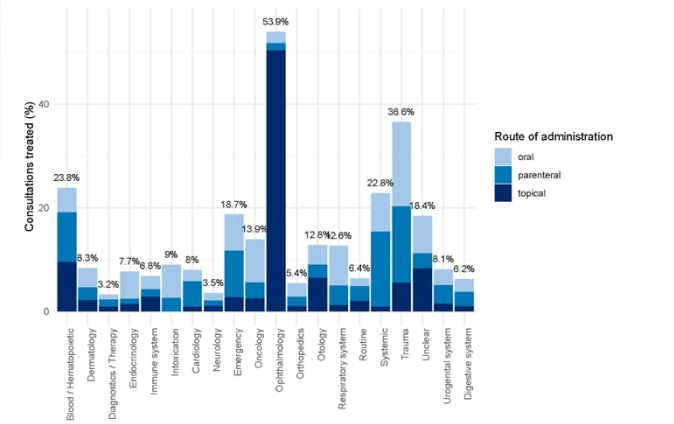
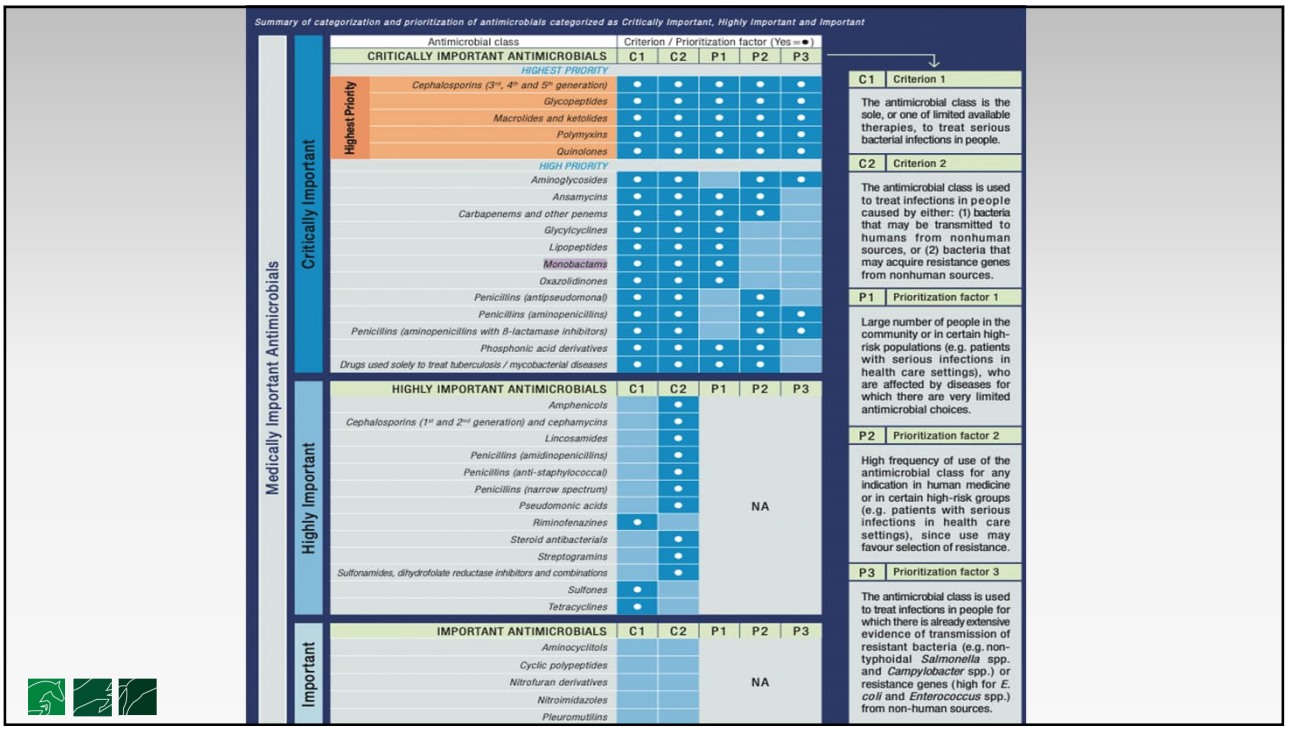


Figure 6. Percentage of consultations with antibiotic treatment per indication group in 7276 treatments of horses from 57 German horse practices from 2018 to 2023. Merle et al.,2025

Verschiedene Organisationen haben Guidelines für den verantwortungsvollen Gebrauch von Antibiotika beschrieben – WHO, EMA, BEVA Protect me,...

- WHO
  - Important
  - Highly important
  - Critically important
    - high priority
    - highest priority



Europäische Arzneimittel-Agentur (EMA)

4 Kategorien

1. Kategorie A (Avoid)
   - Nicht für Verwendung bei Tieren in der EU zugelassen
   - In Ausnahmefällen zur Behandlung von Haustieren (Verordnung (EU) 2019/6 Artikel 112)
   - 18 Präparate im Annex von der Reg (EZ) 2022/1255 aufgenommen → dürfen nie bei Tieren eingesetzt werden dürfen gemäß mit Artikel 112, 113 und 114. Dienen dafür bestimmte Erkrankungen beim Menschen zu behandeln

Table 2
Antibiotics not authorized for use in veterinary medicinal products in the EU. Category A antibiotics are not allowed for use in food producing animals. Antibiotics listed in the annex of Commission Implementation Regulation are banned from use in any animal species.

Antibiotic Class	Examples of EMA Category A substances	Registration in the Annex of Commission Implementation Regulation (EU) 2022/1255
Aminopenicillins*	Mecillinam, pivmecillinam	yes
Carbopenems	Merpenem, doripenem	yes
Carboxypenicillin and ureidopenicillin, including combinations with beta lactamase-inhibitors	Piperacillin-tazobactam	yes
Glycopeptides	Vancomycin	yes
Cyclocyclines	Tigecyclin	yes
Ketolides	Thelithromycin	no
Lipopeptides	Daptomycin	no
Monobactams	Aztreonam	yes
Oxyzolidinones	Linezolid	yes
Phosphonic acid derivatives	Fosfomycin	yes
Pseudomnic acids	Mupirocin	no
Rifamycins (except rifaximin)**	Rifampicin	no
Riminofenazines	Clofazimine	no
Sulfones	Dapson	no
Streptogramins	Pristinamycin, virginiamycin	no
Drugs used solely to treat tuberculosis or other mycobacterial diseases	Isoniazid, ethambutol	no
Other cephalosporins and penems (ATC code JO1D1), including combinations of 3rd-generation cephalosporins with beta lactamase-inhibitors	Ceftobiprole, ceftaproline	yes
Substances newly authorized in human medicine following publication of the AMEG categorisation	To be determined	-

* For veterinary aminopenicillins see Tab. 1
** Rifaximine is authorized in VMPs for intramammary application in dry cows.

Schmerold et al., 2023

Article 112

Use of medicinal products outside the terms of the marketing authorisation in non-food-producing animal species

1. By way of derogation from Article 106(1), where there is no authorised veterinary medicinal product in a Member State for an indication concerning a non-food-producing animal species, the veterinarian responsible may, under his or her direct personal responsibility and in particular to avoid causing unacceptable suffering, exceptionally treat the animals concerned with the following medicinal product:

(a) a veterinary medicinal product authorised under this Regulation in the relevant Member State or in another Member State for use in the same species or another animal species for the same indication or for another indication;

(b) if there is no veterinary medicinal product as referred to in point (a) of this paragraph, a medicinal product for human use authorised in accordance with Directive 2001/83/EC or Regulation (EC) No 726/2004;

(c) if there is no medicinal product as referred to in point (a) or (b) of this paragraph, a veterinary medicinal product prepared extemporaneously in accordance with the terms of a veterinary prescription.

