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DIAGNOSTICS BY HPLC & LC-MS/MS

Methylphenidate and ritalinic acid determination in serum and saliva from patients with attention deficit hyperactivity disorder

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Objective

In the therapy of attention deficit hyperactivity disorder (ADHD) methylphenidate (MPH) nowadays represents first line treatment in combination with psychotherapy. It is one of the best-studied pediatric psychopharmacological drugs with a vast amount of clinical experience.
Since methylphenidate has addiction potential and shows varying metabolic characteristics in children, therapeutic drug monitoring is advised [1]. Similar variations in metabolic properties can be found in patients with hepatic or renal insufficiency. All these patient groups would also benefit from a less invasive and less painful sampling.
However, in pediatric drug therapy there are only few reliable studies, in particular randomised and controlled studies being rare. To avoid pain in children through invasive blood collection, the use of oral fluid would be the diagnostic material of choice. Additionally, it is a noninvasive, simple and cost-effective alternative as part of an optimized pharmacotherapy. In this study we quantified methylphenidate and its metabolite ritalinic acid (RA) from saliva by mass spectrometry.

Methods

From 19 ADHD patients (9 children, 1 adolescent and 9 adults) taking methylphenidate, serum and saliva were obtained for the validation of the Chromsystems ***MassTox***® TDM Parameter Set Antidepressants 2/ Psychostimulants, which includes methylphenidate and its main metabolite ritalinic acid as parameters for LC-MS/MS measurements. The study participants took predominantly long-acting sustained release formulations like Medikinet retard® or Ritalin LA®. The daily intake ranged between 5 and 60 mg MPH, corresponding to a dosage of 0.1 to 1.4 mg/kilogram of body weight.
The blood and saliva samples were taken two to three hours after drug intake, when highest concentrations can be expected in both, serum and oral fluid [2]. After a brief interim storage at -80 °C, serum and saliva samples were processed using the Chromsystems kit Antidepressants 2/Psychostimulants for LC-MS/MS analysis following the manufacturer's instructions. Calibrators and controls for the determination of MPH in serum or plasma were also from Chromsystems. A series of MPH standards in saliva was produced by spiking with MPH hydrochloride.

Results

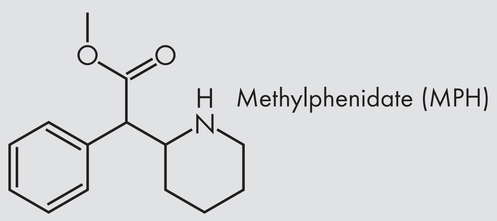
Study population

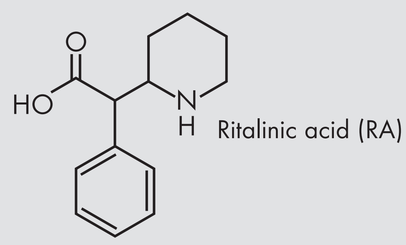
Patients	**19**
Kids (8–12 years) Adolescents (13–18 years) Adults (>18 years)	9 1 9
Age (years) mean ± SD (min., max.)	19.4 ± 13 (8.48)
Female Male	6 13
Height (cm) mean ± SD (min., max.)	155.6 ± 19.3 (133, 193)
Weight (kg) mean ± SD (min., max.)	55.54 ± 25.28 (26.2, 105)
BMI (kg/m^2) mean ± SD (min., max.)	21.7 ± 6 (14.2, 36.3)

Dose rate and serum/saliva concentrations

Dose rate per day (mg), mean ± SD, (min., max.)	26.3 ± 11.8 (5, 60)
Dose rate/kg BW (mg/kg BW), mean ± SD, (min., max.)	0.6 ± 0.4 (0.1, 1.4)
Serum concentration MPH (ng/ml), mean ± SD, (min., max.)	9.3 ± 9.6 (0.1, 35.3)
Oral fluid concentration MPH (ng/ml), mean ± SD, (min., max.)	43.4 ± 51.9 (0.1, 211)

