Antimicrobial susceptibility patterns of blood culture isolates from foals in Switzerland

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Abstract

We report blood culture results of 43 foals admitted to an equine hospital for medical or surgical disorders and determine minimal inhibitory concentrations (MIC) of different antibiotics. Eleven foals had a positive blood culture result despite prior administration of antibiotics in 10 of these animals. MIC values above EUCAST and/or CLSI breakpoints were identified in coagulase-negative staphylococci, methicillin-resistant *Staphylococcus aureus* (MRSA) and *Enterococcus faecium*. Gram-negative isolates were less frequently identified and did not appear to exhibit increased MIC values. This study shows that bloodstream infections in foals in Switzerland are caused by diverse bacteria including Gram-positive bacteria which exhibit resistance to several classes of antibiotics.

Keywords: Antibiotics, Bacteremia, Horse, Minimal inhibitory concentration, Sepsis

Resistenzprofile bakterieller Pathogene in Blutkulturen von Fohlen in der Schweiz

Im Rahmen dieser Studie präsentieren wir Resultate von Blutkulturen von 43 Fohlen, die aufgrund einer internistischen oder chirurgischen Erkrankung in der Pferdeklinik vorgestellt wurden. Elf dieser Fohlen zeigten ein bakterielles Wachstum in der Blutkultur obwohl 10 von ihnen bereits vom Privattierarzt mit Antibiotika vorbehandelt wurden. Koagulase-negative Staphylokokken, Methicillin-resistente *Staphylococcus aureus* und *Enterococcus faecium* zeigten minimale Hemmstoffkonzentrationen oberhalb der EUCAST und/oder CLSI Referenzen. Gram-negative Bakterien wurden seltener identifiziert und zeigten keinen Anstieg minimaler Hemmstoffkonzentrationen. Diese Studie zeigt, dass septische Infektionen bei Fohlen in der Schweiz durch ein breites Spektrum an Bakterien verursacht werden können. Unter Anderem kommt in dieser Studie Gram-positiven Bakterien eine besondere Bedeutung zu, aufgrund der erhöhten Resistenzen gegen diverse Antibiotika.

Schlüsselwörter: Antibiotika, Bakteriämie, Pferd, Minimale Hemmstoffkonzentration, Sepsis

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Selection of appropriate antimicrobials for treatment of bacterial infections is a challenging procedure in veterinary medicine due to the number of specifications that need to be considered. Drug dosages are defined on the basis of pharmacokinetic and -dynamic studies which need to be performed specifically in every species, weight and age group. Bacterial diversity and susceptibility patterns may change over time[13,14] which impedes re-evaluation of drug dosage for target organisms on a regular basis. Furthermore, defined resistance breakpoints are sparse for veterinary pathogens and are often extrapolated from those set in human medicine[16], potentially making interpretation of susceptibility tests difficult. It is therefore imperative to have guidelines for antibiotic susceptibility tests available for veterinary medicine to permit targeted therapy and to perform studies of bacterial prevalence and evaluate and report minimal inhibitory concentrations on a regular basis[13]. This is especially important in populations such as foals where bacterial infections and sepsis often have detrimental consequences[3]. The objective of this study was to determine which bacterial species are present in blood cultures from foals in Switzerland and to assess their minimal inhibitory concentrations to relevant antibiotics.

A total of 43 foals admitted to the equine hospital between 2014 and 2016 were included in the study on the basis that they had an intravenous catheter inserted for the treatment of a medical or surgical disorder. Ten milliliters of blood were collected aseptically into a 10-ml Isolator™ tube (Isolator™ 10 Tube Blood Culture System, Thermo Fisher Scientific, Pratteln, Switzerland) and processed according to the manufacturer's protocol to provide bacteria for further isolation, identification, and susceptibility testing. After centrifugation, 100 µl of the lysed blood concentrate was plated on trypticase soy agar plate containing 5% defibrinated sheep blood

Table 1: Antimicrobials used in foals enrolled in this study prior to admission to the equine hospital and bacterial species isolated from blood cultures

