Hair External Contamination
Literature Review

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Postulated Mechanisms of Drug Incorporation into Hair

- External Exposure
- Sweat / Sebum
- Blood
- DRUG + Metabs
- DRUG
How do drugs get into hair?

- Blood
- Sebum/sweat
- External exposure

Figure 15-1. Diagram of a cross section of human skin.
External Contamination: Definition

- An evidentiary false positive that is the result of exogenous exposure to drug(s) in the environment.
- The drug positive result is not due to the ingestion or use of drug by any route of administration.
- Drug(s) in sweat or sebum from a source other than the user contacting hair to cause a drug positive result.
In summary, our studies show that hair analysis with a sensitive and specific method like GC/MS can be used to detect cocaine use or exposure.

However, it is our opinion that the mechanism(s) for cocaine incorporation into hair appear to be more complex than previously thought.

Thus, there is not, at present, the necessary scientific foundation for hair analysis to be used to determine either the time or amount of cocaine use.

Further, because external contamination may be a possible source for evidentiary "false" positives for cocaine (i.e., drug is present, but not due to ingestion), all hair testing procedures for cocaine must be designed to rigorously guard against any inadvertent contamination of the sample during collection or analysis and external contamination must be ruled out when interpreting hair analysis results.
External Contamination in Hair Literature Review

- Child Exposure Studies
- Narcotic Officer Exposure Studies
- THC Exposure
- Lab Procedures / Approaches to External Contamination Issues
- *In Vitro* Contamination Studies
Child Exposure Studies

External Contamination in Hair
Passive Nicotine Exposure Adversely effects Health of children

Correlation: Number of Cigarettes per day v. Cotinine Concentrations detected in Urine and Hair

African American Children higher concentrations in both Hair and Urine than Caucasian Children with less # of cigarettes
Lewis et al. (1997) – Forensic Sci Int

Determination of drug exposure using hair: application to child protective cases

- Children exposed: Majority positive for Cocaine and Methamphetamine
- N = 23, Age 6 mo- 13 yrs
- N = 3 -Adults aged 19, 24, 30 yrs
- Benzoylcegonine Detected in 6/12 Cocaine Positive Exposed Children, 2/3 Adults.
- Stated “Some” Positive for Cocaethylene – No data presented
Compared COC and BE levels in children of Cocaine-using mothers

Adults 15/16 COC Positive in Hair; Children 22/24 COC Positive in Hair

COC/BE Concentrations
- Adult mean 2.4/0.39 ng/mg
- Children Mean 2.4/0.74 ng/mg

0/22 POS COC Urine <300ng/mL
1/17 POS in Saliva

Skin 19/26 COC POS, 7/26 BE POS
Bassindale (2012) – *Forensic Sci Int*

Quantitative analysis of methamphetamine in hair of children removed from clandestine laboratories: Evidence of passive exposure

- New Zealand Study (52 cases)
- Children removed from Clandestine Labs
- 3X MeOH wash employed prior to SPE
- Hair samples analyzed by LC-MS/MS for MAMP & AMP
- 38 (73%) Positive METH (>0.1 ng/mg)
- AMP detected in 34/38 POS METH samples
- Levels Similar to Adult Users
  - 7.03 ng/mg Mean MAMP: Children
  - 6.28 ng/mg Mean MAMP: Adults
Case Report on female toddler (2 yrs)
Chronic Crack Cocaine Exposure
Both Parents Admitted Crack Users
2 Segmental Sections: 0-3cm & > 3cm

Results

<table>
<thead>
<tr>
<th>Hair Segment</th>
<th>Toddler Hair (ng/mg)</th>
<th>Maternal Hair (ng/mg)</th>
<th>Paternal Hair (ng/mg)</th>
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<tbody>
<tr>
<td>0-3 cm</td>
<td>1.9</td>
<td>7.88</td>
<td>13.06</td>
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<tr>
<td>&gt; 3 cm</td>
<td>7.04</td>
<td>6.39</td>
<td>12.97</td>
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</table>
Narcotic Officer Exposure Studies

External Contamination in Hair

- 9 Officers; 7-male, 2-female
- Mean Age 33 yrs
- Majority of “buy and bust” Cocaine (60%)
- Majority Cocaine “Crack” Cases (79.2%)

Activity:
- 5-Several times per week
- 4-Several times per month

<table>
<thead>
<tr>
<th>Case ID#</th>
<th>Alcohol Wash</th>
<th>Phosphate #1</th>
<th>Buffer #2</th>
<th>Washes #3</th>
<th>Hair Digest</th>
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<td>1.30</td>
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<td>1.20</td>
<td>0.00</td>
<td>0.00</td>
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<td>7</td>
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<td>3.40</td>
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<td>0.10</td>
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<td>0.18</td>
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</table>

Table 1. Wash and Hair Digest Assay Values: Cocaine [ng/10 mg]
Police Officer and Clerk arrested drug trafficking