Chemical structures





Example chromatogram

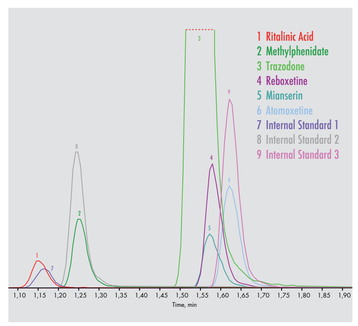


Figure 1: Example chromatogram of a LC-MS/MS measurement with ***MassTox***® TDM Series A Antidepressants 2/Psychostimulants Kit in serum/plasma. Retention times were 1.25 min for and 1.15 min for RA, respectively.

Interassay values

Target (ng/ml)	Mean (n = 10)	SD	CV (%)
25	25.4	1.2	4.89
30	30.0	1.7	5.69
40	40.8	2.5	6.08

Table 1: Saliva was spiked with 25, 30 and 40 ng/ml MPH and CVs determined, ranging from 4.89–6.08 %.

Serum and oral fluid chromatograms of a patient taking methylphenidate

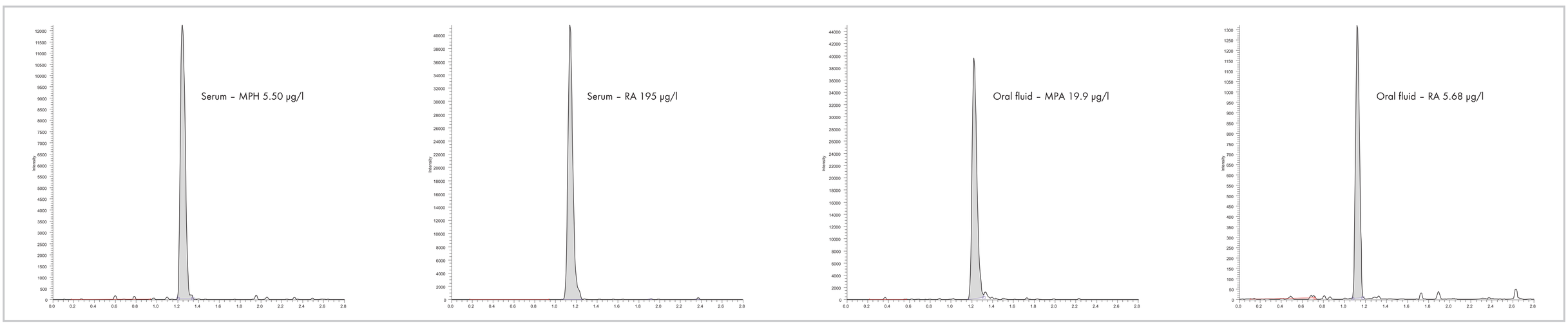
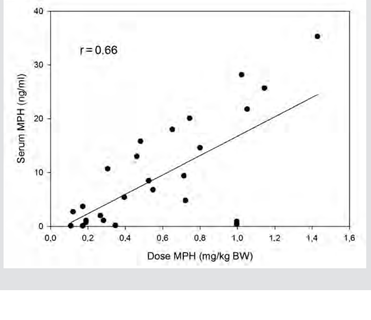
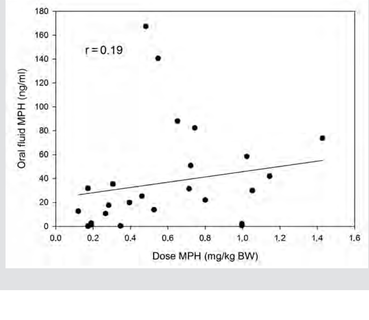


Figure 2: These figures show the chromatograms of a patient taking Medikinet adult® with a dosage of 30 mg per day. The results of the serum levels show a value of 5.5 ng/ml for MPH and 195 ng/ml for its metabolite RA. As described previously by other working groups, the values for MPH in saliva were significantly higher – here about a factor 4, whereas significantly lower values were determined for RA, which could be explained by the higher acidity of the oral fluid in comparison to blood [2,4].

