Plasma pharmacokinetics and muscle disposition of marbofloxacin in chickens

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Abstract:
BACKGROUND: Reports on the pharmacokinetics of marbofloxacin in birds are scarce, even when it is a useful tool in poultry production. OBJECTIVES: Determining marbofloxacin kinetic parameters in plasma and muscle arrangement after intravenous and oral administrations and establishing its withdrawal period. METHODS: Clinical healthy chickens (1.08±0.22 kg) were used as experimental subjects, formed in groups of 5. In Group A (n= 45) birds received 2 mg/kg of marbofloxacin intravenously while group B (n= 65) was given the same oral dose after fasting for 12 hours. Blood samples in the groups and 5 g of muscle were obtained at different times, in A group up to 24 hours and in B group until 120 hours after application. Once the samples were obtained and treated, marbofloxacin was quantified by HPLC. RESULTS: Marbofloxacin in fasted chickens is almost completely absorbed (F= 97%), mean residence time is moderate (6.9 hours), with a high volume of distribution. Orally, mean residence time is less in plasma (4.9 hours) and the withdrawal time was calculated 2.5 days. CONCLUSIONS: The kinetic results are consistent with those presented by other fluoroquinolones in poultry and are in line with short production cycles in chickens.

Key words: chickens, HPLC, marbofloxacin, pharmacokinetics

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Introduction

Marbofloxacin (MBFX) is a second generation fluoroquinolone marketed exclusively for veterinary medicine (Spreng et al., 1995; Martinez et al., 2006). Like other fluoroquinolones, it inhibits DNA gyrase (topoisomerase II) and topoisomerase IV creating complexes with the enzyme, which result in conformational changes, exerting antimicrobial activity against Gram negative bacteria, some Gram positive and Mycoplasma spp (García et al., 1999; Sidhu et al., 2010; Shan et al., 2013). MBFX is an organic acid, with good tissue penetration, high volume of distribution, and weak binding to plasma proteins (Anadón et al., 2002; Goudah and Hasabelnaby, 2010; Yang et al., 2014), being active at low concentrations (Ding et al., 2013). It differs from other fluoroquinolones, in the presence of an oxadiazine ring, conferring a long elimination half-life (t½β) and high bioavailability (Goudah and Hasabelnaby, 2010; Yuan et al., 2010). These characteristics demonstrate that marbofloxacin presents a great potential for the treatment of bacterial infections in Veter-
Investigations on MBFX pharmacokinetics in comestible birds are scarce, counting those of Anadón et al. (2002), Huang et al. (2003), and Ding et al. (2010) in chickens, Goudah and Hasabelnaby (2010) and Yuan et al. (2010) in ducks and Haritova et al. (2006, 2013) in turkeys and quail. Demonstrating short to moderate mean residence time in these species, ranging from 2.99 to 5.96 hours, the latter registered in chickens (Anadón et al., 2002), bioavailability ranges in chickens varies from 56.2% (Anadón et al., 2002) to 95.7% (Huang et al., 2003). Half-life elimination is fast in quails 2.01 (h) (Haritova et al., 2013), but slower in chickens being 5.6 and 6.5 hours after intravenous application, reported by Anadón et al. (2002) and Huang et al. (2003), respectively. The objective of this study was to describe the pharmacokinetic variables of MBFX in plasma and muscle disposition after intravenous and oral administrations, estimating MBFX withdrawal time in chickens.

Materials and Methods

Animals: 110 Ross line chickens from a farm near Río Cuarto city (Argentina) were used; these 30-day-old birds were clinically healthy, with a weight of 1.08±0.22 kg. The birds were transferred to the Veterinary Medicine Faculty at the National University of Río Cuarto and housed in a conditioned box for an acclimatization period of seven days before the study, at a temperature of 18°C, with food and water ad libitum.

