Development of an LC-MS/MS Bioanalytical Method in Plasma for Cocaine, Benzoylecgonine and Ecgonine Methyl Ester

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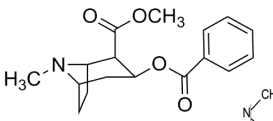
Overview

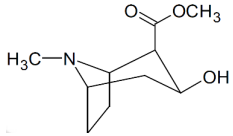
- First validated method for regulated analysis of cocaine and its metabolites, benzoylecgonine (BE) and ecgonine methyl ester (EME), in human plasma.
- Cocaine is rapidly metabolized *in vivo* and *in vitro*. Benzoylecgonine and ecgonine methyl ester are two of the metabolites formed by ester hydrolysis of cocaine.
- Sodium fluoride and potassium oxalate (NaF/KOx) are used as plasma anticoagulants to slow the hydrolysis of cocaine esters.
- All analytes are highly polar.
- Two minute injections allow for rapid analysis of up to nearly 500 samples/day

Structures

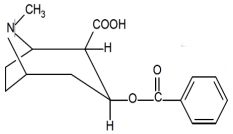
Cocaine



Ecgonine Methyl Ester (EME)



Benzoylecgonine (BE)



Sample Preparation Method

- Validated range: 1.00-1000 ng/mL for cocaine and BE and 0.500-500 ng/mL for EME
- Conventional reverse phase chromatography was unable to retain EME.
- HILIC phase chromatography provided excellent retention and separation of each analyte.
- Isocratic LC program eliminates need for column re-equilibration.
- Triple quadrupole MS with positive electrospray ionization provides excellent sensitivity.
- Declustering potential was applied to reduce response drift during a run (~96 injections).
- A secondary pump delivered unbuffered 50:50 water:methanol to flush buffer salts from the HESI probe between injections.
- Utilizes 50 µL of plasma per analysis.
- Plasma samples are handled on wet ice, which slows ester hydrolysis more than 10-fold compared to room temperature.
- Deuterated internal standards are used for each analyte (Cocaine-D3, BE-D8, EME-D3).
- Analytes were extracted using acetonitrile protein precipitation. The organic supernatant can be directly injected without the need for evaporation or concentration.

Instrumentation

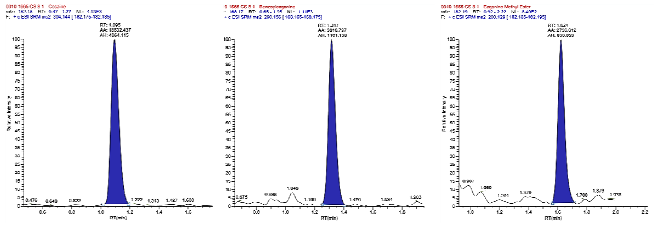
Waters Acquity UPLC		**Thermo Scientific TSQ Vantage MS**	
Run Time:	2 min	Ion Source:	HESI
Column Temp.:	35 ^{0}C	Spray Voltage:	3500
Autosampler Temp.:	7.5 ^{0}C	Ion Transfer Tube Temp:	250 ^{0}C
Injection Volume:	5 µL	Vaporizer Temp:	300 ^{0}C
Flow Rate:	0.5 mL/min	Sheath Gas	50
Mobile Phase:	A: 50 mM ammonium formate pH 3.8 B: Acetonitrile Isocratic 85% B	Aux Gas	6
Analytical Column:	Waters Acquity UPLC® BEH HILIC, 1.7 µm, 2.1 x 100 mm	Resolution	Unit/Unit

SRM Table

Compound	Polarity	Precursor (m/z)	Product (m/z)	Collision Energy (V)	S Lens (V)
Cocaine	Positive	304.154	182.11	19	95
Benzoylecgonine	Positive	290.139	168.11	20	98
EME	Positive	200.129	182.12	18	63

Chromatograms

LLOQ Calibration Standards



Cocaine | Benzoylecgonine | Ecgonine Methyl Ester

Validation Results

- 7 of 7 validation runs met acceptance CS/QC criteria for all three analytes
- Recovery >90% for each analyte and ISTD
- Benchtop stability established through 22 hours at refrigerated temperatures
- 5 freeze/thaw cycles established at -20°C and -80°C on wet ice
- Long term stability for plasma QCs is established through 279 days at both -20°C and -80°C
- Dual plate run (up to 192 injections) was successfully validate

Performance of QC Samples – Core Runs

Cocaine

Summary Statistics	Run ID	LLOQ VS 1.00 ng/mL	LOW VS 3.00 ng/mL	MIDDLE VS 75.0 ng/mL	HIGH VS 750 ng/mL
Mean Concentration Found (ng/mL)	9, 10, 12, 11	1.01	2.99	75.4	743
Inter-run SD		0.0742	0.0953	2.2	24.2
Inter-run %CV		7.3	3.2	2.9	3.3
Inter-run %Bias		1	-0.3	0.5	-0.9
n		30	30	30	30

Benzoylecgonine

Summary Statistics	Run ID	LLOQ VS 1.00 ng/mL	LOW VS 3.00 ng/mL	MIDDLE VS 75.0 ng/mL	HIGH VS 750 ng/mL
Mean Concentration Found (ng/mL)	9, 10, 12, 11	0.991	2.96	75	744
Inter-run SD		0.101	0.155	2.65	25
Inter-run %CV		10.2	5.2	3.5	3.4
Inter-run %Bias		-0.9	-1.3	0	-0.8
n		30	30	30	30

Ecgonine Methyl Ester

Summary Statistics	Run ID	LLOQ VS 0.500 ng/mL	LOW VS 1.50 ng/mL	MIDDLE VS 37.5 ng/mL	HIGH VS 375 ng/mL
Mean Concentration Found	9, 12, 11	0.504	1.52	37.7	374
Inter-run SD		0.0515	0.07	1.3	8.47
Inter-run %CV		10.2	4.6	3.4	2.3
Inter-run %Bias		0.8	1.3	0.5	-0.3
n		24	24	24	24

Conclusions

A sensitive and specific LC-MS/MS assay to measure cocaine and metabolites benzoylecgonine and ecgonine methyl ester in NaF/KOx human plasma has been developed and validated for regulated use. A simple sample processing procedure combined with a robust and efficient LC-MS/MS analysis method delivers reliable results with high sample throughput. This is the first known method validated for analysis of all three analytes together in plasma. Despite known stability issues for cocaine, over 700 clinical samples were successfully analyzed, including successful incurred sample reproducibility (ISR) testing for 10% of samples.

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