2. Except as regards immunological veterinary medicinal products, where there is no medicinal product available as referred to in paragraph 1, the veterinarian responsible may under his or her direct responsibility and in particular to avoid causing unacceptable suffering exceptionally treat a non-food-producing animal with a veterinary medicinal product authorised in a third country for the same animal species and same indication.

3. The veterinarian may administer the medicinal product personally or allow another person to do so under the veterinarian's responsibility, in accordance with national provisions.

4. This Article shall also apply to the treatment by a veterinarian of an animal of the equine species provided that it is declared as not being intended for slaughter for human consumption in the single lifetime identification document referred to in Article 8(4).

5. This Article shall apply also when an authorised veterinary medicinal product is not available in the relevant Member State.

2. Kategorie B (restrict)
   - = WHO critically important antimicrobials (CIA)
   - Nur in der Tiermedizin
     - Basierend auf Kultur und Antibiogramm
     - Antibiotika Kategorie C und D nicht klinisch effektiv

3. Kategorie C (caution)
   - keine Alternativen in der Humanmedizin und keine klinisch wirksamen Alternativen in Kategorie D für die Veterinärmedizin

Table 1
Antibiotic classes for use in the EU in (food producing) animal species and in human medicines. Not all individual compounds listed are licensed for use in human.

Antibiotic class/substance*	EMA Classification	Target food producing animal species and indication**
Cephalosporins, 3rd- and 4th-generation with exception of combinations with beta-lactamase-inhibitors (Cephalosporins, 3rd, 4th and 5th generation***)	B	All mammalian food producing species (compound and species-specific provisions). Treatment of disease (pneumonia) associated with *Pasteurella trehalosi* (former *P. haemolytica* serovar T), *Mannheimia haemolytica* (former *P. haemolytica* biogroup 1) and *Pasteurella multocida*. Bovine, ovine, porcine, chicken, rabbits Prevention and treatment of diseases caused by sensitive bacteria (e.g., Salmonella and *Escherichia coli*).
Polymyxines (Colistin, polymyxin B)	B	All food producing species (compound and species-specific provisions) First. gen., oxolinic acid, flumequine: Treatment of septicaemias, infections (colibacillosis) Second Gen.: cinoxacin, danofloxacin, difloxacin, enrofloxacin. Wide range of applications, extremely important, treatment of septicaemias, respiratory and enteric diseases.
Quinolones: fluoro and other quinolones (Danofloxacin, enrofloxacin, flumequine, marbofloxacin; ibafloxacin, pradofloxacin only companion animals)***	B	All food producing species (compound and species-specific provisions) Extremely important (wide range of applications and the nature of the diseases treated). Particular importance in treating some fish diseases (no or very few treatment alternatives). Useful alternative in respiratory infections of cattle, swine and poultry. Florfenicol is used to treat pasteurellosis in cattle and pigs.
Amphenicols (Florfenicol, thiamphenicol; chloramphenicol is banned for use in food animals)	C	Porcine, rabbit, chicken, turkey (compound- and species-specific provisions) Treatment and prophylaxis of dysentery, pneumonia and mycoplasmal infections in pigs and poultry; swine dysentery (*Brachyspira hyodysenteriae*).
Pleuromutilins (Tiamulin, valnemulin)	C	All food producing species (compound- and species-specific provisions) Mastitis pathogens, mostly Gram-positive bacteria such as Staphylococci (e.g., *Staphylococcus aureus*) and Streptococci (*Streptococcus agalactiae, S. uberis, S. dysgalactiae*).
Lincosamides (Clindamycin (companion animals only), lincomycin, pirlimycin)	C	

Antibiotic class/substance*	EMA Classification	Target food producing animal species and indication**
Cephalosporins, 1st- and 2nd-generation, and cephamycins (Cefacetrile, cefadroxil (companion animals only), cefalexin) Penicillins with beta-lactamase inhibitor (amoxicillin/ clavulanic acid)	C	Cattle, sheep, pig (compound- and species-specific provisions); cefalexin-sensitive infections; bovine: intramammary treatment of mastitis in lactating
Macrolides and ketolides (Erythromycin, gamithromycin, tulathromycin, tylosin, tylvalosin)***	C	All food producing species (compound- and species-specific provisions) Mycoplasma infections (pigs, poultry), haemorrhagic digestive disease in pigs (*Lawsonia intracellularis*) *Fusobacterium necrophorum*) in cattle, where they have very few alternatives. Respiratory infections in cattle.
Aminoglycosides (except spectinomycin) (e.g. streptomycin, gentamicin)	C	Aminoglycosides are very critically important antimicrobials in veterinary medicine and one of few treatment options presenting a lesser risk for Pseudomonas infections in companion animals and horses and weaning diarrhoea due to Enterobacterales in pigs.

Schmerold et al., 2023

4. Kategorie D (prudence)

- First-line therapie
- Nicht unnötig / nicht unterdosieren / kein zu langer Behandlungszeitraum

Penicillins (Aminopenicillins without beta-lactamase inhibitors; natural, narrow-spectrum penicillins (beta-lactamase-sensitive penicillins), anti-staphylococcal penicillins (beta-lactamase-resistant penicillins)	D	All food producing species (compound- and species-specific provisions) For example: used in pigs for treatment and control of *Streptococcal meningitis* and septicaemia caused by *Streptococcus suis*, and for treatment and control of pleuropneumonia caused by *Actinobacillus pleuropneumoniae* and of secondary pneumonia caused by *Pasteurella multocida* Penicillins are used in the treatment of septicaemias, respiratory and urinary tract infections.
Sulfonamides, dihydrofolate reductase inhibitors and combinations (Formosulfathiazole, sulfadiazine, sulfadoxine, trimethoprim)	D	All food producing species (species- and compound-specific provisions) Extremely important; wide range of applications and the nature of the diseases; bacterial, coccidial and protozoal infections; wide range of animal species.
Tetracyclines	D	All food producing species (species- and compound-specific provisions) Very important in the treatment of many bacterial and chlamydial diseases in a broad range of animal species. No alternatives in the treatment against heartwater (*Ehrlichia ruminantium*) and anaplasmosis (*Anaplasma marginale*).
Aminoglycosides: Spectinomycin only	D	All food producing species (compound and species-specific limitations)

Schmerold et al., 2023

Protect ME

BEVA RESET FORM

PRACTICE NAME HERE

Practice Policy: Dose and Routes of Administration

are inconsistent with responsible antimicrobial usage due to the potential to cause sub-therapeutic dosing or administration for a single day.

Once you have completed your documents you should distribute them around your practice. If you choose to SUBMIT this data it will be used by BEVA to demonstrate the profession's engagement and to improve the documents for the future.

Members must establish policies for use in food producing animals

in a web browser you may lose some of the functionality).
2. This form requires Adobe reader software to access. This can be downloaded for free from www.adobe.com/reader.
3. All of the fields highlighted in blue are editable.
4. Once you have completed your policy make sure you can save a copy (this will allow you to update as needed).
5. Print and distribute copies to colleagues (we recommend additional copies are posted in your pharmacy).
6. If you want to clear all your data from the form simply click the reset button at the top of the page.