Animals (n=43)	Antimicrobials used prior cultures	Bacterial species in cultures
Foals with a positive blood culture (n=11)		
Foal 1	cefquinome	*Staphylococcus aureus, Acinetobacter lwoffi*
Foal 5	cefquinome	*Staphylococcus hominis*
Foal 7	cefquinome	*Actinobacillus equuli*
Foal 11	cefquinome, penicillin, amikacin	*Staphylococcus vitulinus*
Foal 12	penicillin, amikacin	*Staphylococcus aureus (MRSA)*
Foal 14	cefquinome, doxycycline	*Staphylococcus equorum*
Foal 25	cefquinome	*Actinobacillus equuli*
Foal 35	penicillin, gentamicin	*Staphylococcus devriesei, Streptococcus uberis*
Foal 37	cefquinome	*Enterococcus faecium, Macrococcus carouselicus*
Foal 41	penicillin, amikacin, cefquinome	*Streptococcus sp.* (alpha-haemolytic), *Staphylococcus xylosus, Escherichia coli*
Foal 43	none	*Staphylococcus vitulinus*
Foals with a negative blood culture (n=32)	none	none

Table 2: Minimal inhibitory concentration (MIC) values of Gram-positive bacterial isolates cultured from foals in Switzerland

	Animals	MIC of antibiotics and resistance breakpoints (mg/L)								
		PEN	**GEN**	**STR**	**TET**	**TMP**	**ERY**	**RIF**	**CHL**	**SMX**
Coagulase-positive staphylococci		*> 0.125*	*> 1*	*NA*	*> 2*	*> 4*	*> 2*	*> 0.5*	*> 8*	*NA*
S. aureus	Foal 1	≤ 0.12	≤ 1	8	≤ 0.5	≤ 2	0.5	≤ 0.016	8	
S. aureus	Foal 12	**> 2**	**> 16**	8	**> 16**	**> 32**	0.5	≤ 0.016	8	≤ 64
		PEN	**GEN**	**STR**	**TET**	**TMP**	**ERY**	**RIF**	**CHL**	**SMX**
Coagulase-negative staphylococci		*≥ 0.25*	*> 1*	*NA*	*> 2*	*> 4*	*> 2*	*> 5*	*> 8*	*NA*
S. hominis	Foal 5	**0.25**	≤ 1	≤ 4	≤ 0.5	≤ 2	**> 8**	≤ 0.016	≤ 4	**> 512**
S. vitulinus	Foal 11	≤ 0.12	≤ 1	≤ 4	≤ 0.5	**8**	≤ 0.25	≤ 0.016	≤ 4	≤ 64
S. vitulinus	Foal 43	≤ 0.12	≤ 1	≤ 4	≤ 0.5	**8**	≤ 0.25	≤ 0.016	8	≤ 64
S. equorum	Foal 14	≤ 0.12	≤ 1	≤ 4	≤ 0.5	≤ 2	**8**	≤ 0.016	8	≤ 64
S. devriesei	Foal 35	**0.25**	≤ 1	≤ 4	≤ 0.5	≤ 2	≤ 0.25	≤ 0.016	≤ 4	≤ 64
S. xylosus	Foal 41	≤ 0.12	≤ 1	≤ 4	≤ 0.5	**8**	0.5	≤ 0.016	8	≤ 64
		PEN	**GEN**	**STR**	**TET**	**TMP**	**ERY**	**RIF**	**CHL**	**SMX**
Streptococci		*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
S. uberis	Foal 35	≤ 0.12	8	> 32	≤ 0.5	≤ 2	≤ 0.25	0.06	≤ 4	> 512
Streptococcus sp. (alpha-haemolytic)	Foal 41	≤ 0.12	4	16	1	≤ 2	≤ 0.25	0.03	≤ 4	> 512
		AMP	**GEN**	**STR**	**TET**	**TMP**	**ERY**	**RIF**	**CHL**	**SMX**
Enterococcus		*≥ 16*	*> 128*	*>512*	*≥ 16*	*> 1*	*≥ 8*	*≥ 4*	*≥ 32*	*NA*
E. faecium	Foal 37	**> 64**	**1024**		**128**	**> 32**	> 128[a)]	0.5	≤ 4	> 512[a)]
		PEN	**GEN**	**STR**	**TET**	**TMP**	**ERY**	**RIF**	**CHL**	**SMX**
Macrococcus		*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
M. carouselicus	Foal 37	≤ 0.12	≤ 1	≤ 4	≤ 0.5	≤ 2	≤ 0.25	≤ 0.016	≤ 4	≤ 64