Experimental design (Broiler management): 110 chickens were randomly divided into two groups of 45 (A) and 65 (B) chickens respectively, with five replicates each one. Both were given a single dose of MBFX of 2 mg/kg, intravenously for group A and orally for B, after 12 hours of fasting. Following MBFX administration, according to the techniques approved by the Bioethics Committee of the National University of Río Cuarto, batches of five animals per time were slaughtered at different times, A (0.25, 0.5, 1, 2, 4, 6, 8, 12, 24 hours) and B (0.25, 0.5, 1, 2, 4, 6, 8, 12, 24, 48, 72, 96, 120 hours). Blood samples from each bird (5 ml) were centrifuged at 2500 rpm x 10 minutes and the plasma obtained was saved in sterile vials. Furthermore, samples of 5 grams of pectoral muscle were obtained and stored at -20 °C along with plasma until processing. Determination of plasma and muscle concentrations of MBFX was taken out by HPLC, using the modified technique of Bottcher et al. (2001).

HPLC conditions: MBFX and internal standard (enrofloxacin 2.5 µg/ml) were eluted isocratically with a flow rate of 0.8 ml/min using a mobile phase consisting of deionized water, acetonitrile, and triethylamine (790:200:10 V/V/V) adjusted to pH 3 with phosphoric acid. Calibrating the wavelength of fluorescence detector at 295 nm (excitation) and 490 nm (emission), respectively.

Sample preparation: The modified method of Böttcher et al. (2001) was used for the quantification of MBFX in plasma and tissue samples. Plasma samples were prepared by placing them in an Eppendorf tube 150 µL of plasma, 600 µL of extraction solution (ES) consisting of deionized water, methanol and perchloric acid in a ratio (500: 500: 1 v/ v/v), 40 µL of internal standard, and 150 µL of deionized water. underwent agitation by vortex for 30 seconds, and then they were centrifuged at 13,500 rpm for 25 min at 4°C. The obtained supernatant was filtered on nylon membrane 0.22 µm. A similar process/procedure was used for muscle samples, taking 150 mg of muscle to which 600 µL of ES, 40 µL of internal standard, and 150 µL of deionized water were added; the samples were mechanically homogenized for 1 minute and kept in refrigeration at 4°C for 12 hours for subsequent centrifugation for 25 min at 13,500 rpm at 4°C, filtering the supernatant through 0.22
µm nylon membrane.

**Calibration of the chromatographic method:** For testing, plasma and muscle samples were used, added with known MBFX concentrations from 0.009 to 2.5 µg/ml for plasma and 0.004 to 1.25 µg/mg for muscle. Determining the degree of adjustment of the area values index and their respective calibration by linear regression.

**Data analysis:** MBFX average concentrations, obtained in plasma at different times and routes, were processed by means of PK Solution 2.0 kinetic software (Farrier, 1999), in order to obtain plasma pharmacokinetic parameters. Oral bioavailability (F) was determined using the equation $F = (\text{AUCoral}) / (\text{AUCiv})$ (Baggot, 2002; Bousquet-Melou and Toutain, 2004).

Withdrawal period in muscle was performed by analysis of muscle residues, using the EMEA WT 1.4 Software (Hekman and Hoogland, 1996), with a confidence interval of 95%. Maximum residue limit (MRL) was established in 150 µg/kg, according to FDA and EMEA directives for MBFX.

**Results**

**Calibration method:** The method proved to be linear in the examined interval ($r^2 > 0.99$). Intra and interassay coefficients of variation were < 1.73%, 50 µl of plasma and muscle injection provides the quantitation limits of 0.006 µg/ml and 0.07 µg/mg, respectability. Recovery tests performed to establish the precision of the extractive method in plasma samples showed a percentage of 86%, whereas in muscle it was 87%.