Drug	Dose per kg	Route	Dosing interval	Spectrum +ve	Spectrum -ve	Spectrum An02	Notes
Sodium Penicillin	20,000iu*	IV	6-8 hours*	++	+	++	Wide distribution, poor penetration into CNS, abscess, sites or necrosis
Procaine Penicillin	20,000iu*	IM	12 hours*	++	+	++	
Ceftiofur	2mg Adults 5mg Foals	IM IV*	12 hours*	+++	++	++	PROTECTED
Oxytetracycline	5mg	IV	12 hours*	++	++	+	NB also Ehrlichia, Rickettsia and Anaplasma
Doxycycline*	10mg	PO	12 hours*	++	++	+	
Trimethoprim / Sulphadiazine	30mg 30mg	IV PO	12 hours* 12 hours*	++	++	-	Ineffective in S equi equi. Oral bioavailability reduced in the presence of food
Gentamicin	8-10mg Adults 10-12mg Foals	IV	24 hours	+	+++	-	Dose in the neonate should be adjusted to reflect high total body water
Streptomycin	20mg	IM	24 hours	+	+	-	Resistance common
Cefazolin*	10mg	IM IV	12 hours 8 hours	++	+	++	Wide distribution, except into CNS
Rifampin*	5mg	PO	12 hours	+++	+	++	Always use in combination (not quinolones)
Azithromycin*	10mg	PO	24 hours	+++	+	+	FOALS ONLY
Enrofloxacin	7.5mg 5mg	PO IV	24 hours 24 hours	+	+++	-	PROTECTED
Metronidazole*	25mg 15mg	PO IV	12 hours 12 hours	-	-	+++	Not in food producing animals
Chloramphenicol	25-50mg	PO	12-24 hours	+++	+++	+++	Wide distribution, good penetration. Not in food producing animals.
Drug		Route	Frequency	-	-	-	

Key	
+++	Effective against most important pathogens, including staphylococci for Gram positive and pseudomonas for Gram negative bacteria
++	Effective against many important bacteria
+	Some effect, but many clinically significant bacteria may not be susceptible
-	Poor effectiveness
*	Indicates a drug, dose, route or dosing frequency that is not listed in the marketing authorisation for that product.

BEVA Protect me

Responsible Antimicrobial Use Policy

Protect ME

PRACTICE NAME HERE

BEVA

CONDITION	FIRST LINE	ALTERNATIVES	NOTES
UROGENITAL			
Cystitis	Trimethoprim / Sulphadiazine	Penicillin & Gentamicin	
Pyelonephritis	Trimethoprim / Sulphadiazine	Penicillin & Gentamicin	
Post Foaling Endometritis	Penicillin	Penicillin & Gentamicin	
Post Covering Endometritis	Penicillin (IU)	Penicillin & Gentamicin (IU)	
Mastitis	Trimethoprim / Sulphadiazine	Gentamicin	
OCULAR			
Conjunctivitis	Cloxacillin	Neosporin	
Mild Corneal Ulceration	Chloramphenicol	Gentamicin	
Severe Corneal Ulceration	Chloramphenicol	Ciprofloxacin & Gentamicin	
Melting Corneal Ulceration	Ciprofloxacin	Ciprofloxacin & Gentamicin	Consider keratomycosis
MISCELLANEOUS			
Endocarditis	Penicillin & Gentamicin	Trimethoprim & Sulphadiazine & Rifampin	
Neutropenia <2.5x10⁹/l Pyrexia Of Unknown Origin	Trimethoprim / Sulphadiazine	Penicillin & Gentamicin	Avoid antimicrobials where viral cause is suspected
Neutropenia <1x10⁹/l	Penicillin & Gentamicin	Penicillin & Gentamicin & Metronidazole	Avoid antimicrobials where viral cause is suspected
NEONATE < 3 WEEKS			
Neonatal Pneumonia	Penicillin & Gentamicin	Ceftiofur*	*PROTECTED but justified in neonate due to high mortality
Septic Arthritis	Penicillin & Gentamicin	Oxytetracycline	
Patent Urachus	Trimethoprim / Sulphadiazine	Doxycycline	
Umbilical Infection	Trimethoprim / Sulphadiazine	Doxycycline	
SEPSIS	Penicillin & Gentamicin	Ceftiofur*	Infection + 2 of: tachycardia, abnormal Temp, Resp, WBC
SEVERE SEPSIS	Penicillin & Gentamicin & Metronidazole	Ceftiofur*	Defined as sepsis with organ dysfunction, hypoperfusion, or hypotension
Normal Foal Post Foaling	None indicated	Trimethoprim / Sulphadiazine	Avoided except for metaphylaxis
Normal Foal With Unobserved Foaling	Trimethoprim / Sulphadiazine	Doxycycline	
Premature/Dysmature	Trimethoprim / Sulphadiazine	Doxycycline	
Meningitis	Trimethoprim / Sulphadiazine	Ceftiofur*	
SKIN / HOOF			
Cellulitis	Doxycycline	Penicillin & Gentamicin	
Subsolar Abscess	Not indicated	Doxycycline	Drainage alone usually curative
Subsolar Abscess With P3 involvement	Doxycycline	Penicillin & Gentamicin & Metronidazole	If recurrent, rule out keratoma
Pyoderma	Trimethoprim & Sulphadiazine	Doxycycline	

NB THIS POLICY DOES NOT APPLY TO ANIMALS DESTINED TO ENTER THE FOOD CHAIN

Responsible Antimicrobial Use Policy

Protect ME

PRACTICE NAME HERE

BEVA

CONDITION	FIRST LINE	ALTERNATIVES	NOTES
WOUNDS			
Contaminated Wounds With Synovial Sepsis	Penicillin & Gentamicin	Oxytetracycline & Metronidazole	
Contaminated Wound With Open Fracture	Penicillin & Gentamicin & Metronidazole	Chloramphenicol	
Contaminated Wounds (Non Complicated)	Not indicated	Trimethoprim / Sulphadiazine	
UPPER RESPIRATORY TRACT DISEASE			
Strangles Formed Abscess Prophylaxis Airway Obstruction	Not indicated Penicillin Penicillin	Penicillin Trimethoprim & Sulphadiazine Oxytetracycline	TMS is contraindicated since inactivated in the presence of pus. ACVIM consensus statement
Primary Sinusitis	Penicillin	Doxycycline	
Guttural Pouch Empyema/Chondroids	Penicillin	Doxycycline	S equi is most common implicated bacteria
Other URT Diseases	Trimethoprim & Sulphadiazine	Doxycycline	
LOWER RESPIRATORY TRACT DISEASE			
Primary Pneumonia	Penicillin & Gentamicin	Oxytetracycline & Metronidazole	Primary pneumonia is uncommon. Affected animals usually systemically ill
Secondary Pneumonia e.g. RAO/COPD	Doxycycline	Penicillin / Gentamicin	Secondary pneumonia more common than primary in UK
Rhodococcus Pneumonia	Rifampin & Azithromycin	Rifampin & Doxycycline	ACVIM consensus statement 2011
GASTROINTESTINAL			
Periodontal Disease	Trimethoprim & Sulphadiazine	Doxycycline	
Periapical Abscessation	Doxycycline	Penicillin & Gentamicin	
Acute Diarrhoea	Not indicated	Penicillin & Gentamicin	AM use is controversial
Bacterial Cholangiohepatitis	Trimethoprim & Sulphadiazine	Penicillin & Gentamicin	Biopsy sample should be submitted for culture
Peritonitis	Penicillin & Gentamicin (+/- Metronidazole)	Chloramphenicol	
PROPHYLAXIS	**PRE-OPERATIVE**	**POSTOPERATIVE**	**DURATION OF POST OPERATIVE TREATMENT**
Clean Surgery		Penicillin TID IV or BID IM	24 hours
Contaminated Surgery	Penicillin	Penicillin & Gentamicin	3 days
High Risk Surgery	Penicillin & Gentamicin	Penicillin & Gentamicin	5 - 10 days then reassess. Consider TMP-S if longer treatment required
Drug	Firstline	Alternatives	Notes
Drug	Firstline	Alternatives	Notes