(TSA-SB) (BD™ Trypticase™ Soy Agar II with 5% Sheep Blood, Becton Dickinson, Allschwil, Switzerland) for the cultivation of aerobic and capnophilic bacteria, selective BROLAC agar (Thermo Fisher Scientific, Pratteln, Switzerland) for Enterobacteriaceae, Brucella Blood Agar with Hemin and Vitamin K1 for anaerobic bacteria (Becton Dickinson, Allschwil, Switzerland) and in thioglycolate medium for enrichment (Becton Dickinson, Allschwil, Switzerland). All the media were incubated at 37 °C for 48h under appropriate atmospheres. The resulting cultures were subcultivated on TSA-SB and isolates were identified by Matrix-Assisted-Laser-Desorption/Ionization-Time-Of-Flight-Mass-Spectrometry (MALDI-TOF MS) (Microflex LT, Bruker Daltonics GmbH, Bremen). Antimicrobial susceptibility to antibiotics representing major drug classes was determined by microbroth dilution in Müller-Hinton broth using different sensititre plates (Sensititre™ Complete Automated System, Thermo Fisher Scientific, CH- Reinach) and according to the EUCAST guidelines. (www.eucast.org). Minimal inhibitory concentrations (MIC) of antibiotics were tentatively interpreted using CLSI[2] and EUCAST[6] criteria set for human bacteria as no criteria exist for bacteria isolated from blood cultures of horses in the CLSI guidelines for bacteria from animals[1] (Table 2 and Table 3). The use of these criteria is only indicative of the presence of a possible resistance mechanism in the bacteria under test and may not be appropriate for clinical use. Characterization of methicillin-resistant *Staphylococcus aureus* (MRSA) was performed as previously described[12]. In addition to blood culture results, the following information was recorded: age, sex, breed, diagnosis, and antibiotic treatment prior to presentation.

Forty-three foals of various breeds were included in the three-year study period. Foals were aged between 1 and 146 days (9.4 ± 23.8 [mean ± SD]) and there were 20 fillies and 23 colts. Reasons for hospitalization included failure of transfer of passive immunity, sepsis, herniation, colic, meconium impaction, perinatal asphyxia syndrome, pneumonia, choke, lameness, injury, renal disease, neonatal isoerythrolysis and prematurity. Hospitalization time ranged from 1 to 30 days. Thirty foals survived and were discharged. Five died and eight were euthanized. Eleven foals had a positive blood culture. Ten of them received an antibiotic treatment prior to presentation, including cefquinome, penicillin, gentamicin, amikacin or doxycycline (Table 1). None of the 32 foals with a sterile blood culture were pre-treated with antimicrobials (Table 1). Out of the 11 foals with positive blood culture, one microorganism was cultured in

CIP	CLI	FUS	KAN	TIA	VAN	LZD	MUP	FOX	OXA
> 1	*> 0.5*	*> 1*	*NA*	*NA*	*> 2*	*> 4*	*NA*	*> 4*	*> 2*
0.5	0.25	≤ 0.5	≤ 4	1	≤ 1	2	≤ 0.5	4	≤ 0.25
0.5	≤ 0.12	≤ 0.5	**> 64**	≤ 0.5	≤ 1	2	≤ 0.5	**> 8**	**> 8**

CIP	CLI	FUS	KAN	TIA	VAN	LZD	MUP	FOX	OXA
> 1	*> 0.5*	*> 1*	*NA*	*NA*	*> 4*	*> 4*	*NA*	*NA*	*> 2*
≤ 0.25	≤ 0.12	**> 4**	≤ 4	≤ 0.5	≤ 1	≤ 1	≤ 0.5	4	≤ 0.25
≤ 0.25	≤ 0.12	1	≤ 4	1	≤ 1	2	≤ 0.5	≤ 1	2
≤ 0.25	≤ 0.12	1	≤ 4	≤ 0.5	≤ 1	2	≤ 0.5	≤ 1	0.5
≤ 0.25	≤ 0.12	≤ 0.5	≤ 4	1	4	≤ 1	≤ 0.5	2	≤ 0.25
≤ 0.25	≤ 0.12	≤ 0.5	≤ 4	≤ 0.5	≤ 1	≤ 1	≤ 0.5	2	≤ 0.25
≤ 0.25	0.25	1	≤ 4	**> 4**	2	2	≤ 0.5	2	0.5