**Intravenous and oral administrations of marbofloxacin:** Figure 1 shows mean (±SD) plasma and muscle marbofloxacin concentrations versus time, whereas in Table 1 mean (±SD) values for intravenous and oral plasma pharmacokinetics parameters are shown. After a 2 mg/kg single oral dose, marbofloxacin was quickly absorbed, resulting in 0.8 µg/ml Cmax, evidenced by Tmax and t½abs values of 1 and 0.126 hours respectively in plasma. It was also rapidly and widely distributed after intravenous administration, reflected by a 0.9 hour t½α and a 3.88 L/kg Vdárea, suggesting good tissue penetration; removal was slow (t½β 6.45 hours) and the plasma clearance (Clt) was 6.94 ml/min/kg.

**Marbofloxacin analysis in muscle:** Orally, MBFX residues were detected in muscle

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**Figure 1.** Marbofloxacin plasma and muscle concentration vs. time profiles, after intravenous and oral 2 mg/kg single dose in chickens (data as mean ± SD). i.v plasma → oral plasma → i.v muscle → oral plasma →

<table>
<thead>
<tr>
<th>Pharmacokinetic parameters</th>
<th>IV</th>
<th>Oral</th>
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<tr>
<td>Cmax(µg/ml)</td>
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<td>Tmax (h)</td>
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<td>t½abs (h)</td>
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<td>AUC (µg-h/ml)</td>
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<td>4.7</td>
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<tr>
<td>F%</td>
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<tr>
<td>Vdárea L/kg</td>
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<tr>
<td>MRT (h)</td>
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<tr>
<td>Clt (L/h/kg)</td>
<td>0.416</td>
<td>0.417</td>
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Table 1. Mean ± SD marbofloxacina pharmacokinetics parameters, after intravenous and oral 2 mg/kg single dose in chickens. Abbreviations: Cmax, maximum plasma concentration; Tmax time to peak concentration; t½abs, absorption half-life; t½α distribution half-life; t½β elimination half-life; AUC, area under the curve; F (%), bioavailability; Vd area, volume of distribution; MRT, mean residence time and Cl, plasma clearance.
up to 48 hours after administration, reaching a maximum concentration of 0.351 µg/mg 2 hours post-administration, while intravenously, the maximum concentration was 0.342 µg/mg, and residues were detected until 24 hours post-application (Fig. 1).

Withdrawal time for MBFX in muscle was estimated to be 2.5 days.

Discussion

Plasma kinetic parameters indicate that marbofloxacin oral administration has rapid absorption, reflected by a Cmax of 0.8 µg/ml, 1 hour post-administration, similar to 1.05 µg/ml obtained by Anadón et al. (2002), but less than 1.84 µg/ml obtained by Huang et al. (2003) at higher doses (2.5 mg/kg). Yuan et al., 2011 showed a Cmax of 1.13 µg/ml in ducks with a of 2.5 mg/g dose, meanwhile Haritova et al. (2003) reported 0.67 µg/ml in turkeys with a dose of 2 mg/kg, reaching Tmax 1 hour post-administration, similar to Anadón et al., 2002, Huang et al., 2003, and Ding et al., 2013 in chickens. The volume of distribution indicates a high tissue passage after intravenous application, greater than that obtained by Anadón et al. (2002) and Huang et al. (2003).

Under the rapid dissolution in intestinal media of fluoroquinolones (Kim & Nightingale, 2000; Scholar, 2002), marbofloxacin plasma concentrations could be measured from 15 minutes to 48 hours after oral administration, and these data were consistent with other studies conducted with these drugs in chickens (Anadón et al., 2002; Huang et al., 2003).

The AUC área obtained in the study, 4.8 mg-h/ml, is lower than in chickens. Anadón et al. (2002) observed values of 10.5 mg-h/ml, giving 2 mg/kg repeated for three days, whereas Ding et al. (2013) obtained 9.8 g-h/ml, in infected animals at 5 mg/kg in repeated doses. Since fluoroquinolones are dose-dependent antimicrobials, treatments with high and repeated doses may increase the AUC.