SUBMIT (optional)

NB THIS POLICY DOES NOT APPLY TO ANIMALS DESTINED TO ENTER THE FOOD CHAIN

BTK Leitlinien

Antibiotic Stewardship
Angemessene Anwendung

TABLE 2: Factors contributing to appropriate antimicrobial use

Factors	Criteria for appropriateness
Indication	• A bacterial disease is present • Patient is unlikely to recover without antimicrobial therapy • Patient is likely to respond to antimicrobial therapy
Antimicrobial selection	• Empirical therapy is chosen with knowledge of likely bacterial pathogen and resistance patterns • Antimicrobials of low importance to human health are prioritised • Narrow spectrum antimicrobials are chosen in preference to broad-spectrum agents where possible • Diagnostic tests are utilised when appropriate and always when critically important antimicrobials are used
Dosing	• A dosing regimen is used that is likely to result in appropriate concentrations at the site of infection
Timing	• Antimicrobials are used at a time when they are most likely to treat or prevent disease (especially for surgical prophylaxis)
Route of administration	• Topical or local therapy is selected over systemic therapy when possible
Duration of therapy	• Duration is restricted to the shortest possible length of therapy while still effectively treating the disease
Modification of therapy	• Treatment is reviewed regularly and escalated or de-escalated based on results of culture and susceptibility testing (when performed) and clinical response • Empirical therapy should be given sufficient time to evaluate a response (48–72 h) before changing antimicrobials empirically

*Note that any deviation from the data in the marketing authorisation constitutes off-label use, which may carry legal responsibilities.

Hardefeldt et al., 2021

Antibiotic Stewardship
Angemessene Anwendung

1. Nur im Fall einer bakteriellen Infektion + unwahrscheinlich dass Pferd sich ohne Behandlung erholt

Nicht bei:

- Equines Asthma
- Virale Atemwegserkrankungen
- Unkomplizierte Verletzungen
- Unkomplizierte Druse
- Durchfall

Can the use of antimicrobials in adult equine patients with acute colitis be justified in the era of antimicrobial stewardship?

Inge Durie[1] | Gaby van Galen[2]

Surgical antimicrobial prophylaxis: Current standards of care

Louise L. Southwood

2. Gezielte Therapie

→ Kultur + Antibiogramm

- In 49.2% der Fälle nicht getan (De Briyne et al., 2013)
- Warum?
  - Dringender Start der Therapie – empirische Therapie
  - Finanzielle Beschränkungen
  - Probleme bei der Probenentnahme
  - Bedenken hinsichtlich der Relevanz von in vitro Tests und Dauer bis zum vorliegen der Ergebnisse

→ Penetration in Gewebe

TABLE 3: Antibiogram for empiric therapy of common equine pathogens

Bug	Drugs: Procaine benzylpenicillin	Ampicillin	Doxycycline	Oxytetracycline	Trimethoprim sulpha	Chloramphenicol	Gentamicin	Metronidazole	Ceftiofur	Clarithromycin or Azithromycin + rifampin*	Enrofloxacin	[redacted]
Beta-haemolytic streptococci	✓	+	±	±	±	+	IR		+		+	[redacted]
Staphylococcus aureus†	±		±	±	±	+	±				+	±
Enterococcus faecalis†	+	✓	±	±	IR	±	IR		IR		±	[redacted]
Enterococcus faecium†			±	±	IR	±	IR		IR		±	IR
Rhodococcus equi										✓		[redacted]
Escherichia coli†	IR	±	±	±	±	±	✓		+		+	+
Klebsiella spp. †	IR	IR	±	±	±		✓		±		±	[redacted]
Enterobacter spp. †	IR	IR	±	±	±	±	±		±		+	+
Pseudomonas aeruginosa†	IR	IR	IR	IR	IR	IR	✓		IR		±	[redacted]
Actinobacillus equuli	±	±	✓	✓	✓	±	✓		+		+	+
Pasteurella spp.	✓	+	+	+	±	±	✓		+		+	[redacted]
Salmonella spp. †		±	+	+	±		±					±
Lawsonia intracellularis			✓	✓								[redacted]
Bacteroides spp.	IR	IR	±	±		+	IR	+				IR
Clostridium spp.	✓	+	±	±			IR	+	±			[redacted]

✓, drug of choice; + good susceptibility; ± variable susceptibility; IR, intrinsically resistant.
Traffic light system is based off ASTAG rating system for importance of antimicrobials. From U. Melbourne and Equine Veterinarians Australia pocket guide for antimicrobial therapy (Asia Pacific Centre for Animal Health and National Centre for Antimicrobial Stewardship, 2017).
* Clarithromycin or Azithromycin + rifampin should not be used in adults
† Susceptibility is poorly predicable, culture and susceptibility testing are strongly recommended

(Hardefeldt et al., 2021)

2. Gezielte Therapie

→ Klinisch wichtige Antibiotika für bestimmte klinische Szenarien vorbehalten

- 8.5-11% der Pferdetierärzte setzen Reserveantibiotika als Erstlinienbehandlung ein!

Antimicrobial selection and dosing in the treatment of wounds in the United Kingdom

S. E. Ross, M. Duz, D. I. Rendle

Antibiotic Use in Horses: Analysis of 57 German Veterinary Practices (2018–2023)

Roswitha Merle [1,*], Leonie Feuer [2], Katharina Frenzer [1], Jan-Lukas Plenio [1], Astrid Bethe [3,4], Nunzio Sarnino [1], Antina Lübke-Becker [3] and Wolfgang Bäumer [2]

Antimicrobial prescribing practices by Swiss, German and Austrian equine practitioners

J. Schwechler med.vet., R. van den Hoven DVM, PhD, Dip. ECEIM, Dip ECVPT (ret), A. Schoster Dr.med.vet, PhD, DVSc, Dip. ACVIM, Dip. ECEIM

3. Dosierung

→ Richtige Dosierung

- Falsche Dosis
- Gewicht falsch eingeschätzt
- Intraoperative Antibiotikagabe nicht richtig getimed

→ Therapeutische Konzentration am Infektionsherd

- Zeitabhängige Antibiotika vs. konzentrationsabhängige Antibiotika
- Fohlen vs. Erwachsenes Pferd

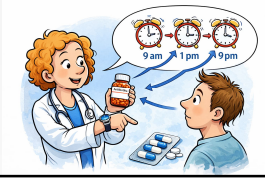
4. Timing

→ Chirurgische Prophylaxe

- effektive Konzentrationen an der Operationsstelle zum Zeitpunkt des ersten Schnittes! Nicht nach Vollendung der OP!
  - IV Antibiotika ca. 30-60 min. vorher
  - IM Antibiotika → Zeit bis zum Erreichen der maximalen Konzentration verwenden. Z.B. Procain Penicillin ca. 3.5h vor dem ersten Schnittes
- Wiederholte intraoperative Dosierung

  = 2x Eliminationshalbwertszeit + gemessen ab Zeitpunkt der präoperativen Dosis.