CIP	CLI	FUS	KAN	TIA	VAN	LZD	MUP	FOX	
NA	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	
0.5	≤ 0.12	> 4	32	≤ 0.5	≤ 1	≤ 1	≤ 0.5	1	
2	≤ 0.12	> 4	16	≤ 0.5	≤ 1	≤ 1	≤ 0.5	8	

CIP	CLI	FUS	KAN	TIA	VAN	LZD	MUP	FOX	
> 4	*NA*	*NA*	*NA*	*NA*	*> 4*	*> 4*	*NA*	*NA*	
> 16	**> 4**	4	**> 64**	1	≤ 1	1	1	> 16[a)]	

CIP	CLI	FUS	KAN	TIA	VAN	LZD	MUP	FOX	
NA	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	
≤ 0.25	≤ 0.12	≤ 0.5	≤ 4	≤ 0.5	≤ 1	≤ 1	> 256	≤ 0.5	

Legend

MIC values higher than the breakpoint for the specific antibiotic and MIC values without breakpoints that are interpreted as decreased susceptibility by the laboratory are highlighted with bold letters. MIC were interpreted using EUCAST[1] interpretation criteria and CLSI[2] criteria if no EUCAST criteria were available.

PEN=Penicillin, GEN=Gentamicin, STR=Streptomycin, TET=Tetracycline, TMP=Trimethoprim, ERY=Erythromycin, RIF=Rifampin, CHL=Chloramphenicol, SMX=Sulfamethoxazole, CIP=Ciprofloxacin, CLI=Clindamycin, FUS=Fusidic acid, KAN=Kanamycin, TIA=Tiamulin, VAN=Vancomycin, LZD=Linezolid, MUP=Mupirocin, FOX=Cefoxitin, OXA=Oxacillin sodium, NA=No human breakpoints available for the specific combination of bacterial species and antibiotic.

[a)] intrinsic resistance to macrolides, sulfonamides and cephalosporins.

[1] EUCAST. The European Committee on Antimicrobial Susceptibility Testing. Breakpoint tables for interpretation of MICs and zone diameters. Version 8.1, 2018. http://www.eucast.org

[2] CLSI: Performance Standards for Antimicrobial Susceptibility Testing. 27th ed. CLSI supplement M100. Wayne, PA: Clinical and Laboratory Standards Institute. 2017.

seven animals (foals 5, 7, 11, 12, 14, 25, 43), whereas in four animals (foals 1, 35, 37 and 41) several bacteria could be cultured. The blood culture of two foals contained both Gram-positive and Gram-negative bacteria. Overall 12 Gram-positive and four Gram-negative bacteria were isolated and revealed 14 different species of *Staphylococcus, Enterococcus, Streptococcus, Macrococcus, Acinetobacter, Escherichia* and *Actinobacillus* (Table 1).

Staphylococci were the most frequent Gram-positive bacteria. Among them, two *S. aureus* were cultured, of which one was confirmed as MRSA sequence type ST 398 based on an MIC > 8 mg/l for oxacillin sodium, presence of the *mecA* gene, and multilocus sequence typing. In addition to resistance to beta-lactams, this MRSA showed markedly increased MIC values for other antibiotics including gentamicin, tetracycline and trimethoprim (Table 2). Among the coagulase-negative staphylococci, decreased susceptibility was observed for several antibiotics including penicillin, erythromycin, trimethoprim, sulfamethoxazole and fusidic acid (Table 2). *Enterococcus faecium* showed increased MIC values for ampicillin, tetracycline, ciprofloxacin, trimethoprim and for high-level resistance to gentamicin. None of the Gram-negative isolates exhibited MIC above EUCAST or CSLI breakpoints when these values were available. Additionally MICs were frequently situated below the lowest concentrations of the antibiotics tested suggesting the absence of acquired resistance against these antibiotics (Table 3).