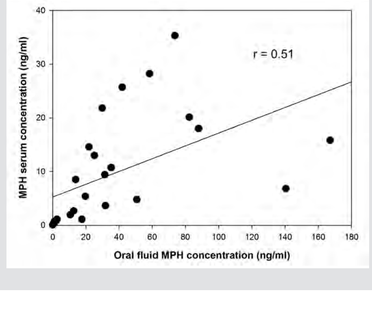
MPH dose/serum correlation



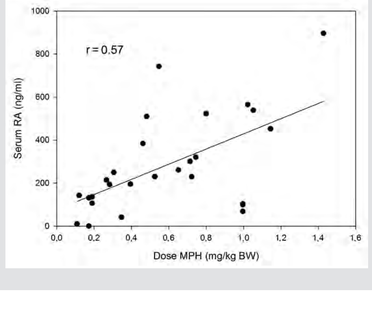
MPH dose/oral fluid correlation



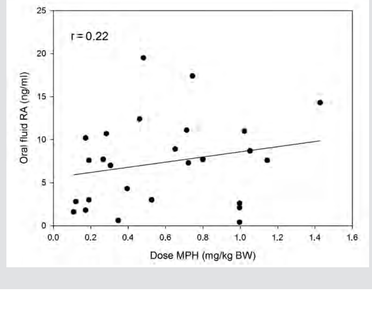
MPH oral fluid/serum correlation



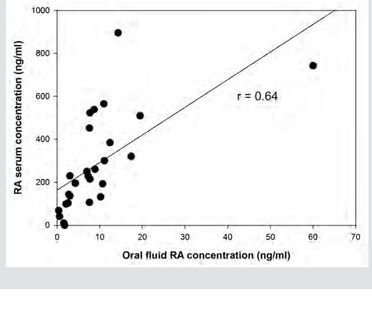
RA dose/serum correlation



RA dose/oral fluid correlation



RA oral fluid/serum correlation



Conclusion

- The ***MassTox***® TDM Parameter Set Antidepressants 2/Psychostimulants from Chromsystems is methodologically and analytically suitable for the determination of MPH and its main metabolite RA in serum/plasma as well as saliva by LC-MS/MS.
- This allows a substantially simplified form of drug monitoring in pediatric pharmacotherapy.
- The measured serum concentrations for methylphenidate correspond with the usual and published data [3].
- Correlations between serum and oral fluid concentrations described by Marchei et al. (2010) range between r = 0.22 (fast-release formulation) and r = 0.79 (extended-release formulation) for MPH, and r = 0.4 (fast-release formulation) and r = 0.79 (extended-release formulation) for RA. Our results with r = 0.51 for MPH and r = 0.64 are precisely in between. Probably the fast-releasing pharmaceutical form causes buccal contamination and falsifies the saliva concentration [4].

References

[1] van den Anker JN, Schwab M, Kearns GL. (2011) Developmental pharmacokinetics. *Handbook of experimental pharmacology* **205**: 51–75.
[2] Marchei E, Farrè M, Pellegrini M, Rossi S, García-Algar Ó, Vall O, Pacifici R, Pichini S. (2010) Pharmacokinetics of methylphenidate in oral fluid and sweat of a pediatric subject. *Forensic Science International* **196**(1–3): 59–63.
[3] Novartis Pharma. (2013) Fachinformation Ritalin® 10 mg Filmtabletten.
[4] Marchei E, Farrè M, Garcia-Algar O, Pardo R, Pellegrini M. (2010) Correlation between methylphenidate and ritalinic acid concentrations in oral fluid and plasma. *Clinical Chemistry* **56**(4): 585–92.