  → IV Antibiotika mit kurzer Halbwertweit. Z.B. Natriumbenzylpenicillin Wiederholungsdosis alle 80 min.



À propos chirurgische Prophylaxe

- Antibiotika ersetzen nicht aseptische und atraumatische Techniken → Halsted Principles
- Wundkategorien:
  - Saubere → keine Prophylaxe notwendig
  - Sauber kontaminiert und kontaminiert → perioperative Prophylaxe
  - Dreckig und infiziert → therapeutische, nicht prophylaktische Behandlung
- Wenige Studien in der Pferdechirurgie

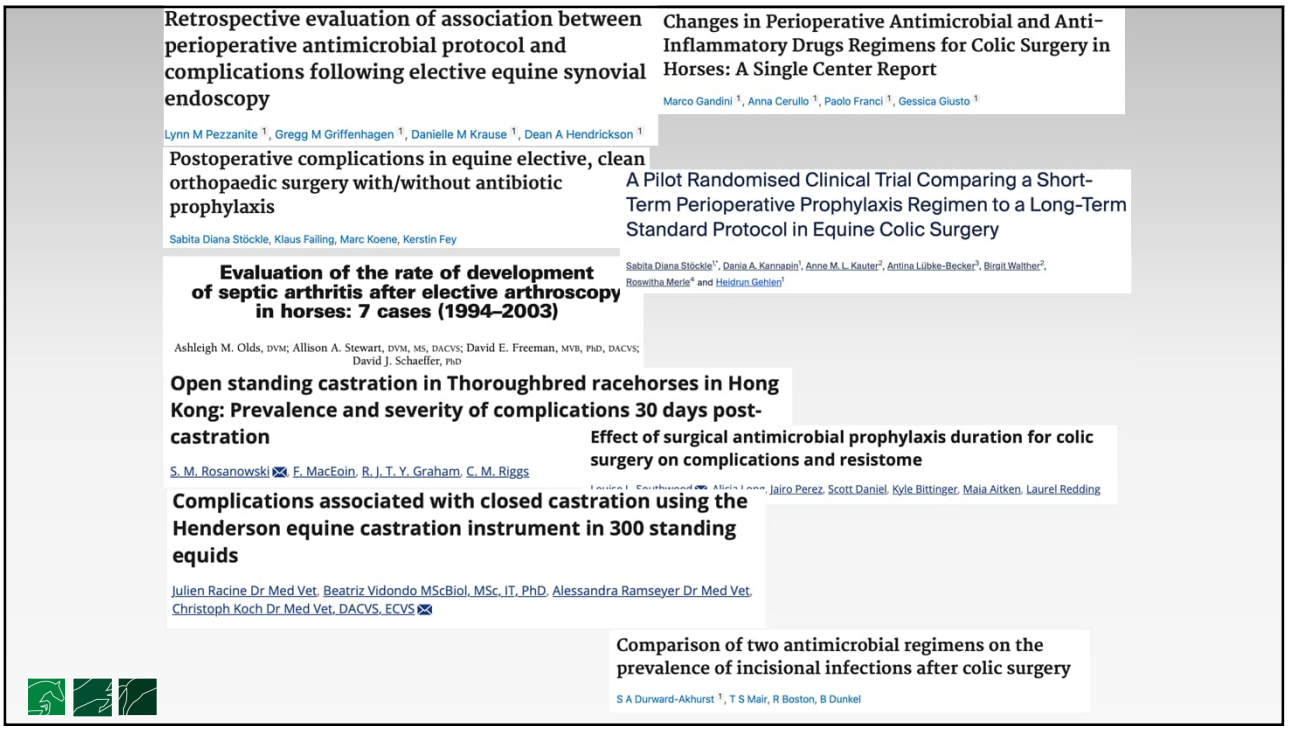
TABLE 2 Halsted principles (Verwilghen, 2019).

1	Apply strict asepsis during preparation and surgery
2	Assure good haemostasis to improve conditions for the procedure and limit infection
3	Avoid the formation of dead space
4	Minimise tissue through careful tissue handling
5	Maintain blood supply
6	Avoid undue tension on tissues
7	Carefully adapt corresponding tissue layers

TABLE 3 Classification of surgical wounds.

Category	Definition
Clean	Elective, primary closure, no drains, non-traumatic, no infection, no inflammation, aseptic technique maintained, e.g., arthroscopy
Clean-Contaminated	Gastrointestinal, respiratory, urogenital tracts entered under controlled conditions and with expected amount of contamination; or minor break in aseptic technique e.g. small intestinal resection and anastomosis, pelvic flexure enterotomy
Contaminated	Open, fresh traumatic wound; gross contamination from gastrointestinal tract; opening of urogenital or biliary tract with infected bile or urine; incisions in which non-infected purulent material is encountered or major break in aseptic technique
Dirty and Infected	Traumatic wound with retained devitalised tissue and foreign bodies, faecal contamination, or delayed treatment or from a dirty source; perforated viscus encountered; or acute bacterial inflammation with purulent exudate encountered, e.g., abdominal abscess, septic peritonitis secondary to a uterine tear

(Southwoood et al., 2023)



5. Verabreichungsweg

→ Fohlen Sepsis → IV

→ Topikale/Lokale Verabreichung

- ↑ Konzentration lokal (vor allem distale Gliedmaße/Gelenke)
- ↓ Einfluss auf GI Mikrobiom
- Konzentrationsabhängige Antibiotika am besten geeignet

  → postantibiotischer Effekt = proportional zur Spitzenkonzentration

  → Achtung! Lokale Entzündungsreaktionen möglich (Enrofloxacin)

6. Dauer der Therapie

→ Kürzeste effektive Dauer

- Der hohe Gebrauch/lange Dauer in der Chirurgie = wahrscheinlich unnötig
- Bakterielle Infektionen = Challenge
  - Informationen aus der Human- und Kleintiermedizin
  - Therapiebedarf regelmäßig überprüfen

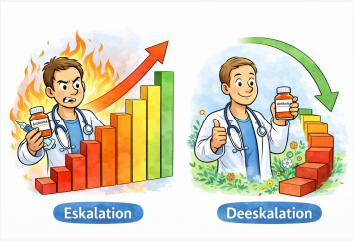
7. Eskalation und Deeskalation

→ Deeskalation

- Schmaleres Spektrum
- Antibiotikum mit geringer Bedeutung für Humanmedizin

→ Eskalation

- Empirische Behandlung = unzureichend lt. Antibiogramm + keine klinische Reaktion
  - Klinische Reaktion = sehr wichtig – In vitro Tests möglicherweise keine genaue Darstellung Gewebepenetration
  - Neue Proben nehmen vor empirische Antibiotikaumstellung bei Therapieversagen



Dokumentationspflicht 2026

2. Antibiotikameldungen ab 2026 für die Tierarten Pferde (inkl. Nicht-Schlachttiere), Gänse, Enten, Schafe, Ziegen, zur Lebensmittelgewinnung dienende Kaninchen und Fische der Arten Atlantischer Lachs, Regenbogenforelle, Goldbrasse, Wolfsbarsch und Karpfen

Bereits **seit 2023** müssen für alle Rinder, Schweine, Hühner und Puten (**1. Stufe**) die Daten zu den Antibiotikaverbrauchsmengen erhoben werden (§ 56 TAMG). Die Datenerhebung für die in der **Überschrift genannten Tierarten** (2. Stufe) muss zum **01. Januar 2026** beginnen.