This study, although including a low number of cases, gives an overview of species diversity and antibiotic susceptibility patterns of bacteria cultured in blood samples of diseased foals in Switzerland. Bacterial diversity and resistance patterns were previously published including a higher number of septic foals in the US[9,13,14], Australia[11], New Zealand[15], the UK[4] and the Czech Republic[7], but MIC values were only reported in one study[14]. These studies reported increasing prevalence of Gram-positive bacteria over recent years[7,11,13,14] although, with the exception of a single study looking at bacterial cultures from foals in general[15], more Gram-negative than Gram-positive bacteria were cultured. This reflects the general bacterial diversity in the equine population as reflected by culture results from a Swiss equine hospital[17]. The low number of positive blood samples in this study did not allow the description of bacterial prevalence over time. However, we observed more Gram-positive than Gram-negative isolates in the blood cultures from foals, comparable to trends in human medicine[10]. A possible explanation for the predominance of Gram-positive bacteria in our study group may be associated with skin contaminants (e.g. coagulase-negative staphylococci) even if the catheters were placed aseptically or with the potential influence of prior antimicrobial treatment on bacterial distribution in the blood cultures. Antimicrobial treatment has been shown to influence the selection of resistant *E. coli* in horses[5] but there is, to our knowledge, no report about the influence of antimicrobial treatment on bacterial diversity in septic foals. The presence of multidrug resistant bacteria

Table 3: Minimal inhibitory concentration (MIC) values of gram-negative bacterial isolates cultured from foals in Switzerland

	Animals	MIC of antibiotics and resistance breakpoints (mg/L)							
		AMP	**GEN**	**TET**	**TMP**	**AZI**	**CHL**	**COL**	**FOT**
Species: *Acinetobacter*		*NA*	*> 4*	*NA*	*NA*	*NA*	*NA*	*>2*	*NA*
Acinetobacter lwoffi	Foal 1	16	2	≤ 2	2	≤ 2	≤ 8	≤ 1	1
		AMP	**GEN**	**TET**	**TMP**	**AZI**	**CHL**	**COL**	**FOT**
Species: *Escherichia*		*> 8*	*> 4*	*≥ 16*	*> 4*	*NA*	*> 8*	*> 2*	*> 2*
Escherichia coli	Foal 41	4	1	≤ 2	1	8	≤ 8	≤ 1	≤ 0.25
		PEN	**AMP**	**TIO**	**GEN**	**NEO**	**OXY**	**ENR**	**TUL**
Species: *Actinobacillus*		*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
Actinobacillus equuli	Foal 7	0.5	≤ 0.25	≤ 0.25	≤ 1	≤ 4	≤ 0.5	≤ 0.12	≤ 1
Actinobacillus equuli	Foal 25	0.25	≤ 0.25	≤ 0.25	≤ 1	≤ 4	≤ 0.5	≤ 0.12	≤ 1

Legend

MIC values higher than the breakpoint for the specific antibiotic and MIC values without breakpoints that are interpreted as decreased susceptibility by the laboratory are highlighted with bold letters. MIC were interpreted using EUCAST[1] interpretation criteria and $CLSI_2$ criteria if no EUCAST criteria were available.

PEN=Penicillin, AMP=Ampicillin, TIO=Ceftiofur, GEN=Gentamicin, NEO=Neomycin, TET=Tetracycline, OXY=Oxytetracycline, ENR=Enrofloxacin, TMP=Trimethoprim, AZI =Azithromycin, TUL=Tulathromycin, CHL=Chloramphenicol, COL=Colistin, FOT=Cefotaxime, TAZ=Ceftazidime, SXT=Trimethoprim/Sulfamethoxazole, SMX =Sulfamethoxazol, SDM=Sulfadimethoxine, CIP=Ciprofloxacin, CLI=Clindamycin, TIA=Tiamulin, NAL=Nalidixic acid, MER=Meropenem, TGC=Tigecycline, SPE=Spectinomycin, FFN=Florfenicol, TIL=Tilmicosin, CTE=Chlortetracycline, DAN=Danofloxacin, TYL=Tylosin, NA=No human breakpoints available for the specific combination of bacterial species and antibiotic

defined as isolates with acquired resistance towards ≥1 agent in ≥3 defined antimicrobial categories[8], is of more concern since treatment of infections caused by such bacteria may require the use of so-called human medicine "last resort" antibiotics like vancomycin[19]. The occurrence of multidrug resistant bacteria with clinical significance (also including *S. aureus*, coagulase-negative staphylococci and enterococci) has previously been reported in Switzerland[18]. It is therefore not surprising to observe the presence of such antibiotic-resistant isolates in blood cultures of foals.