Oral bioavailability (F= 98%) is similar to 95% reported by Huang et al. (2003), but higher than 56.8% cited by Anadón et al. (2002); this difference is attributable to the 12 hour fasting.

The high dissolution in the intestinal environment and the amphoteric character of marbofloxacin must be considered.

Plasma t½β was 6.4 hours, similar to that presented in other studies with MBFX in chickens by Anadón et al. (2002), Huang et al. (2003), and Ding et al. (2013), in which the time periods were 5.26, 6.48, and 6.8 hours, respectively. An oxadiazinic ring in MBFX structure determines the pharmacokinetic characteristics associated with elimination half-life and bioavailability (Haritova et al., 2006), showing a moderate plasma permanence reflected by t½β and TMR. These data are consistent with the history of fluoroquinolones in poultry (Anadón et al., 2002; Ding et al., 2013) with greater tissue retention.

Marbofloxacin kinetic profile after oral and intravenous administration is consistent with that described by Anadón et al. (2002), Huang et al. (2003), Haritova et al. (2006), Yuan et al. (2011), and Ding et al. (2013) for this drug in birds.

After oral administration, muscle disposition occurs quickly detecting levels at 15 minutes and after 72 hours post-application (Anadón et al., 2002; Huang et al., 2003; Ding et al., 2013). The disposition curve versus time in muscle shows the most significant levels between 1 and 4 hours; considerable tissue levels are attributable to reduced plasma proteins binding, lipid solubility, and amphoteric characteristics determining poor ionization of the drug in blood thus facilitating passage through membranes, and slower elimination compared to the plasma (Thomas et al., 2000; Anadón et al., 2002; Baggot, 2002; Guiguére et al., 2013.)

The withdrawal period of 2.5 days agrees with that calculated by Anadón et al. (2002), but is less than that presented by Yang et al.
(2014), estimated in four days but not calculated with the software used here. The withdrawal period of this experience, which influences when choosing an antimicrobial in poultry, is reasonable and consistent with the brevity of broiler production cycles.

References


Marbofloxacin in poultry

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فaramakokinetic marbofloxacin in sows and its effect on muscle in piglets

نام اول: ارکاده، گویلدو پرفتو؛ کارلوس لودرس، اداردو پیکو؛ کارلوس اراقالد و ناتالی ارزوا

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چکیده
زمینه مطالعه: گزارشات اندکی در مورد فارماکوکینتیک ماربوفلوکاسین در پرندگان وجود دارد و یک داروی مفید در پرورش حیوانات است. هدف: تعیین پارامترهای کینتیک ماربوفلوکاسین پس از تزریق داخل وریدی و تجویز خوراکی در پلاسما و عضله و تخمین دوره قطع دارویی با استفاده از آنالیز HPLC. مطالعه تایید شد و به‌طور کلی موفقیت بالایی داشت.

روش کار: در دستگاه‌های 1.08 ± 0.22 kg وزنی جوجه‌هایی که از نظر کلینیک سالم بودند با محدوده وزنی 2/500 میلی‌گرم در هر گرم وزن جسمانی دریافت می‌گردند. در گروه A، تاید قطع دارو در پلاسما و عضله جوجه در زمان‌های مختلف جمع‌آوری شدند. در گروه B، زمان قطع دارو در پلاسما و عضله جوجه در زمان‌های مختلف جمع‌آوری شدند.

نتایج: زمان قطع دارو در پلاسما و عضله جوجه در دستگاه‌های 1.08 ± 0.22 kg وزنی مشابه بوده و تعیین دارویی در بررسی‌های سه روزه صورت گرفته و نتایج با داده‌های دیگر مطابقت داشت. ماربوفلوکاسین بحث‌های سایر فلوروكینولون‌ها در حالت مختلف و برای بررسی قطع دارو در پلاسما و عضله جوجه همکاری می‌کند.

واژه‌های کلیدی: ماربوفلوکاسین، HPLC، فارماکوکینتیک