Die **Regelungen zur Erfassung von antibiotisch wirksamen Arzneimitteln** sind in **§ 61a des GE** festgelegt. Damit wird die in Art. 57 der Verordnung (EU) 2019/6 festgelegte Verpflichtung zur Antibiotikadatenerfassung umgesetzt. Demnach muss jeder Mitgliedstaat der EU die Antibiotikaverbrauchsmengen an die Europäische Arzneimittel-Agentur (EMA) mitteilen. In Bezug auf die meldepflichtigen Angaben wurden die bereits für die 1. Stufe geltenden Regelungen weitestgehend übernommen. So erfolgt die **Auswahl der meldepflichtigen Arzneimittel analog zum § 56 Absatz 1 Satz 1 TAMG** (Nr. 3 und 4 Absatz 1 bis 5 und Absatz 10 des Anhangs der Delegierten Verordnung (EU) 2021/578).

Folgende **Angaben müssen laut § 61a Absatz 2 GE gemeldet** werden:

Folgende **Angaben müssen laut § 61a Absatz 2 GE gemeldet** werden:

- **UPD-Package Identifier** (UPD-PI) - (Nr. 4, Anhang II, VO (EU) 2022/209): Alternativ kann die Packungs-ID übermittelt werden (nachträgliche Konvertierung zum UPD-PI)
- **Zulassungsnummer** - (Nr. 5, Anhang II, VO (EU) 2022/209): Bezugsnummer der nationalen Arzneimitteldatenbank
- **Arzneimittelbezeichnung** - (Nr. 6, Anhang II, VO (EU) 2022/209): Name des Arzneimittels
- **Packungsgröße** - (Nr. 9, Anhang II, VO (EU) 2022/209): größtenteils automatisiert, kann aus der Packungsidentifikation (Packungs-ID o. UPD-PI) abgeleitet werden
- **Name der Tierärztin** oder des **Tierarztes** bzw. der **Tierarztpraxis**: Entsprechend der Stammdaten zur Betriebsnummer, die zur Anmeldung in HI-Tier erforderlich ist
- Insgesamt angewendete, abgegebene oder verschriebene (zur Einlösung i. d. Apotheke) **Menge des Arzneimittels**: Eintrag erfolgt mit Auswahl der dazugehörigen Einheit
- **Tierart** des oder der behandelten Tiere.

Die **Meldung muss** gemäß § 61a Absatz 3 **elektronisch** erfolgen. Als Meldeportal fungiert die **Tierarzneimitteldatenbank (TAM-DB) der HI-Tier**, wie es auch für die 1. Stufe der Fall ist. Die Daten können entweder direkt aus der Praxissoftware übermittelt werden (fragen Sie bei Ihrem Anbieter nach dem Umsetzungsstand) oder online in die Erfassungsmaske von HI-Tier eingetragen werden.

Nach § 95 Nr. 1 des GE muss die **erste Meldung** der Daten aus dem Jahr 2026 **bis zum 14. Januar 2027** erfolgen. Dabei muss eine Zuordnung zum jeweiligen Kalenderhalbjahr gewährleistet sein (§ 61a Abs. 2 Satz 3). **Ab dem Jahr 2027** sollen nach Art. 2 des GE die **Mitteilungspflichten von halbjährlich auf jährlich geändert** werden, so dass dann lediglich eine **Zuordnung zum Kalenderjahr** erforderlich sein würde. Eine Änderung ab 2026 ist aus technischen Gründen der TAM-Datenbank nicht möglich.

Folgende Angaben können **optional** gemeldet werden:

- **Anzahl der Behandlungstage**
- **Anzahl der behandelten Tiere**
- **Datum** der ersten Anwendung, der Abgabe oder Verschreibung (zur Einlösung i. d. Apotheke).

Diese **Daten** werden **in der Regel** (u. a. aufgrund anderer Vorschriften) **bereits** bei der Eintragung der Behandlung **erhoben**. **Für die Auswertung** der Daten liefern diese Informationen einen **entscheidenden Mehrwert**, da mit den zusätzlichen Parametern versehentlich falsch eingetragene Werte (z. B. „kg“ statt „g“ bei Auswahl der Einheit) erkannt und aus dem Datensatz entfernt werden können. Somit kann die **Übermittlung von falsch hohen Mengen des Antibiotikaverbrauchs** an die EMA **verhindert werden**. Auch für eine nachträgliche Korrektur und zur Zuordnung der Daten seitens der Meldenden sind diese Daten, insbesondere das Datum, wichtig. Sollten die **Datensätze aggregiert** werden, muss im Datums-Feld ein **Datum eingetragen** werden, das den **letzten Tag der Aggregationsperiode** definiert, auf die sich die Meldung bezieht (z. B. Samstag/Sonntag, wenn pro Woche aggregiert wird). Nur so kann sichergestellt werden, dass die **erforderliche Zuordnung zum jeweiligen Halbjahr bzw. Jahr** möglich ist.

Wo finden Sie Unterstützung?

Weitere Informationen finden Sie auf unserer Webseite: www.bvl.bund.de/verbrauchsmengenerfassung.

Ein ausführliches FAQ Dokument können Sie hier herunterladen: ⭳ https://www.bvl.bund.de/SharedDocs/Downloads/05_Tierarzneimittel/FAQ_Antibiotikameldungen.html

Zudem informieren wir Sie regelmäßig über Neuigkeiten und stellen hilfreiche Artikel auf der Newstickerseite für Sie bereit: https://www.bvl.bund.de/DE/Arbeitsbereiche/05_Tierarzneimittel/01_Aufgaben/05_AufgAntibiotikaResistenz/07_Newsticker/tam_newsticker_node.html

Allgemeine Informationen zur TAM DB und zu den Änderungen werden unter https://www.hi-tier.de/info-TA.html veröffentlicht.

Wenn Sie Fragen und/oder Rückmeldungen haben, senden Sie gern eine E-Mail an: verbrauchsmengenerfassung@bvl.bund.de

Sulfonamide

- Potenzierte Sulfonamide: Trimethoprim-Sulfadiazin, Trimethoprim-Sulfamethoxazol, Pyrimethamin-Sulfadiazin
- Bakterizid – zeitabhängig
- Orale Verfügbarkeit = gut → Einfluss durch Fütterung (nüchtern)
- Gute Distribution: Synovia, Peritonealflüssigkeit, Liquor und Harn
- Elimination über Harn, Faeces, Galle, Milch, Schweiß und Tränen

- Wirkung ↓ nekrotischen Gewebe, Eiter
- Breites Spektrum: Gramm + und Gramm -

☺ *Streptococcus* spp., *Proteus* spp., *E. coli*, *Pasteurella* spp., *Haemophilus*, *Salmonella* spp., *Staphylococcus* spp., *Corynebacterium*, Pasteurella spp., Klebsiella spp. und Enterobacter spp. (sensibel aber schnell Resistenzen)

☹ *Pseudomonas* spp., *Bacteroides* spp., *Enterococcus* spp.
Viele Resistenzen!!