The major limitation of this report is the low number of positive blood cultures in the study population and the fact that contamination with bacteria of the normal skin flora cannot be excluded, especially in horses where polymicrobial growth could be observed.

In conclusion, blood stream infections in this geographical area of Switzerland are caused by a diversity of Gram-negative and Gram-positive bacteria, some of the latter exhibiting resistance to several classes of antibiotics. MIC values above EUCAST and/or CLSI breakpoints were identified in coagulase-negative staphylococci, MRSA and *Enterococcus faecium* whereas the four Gram-negative isolates did not appear to exhibit increased MIC values. This study emphasizes again the importance of vigilant use of antimicrobial drugs in veterinary medicine and use of antimicrobial susceptibility testing to identify isolates with increased MIC values.

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TAZ	SMX	CIP	NAL	MER	TGC				
NA	*NA*	*> 1*	*NA*	*> 8*	*NA*				
≤ 0.5	1024	≤ 0.015	≤ 4	0.12	≤ 0.25				

TAZ	SMX	CIP	NAL	MER	TGC				
> 4	*NA*	*> 0.5*	*NA*	*> 8*	*> 2*				
≤ 0.5	64	≤ 0.015	≤ 4	≤ 0.03	0.5				

SXT	SDM	CLI	TIA	SPE	FFN	TIL	CTE	DAN	TYL
NA	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2/38	≤ 256	2	8	≤ 8	≤ 0.25	≤ 4	1	≤ 0.12	16
2/38	≤ 256	2	8	16	≤ 0.25	≤ 4	1	≤ 0.12	16

[1] EUCAST. The European Committee on Antimicrobial Susceptibility Testing. Breakpoint tables for interpretation of MICs and zone diameters. Version 8.1, 2018. http://www.eucast.org

[2] 2 CLSI: Performance Standards for Antimicrobial Susceptibility Testing. 27th ed. CLSI supplement M100. Wayne, PA: Clinical and Laboratory Standards Institute. 2017.

Sensibilité aux antimicrobiens d'isolats d'hémoculture issus de poulains en Suisse

Nous rapportons les résultats d'hémoculture de 43 poulains admis dans un hôpital équin pour des affections médicales ou chirurgicales et déterminons les concentrations minimales inhibitrices (CMI) de différents antibiotiques. Le résultat de l'hémoculture a été positif pour onze poulains malgré l'administration préalable d'antibiotiques à 10 de ces animaux. Des valeurs de CMI supérieures aux seuils EUCAST et/ou CLSI ont été identifiées chez des staphylocoques coagulase négative, chez *Staphylococcus aureus* résistant à la méthicilline (MRSA) et chez *Enterococcus faecium*. Les isolats Gram négatifs étaient moins fréquemment identifiés et ne semblaient pas présenter de valeurs de CMI augmentées. Cette étude montre que les infections sanguines des poulains en Suisse sont causées par diverses bactéries, notamment des bactéries Gram positif, qui résistent à plusieurs classes d'antibiotiques.

Mots-clés: antibiotiques, bactériémie, septicémie, cheval, concentration minimale inhibitrice

Modelli di suscettibilità antimicrobica degli isolati delle emocolture dei puledri in Svizzera

In questo studio vengono riportati i risultati delle emocolture di 43 puledri che sono stati ricoverati in un ospedale equino per dei disturbi medici o chirurgici e sono state determinate le concentrazioni minime inibitorie (MIC) di diversi antibiotici. Undici puledri hanno avuto un risultato positivo dell'emocoltura nonostante la precedente somministrazione di antibiotici in 10 di questi animali. I valori delle MIC superiori ai breakpoint EUCAST e/o CLSI sono stati identificati negli stafilococchi coagulasi-negativi, *Staphylococcus aureus* (MRSA) resistente alla meticillina e *Enterococcus faecium*. Gli isolati Gram-negativi venivano identificati meno di frequente e non sembravano mostrare i valori delle MIC aumentati. Questo studio dimostra che le infezioni del sangue nei puledri in Svizzera sono causate da diversi batteri, tra cui i batteri Gram-positivi che mostrano resistenza a diverse classi di antibiotici.

Parole chiave: antibiotici, batteriemia, cavallo, concentrazione minima inibitoria, sepsi

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