Drug	Dose per kg	Route	Dosing Interval	Spectrum +ve	Spectrum -ve	Spectrum An02	Notes
Sodium Penicillin	20,000iu*	IV	6-8 hours*	++	+	++	Wide distribution, poor penetration into CNS, abscess, sites or necrosis
Procaine Penicillin	20,000iu*	IM	12 hours*	++	+	++	
Ceftiofur	2mg Adults 5mg Foals	IM IV*	12 hours*	+++	++	++	PROTECTED
Oxytetracycline	5mg	IV	12 hours*	++	++	+	NB also Ehrlichia, Rickettsia and Anaplasma
Doxycycline*	10mg	PO	12 hours*	++	++	+	
Trimethoprim / Sulphadiazine	30mg	IV	12 hours*	++	++	-	Ineffective in S equi equi. Oral bioavailability reduced in the presence of food

(BEVA Protect me)

Dosierung:
o 15-30 mg/kg PO/IV q12h

- Durchfall → Dysbiose
- IV Injektion + gleichzeitige Gabe Detomidine: Arrhythmie, Hypotension, Tot
- Irritation bei intramuskulärer/intrauterinen Gabe
- Penicillin = Antagonist
- Thrombophlebitis/Anaphylaxie bei schneller IV Verabreichung
- Anämie, Thrombozytopenie und Leukopenie - Langzeitgabe

Aminoglykoside

- Gentamicin, Amikacin, Tobramycin, Kanamycin, Streptomycin, Neomycin
- Bakterizid – konzentrationsabhängig
- Gute Distribution: Synovia, Peri Lymphe, Pleura-, Peritoneal- und Perikardialflüssigkeit
- Schlechte Distribution: Galle, Liquor, Atemwege, Augenflüssigkeiten
- Wirkung ↓ Eiter
- Gut geeignet für lokale Anwendungen: intraartikulär, IVRP, Beads oder Kollagenchwämme
- Elimination über Harn

- Gramm negatives Spektrum, aerobe Bakterien
  - ☺ *Pseudomonas* aeroginosa, *E. coli*, *Klebsiella pneumoniae*, *Actinobacillus equuli*, *Pasteurella* spp.
  - ☹ *Enterococcus* spp., beta-hämolytische Streptococcen, Anaerobe (*Bacteroides* spp. und *Clostridium* spp.) und intrazelluläre Bakterien (*Salmonella* spp. und *Brucella* spp.)
  - ± *Staphylococcus* spp., *Enterobacter* spp., Mycobakterien, Spirocheten und Mycoplasmen

Dosierung

- Gentamicin
  - Adulte: 6.6 mg/kg – 10 mg/kg IV q24h
  - Neonaten: 12 mg/kg IV q36h
- Amikacin
  - Adulte:10 mg/kg IV q24h
  - Neonaten: 25 mg/kg IV q24h

- Nephrotoxizität → proximale Tubulus Zellen
  - Risikofaktoren: Lange Therapie (7-10 Tage), Azidose, Elektrolytstörungen (Hypokaliämie und Hyponatriämie), Hypovolämie, zeitgleiche Therapie mit anderen nephrotoxischen Medikamenten
  - Risiko ↓
    - Kalzium Supplementation
    - Antioxidantien: Vit E, Silymarin
    - Diät: hoch in Kalzium und Proteine
  - Monitoring: Drug Monitoring, GGT:CREA Ratio, Proteinurie, Azotämie
- Ototoxizität:
  - Gentamicin: Cochlea → Vestibulares Syndrom
  - Amikacin: Gehör
- Neuromuskuläre Blockade (selten), Kombination mit Anästhetika

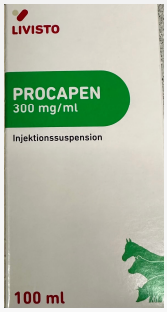
Beta-Laktam Antibiotika

- Benzylpenicilline, Aminopenicilline, Cephalosporine, Carbapeneme, antipseudomonale Penicilline
- Bakterizid + zeitabhängig

Benzylpenicillin

☺ Meisten Gramm + Bakterien und Anaerobe: beta-hämolytische Streptococcen, beta-laktamase negative Staphylococcen, *Actinomyces* spp., *Corynebacterium* spp., *Bacillus anthracis*

☹ Meisten Gramm - Bakterien, intrazelluläre Bakterien, beta-laktamase produzierende Bakterien (viele Staphylococcen, z.B. *Staphylococcus aureus* und *Bacteroides* spp.)



Verschiedene Formulierungen

- Intramuskulär: Procain Penicillin
- Intravenös: Natrium- oder Kalium Penicillin

- Typ II Hypersensitivitätsreaktion → immunvermittelte hämolytische Anämie
- Typ I Hypersensitivitätsreaktion → Anaphylaxie
- Zentralnervöse Reaktion bei Procain Injektion IV
  - Gekühlt aufbewahren
  - Aspiration bei IM Injektion
- Elektrolytstörung bei den IV Formulierungen
- Arrhythmie bei schneller Injektion von Kalium Penicillin

Dosierung

- 22000-44000 IU/kg IM q 12-24h
- 22000-44000 IU/kg IV q6h

Aminopenicilline

- Ampicillin, Amoxicillin
- Gramm – Spektrum besser als Benzylpenicillin – Amoxi > Ampi

  ☺ gramm + Bakterien, Anaeroben, *E. coli*, *Salmonella* spp., *pasteurella* spp.

  ☹ *Klebsiella* spp., *Proteus* spp., *Pseudomonas* spp, *S. aureus*, *Bacteroides* spp.

- Kombination mit Clavulansäure/Amoxicillin = beta-laktamase Inhibitor

- Selben wie Benzylpenicillin

Dosierung:

- Ampicillin: 20 mg/kg IM/IV q6-8h
- Amoxicillin: 30 mg/kg PO q8h ; 20-40 mg/kg IV q 6-12h

Cephalosporine

- Breitspektrum beta-laktam Antibiotika
- Eingeteilt in Generationen mit steigernder antibakterieller Wirkung und beta-laktamase-stabilen Eigenschaften
- IM und SC → schnelle Absorption
- Elimination über Harn
- Blut-Hirn-Schranke: Cefotaxime und Ceftriaxone
- Fohlen → viele Keime assoziiert mit Sepsis = resistent gegen Ceftiofur
- Kann als Dauerinfusion eingesetzt werden

TABLE **2.7** **Pharmacokinetics of Cephalosporins in Horses**

Classification of Cephalosporins

	Characteristics	Examples
First generation	Effective against almost all gram-positive bacteria, including β-lactamase–positive staphylococci; enterococci are resistant; effective against some gram-negative bacteria,[a] although sensitive to enterobacterial β-lactamase	Cephacetrile, cephaloridine, cephalothin, cephapirin, cefazolin,[a] cefadroxil, cephadrine, cephalexin
Second generation	Greater activity against gram-negative bacteria due to increased resistance to β-lactamases[b]; similar gram-positive spectrum to first-generation drugs	Cefaclor, cefotetan,[b] cefoxitin,[b] cefuroxime, cefuroxime axetil, cefamandole, cefmetazole, cefonocid, cefprozil
Third generation	Greater activity against gram-negative organisms; some drugs active against *Pseudomonas aeruginosa*[c]; resistant to many β-lactamases; less active against gram-positive cocci, with a few exceptions[d]	Cefoperazone,[c] cefsulodin, ceftazidime,[c] cefotaxime,[d] ceftizoxime proxetil, ceftriaxone, ceftiofur,[d] cevofecin, cefdinir, latamoxef (moxalaxtam), cefetamet, cefixime, cefpodoxime, cefovicin
Fourth generation	Broad spectrum of activity against gram-positive and gram-negative bacteria; resistant to staphylococcal, enterobacterial, and pseudomonal β-lactamases	Cefepime, cefquinome, cefpirome

Relative Activity of Cephalosporins against Common Bacteria[e]

Drug	Generation	*S. aureus*[f]	*E. coli, Klebsiella, Proteus*	*Enterobacter*	*Pseudomonas aeruginosa*	*Bacteroides*	Other Anaerobes
Cephalothin	1	+++	++	–	–	–	+
Cefuroxime	2	++	+++	–	–	–	+
Cefoxitin	2	+	+++	+	–	++	++
Cefotaxime	3	++	+++	+	–	+	++
Ceftriaxone	3	+	+++	+	–	–	+
Ceftazidime	3	+	+++	++	+++	–	–
Ceftiofur	3	++	++	+	–	–	+
Cefepime	4	++	+++	+++	+++	–	+

(Reed and Bayly, 2018)

☺ beta-haemolytische Streptococcen, beta-laktamase produzierende Staphylococcen, *E. coli*, *Salmonella* spp., *Proteus* spp., *Klebsiella* spp., *Pasteurella* spp., *Enterobacteriaceae* (3.+4. G), *Corynebacterium* spp., meisten Anaeroben

☹ *Enterococcus* spp., MRSA, Mycobakterien, *Pseudomonas aeroginosa* (außer manche 3.+4. G)

Dosierung

- Adulte: 2.2 mg/kg IV/IM q12-24h
- Neonaten: 5-10 mg/kg SC/IM/IV q6-12h

TABLE 1 Summary of cephalosporin generations and general antimicrobial activities.[25,52,53]

	First generation	Second generation	Third generation	Fourth generation
Exhibits activity against	• *Staphylococcus aureus* • *Staphylococcus pseudointermedius* • Some fastidious or beta-lactamase producing Gram-negative Enterobacteriaceae	• increasing efficacy against some Gram-negative bacteria (e.g. *Enterobacter* and *Serratia* spp.)	• Streptococci • Most Enterobacteriaceae	• Enterobacteriaceae • Moderate activity against *P. aeruginosa* • Enhanced activity against Staphylococci • Resistance to many beta-lactamases
No activity against[a]	• *Enterobacter* spp. • *Pseudomonas aeruginosa*	• *P. aeruginosa* • Enterococci • Some Enterobacteriaceae	• Variable activity against Staphylococci	
Formulations available	• Oral (not commonly used in horses) • Parenteral	• Oral (not commonly used in horses) • Parenteral	Parenteral	Parenteral

[a]Most cephalosporins in all generations are ineffective against methicillin-resistant *Staphylococcus psuedointermedius* or *Staphylococcus aureus*.[30]

Ryan et al., 2022

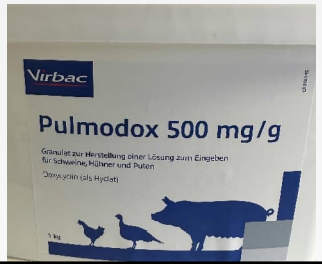
- Durchfall
- Allergische Reaktionen (selten)
- Nephrotoxizität bei hoher Dosierung
- IM Injektion → lokale Reaktionen
- Anämie, Thrombozytopenie → hohe Dosierung Ceftiofur und Cefotaxime

Tetrazykline

- Oxytetracyclin, Doxycyclin, Minocyclin
- Bakteriostatisch – zeitabhängig
- Gute Distribution in lokale Infektionsherde → Arthritis, Physitis, Omphalophlebitis, Pneumonie
- Andere Eigenschaften: antikollagenolytische und entzündungshemmende Aktivität und Förderung Hornhautreparatur

- Breites Spektrum
  - ☺ Gramm + und Gramm – Keime
    Intrazelluläre Bakterien: *Lawsonia intracellularis*, *Rhodococcus equi* (*hoagii*), *Anaplasma phagocytophilum*, *Chlamydia* spp., *Mycoplasma* spp., *Rickettsia* spp. und manche Protozoa
    Anaeroben
  - ☹ *Bacteroides* spp., *Clostridium* spp., *Staphyloccous* spp. (limitiert), *Enterococcus* spp., *Pseudomonas* spp., *Klebsiella* spp., *Proteus* spp.
- Dosierung
  - Oxytetracyclin: 5-10 mg/kg IV q12h → Langsam!!
  - Doxycyclin: 10 mg/kg PO q 12h
  - Minocyclin: 4 mg/kg PO q12h ; 2.2 mg/kg IV q12h

- Durchfall
- Nephrotoxizität – Oxytetracyclin
- Schnelle Verabreichung OTC → Hypotension und Kollaps
- Lokale Reaktionen bei IM Injektion → OTC
- Tachykardie, Arrhythmie, Hypertension und Kollaps → Doxycyclin IV
- Muskellähmung bei neuromuskulären Erkrankungen (Botulismus)



Fluorochinolone

- Enrofloxacin, Marbofloxacin, Ciprofloxacin,...
- Bakterizid – konzentrationsabhängig
- IM Injektion Bioverfügbarkeit fast 100%
- Hohe Gewebekonzentrationen → ZNS
- Gute Distribution in lokale Infektionsherde
- Bei Fohlen mit Makrolide resistenten Rhodococcen

- Breites Spektrum
  - ☺ Gramm – Bakterien: *E. coli*, *Pasteurella* spp., *Actinobacillus equi*, *Enterobacter* spp.
    Einige gramm + Bakterien: *Staphylococcus* spp., beta-hämolyische Streptococcen
    Intrazelluläre Bakterien: *Mycoplasma* spp., *Chlamydia* spp. *Rickettsia* spp., *Brucella* spp. und *Mycobacterium*
  - ☹ Anaeroben, *Enterococcus* spp., *Pseudomonas* spp (schnell Resistenzen)

Dosierung
- Enrofloxacin: 7.5 mg/kg PO q24h ; 5.5 mg/kg IV q24h
- Marbofloxacin 2 mg/kg IV q24h ; 3.5-4 mg/kg PO q24h

- Gastrointestinale Irritation – Durchfall
- Knorpelschäden → Fohlen < 12 Monate – Marbo < Enro
- ZNS Symptome bei schneller IV Gabe → Krampfanfälle
- Wechselwirkungen mit Ca2+/Mg2+ → ↓ orale Bioverfügbarkeit

Metronidazol

- Bakterizid – konzentrationsabhängig
- Hohe Gewebskonzentrationen → Knochen, Abszesse und ZNS

☺ Anaeroben: *Bacteroides fragilis*, *Fusobacterium* spp. und *Clostridium* spp.
Protozoa: *Giardia* und *Trichomonas* spp.

Dosierung:

- 25 mg/kg PO q12h ; 15-20 mg/kg PO q8h ; 25-60 mg/kg Per Rektum q8-12h
- Fohlen: 10 mg/kg q12h

- Durchfall
- Anorexie und Speicheln
- Periphere Neuropathie und Hepatopathie bei Langzeittherapie mit hohe Dosierungen
- ZNS Erregung bei Fohlen, vor allem bei IV Anwendung → langsame Verabreichung

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