Resale of seized drugs

2 Subjects: POS 6-AM + MOR in Hair

Claimed External Contamination

11 other Police Officers: NEG

Table 1

<table>
<thead>
<tr>
<th></th>
<th>Hair</th>
<th>Heroin</th>
<th>Other drugs of abuse</th>
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</thead>
<tbody>
<tr>
<td>Police officer</td>
<td>Chest</td>
<td>6-AM: 0.5 ng/mg</td>
<td>Not detected</td>
</tr>
<tr>
<td></td>
<td></td>
<td>morphine: 0.2 ng/mg</td>
<td></td>
</tr>
<tr>
<td>Clerk</td>
<td>Head</td>
<td>6-AM: 0.8 ng/mg</td>
<td>Not detected</td>
</tr>
<tr>
<td></td>
<td></td>
<td>morphine: 0.4 ng/mg</td>
<td></td>
</tr>
<tr>
<td>Informer</td>
<td>Chest</td>
<td>Not detected</td>
<td>Not detected</td>
</tr>
<tr>
<td>Police officer 1</td>
<td>Chest</td>
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<td>Not detected</td>
</tr>
<tr>
<td>Police officer 2</td>
<td>Head</td>
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<td>Not detected</td>
</tr>
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<td>Police officer 3</td>
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<tr>
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<td>Not detected</td>
</tr>
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<td>Police officer 7</td>
<td>Chest</td>
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<td>Not detected</td>
</tr>
<tr>
<td>Police officer 8</td>
<td>Chest</td>
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<tr>
<td>Police officer 9</td>
<td>Head</td>
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<td>Not detected</td>
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<tr>
<td>Police officer 10</td>
<td>Chest</td>
<td>Not detected</td>
<td>Not detected</td>
</tr>
<tr>
<td>Police officer 11</td>
<td>Chest</td>
<td>Not detected</td>
<td>Not detected</td>
</tr>
</tbody>
</table>

Not detected: lower than the limit of quantitation (0.05 ng/mg for cannabis, 0.1 ng/mg for opiates and cocaine, 0.2 ng/mg for amphetamine and methamphetamines).
THC External Contamination?

External Contamination in Hair
Identification of THC metabolite unique marker of marijuana use

Distinguishes External Exposure to Smoke

THC parent possibly present due to exposure to marijuana smoke
“Detection of THCCOOH should be offered to prove consumption and *metabolism* of THC”
Widely Accepted Strategy – THC-COOH detection to prove active Cannabis Consumption.

THCA A: preliminary end product of THC biosynthesis in Cannabis

Oral intake of THCA, regular basis, No incorporation into Hair

THCA A potentially a marker for exposure to Cannabis side stream smoke
Lab Procedures and Approaches to External Contamination

External Contamination in Hair
Lab Procedure Approach to External Contamination

Procedure claims distinguishing external contamination from drug use by:
- Measure Wash Kinetic/Digest Profiles
- Different for Use v. Contamination

Divides Hair Regions into:
- Accessible Domain
- Semi-Accessible Domain
- Inaccessible Domain
Removing and identifying drug contamination in the analysis of human hair

- 2 Models, Soaking and Sweat to contaminate Drug free Hair
- Multi-Part Washed Procedure Described & Used
- Wash Criterion Used
- Contaminated Samples Identified
- Hair from Drug Users (Urine COC +)
- Application of Wash Procedure and Criterion ID’d COC Users
Analytical Paper: GC/MS/MS procedure
Detection of COC, BE, EME, CE & NCOC in Hair
No Decontamination Procedure Employed
N=30 retrospective hair cocaine positives
CE detected in 19/30 samples, NCOC 29/30
% to COC Hair : BE=12.8%, EME=1.8%, CE=15.4% & NCOC= 2.5%
% to COC in confiscated “Street Samples”: BE=0.7 %, EME=2.6%, CE*=n.d., NCOC= 0.2%
Proposed CE and NCOC as potential biomarkers to distinguish Use v. Exposure
Drug-free Hair contaminated *in vitro* compared to “Street” User and “Clinical” Cocaine Positives

**LC-MS/MS**: COC, BE, CE and NCOC

Hair Decontamination Procedure used

Street Cocaine User Hair % to COC

- BE-29%
- CE-3%
- NCOC-1%

Criteria – Use vs. Contamination did not improve with addition of CE and NCOC
In Vitro Contamination Studies

External Contamination in Hair
Romano et al. (2001)- Forensic Sci Int
Hair Testing for Drugs of abuse: evaluation of external cocaine contamination and risk of false positives.

- N = 4 “drug free volunteers”
- Applied 10 mg of COC HCL to hands then rubbed in Hair , roots to ends
- Decontamination Procedures proposed by Baumgartner and Hill
- Results: After 10 washes Positive COC and BE results remained in final extraction
- COC > 1ng/mg ; BE > 0.5 ng/mg
- BE/COC Ratio > 0.05
Evaluation of Hair Testing Industry’s decontamination procedures

Hair Locks (5 subjects)

Contaminated with COC HCL (15 mg) to 5 (12g) hair locks

Treated with Synthetic Sweat Solution & “Hygienic” Treatments

Shampooed Daily (M-F) 10 weeks

COC HCL purity examined; 0.6% CE, 0.1% NCOC

3 Commercial Analytical Laboratories

3 Protocols

No Decontamination

Lab Decontamination Procedure

RTI Decontamination Procedure
Labs Reported Quant Results:
- Cocaine (COC)
- Benzoylecgonine (BE)
- Cocaethylene (CE)
- Norcocaine (NCOC)

Hair not contaminated COC:BE ratio more significant

Only hair samples with all 4 drugs/metabolites below detection limits – Decontaminated 1 hour after contamination

BE/COC ratios increased over 10 week period

From 21 days to end of Study: BE/COC ratio >0.05
Hair samples contaminated with Cocaine:
- rubbing 15 mg COC HCL into 5 (12g) hair samples
- Sweat application / Shampoo treatments
- Repeated Stout’s Protocol

Amt of Drug in last wash used as wash criterion

LC-MS/MS Analysis of Cocaine and metabolites

Procedure applied to 2 sets of samples:
- Previous “Govt-Sponsored Cooperative Study”
- Parallel in-House Study

All contaminated samples identified as contaminated
<table>
<thead>
<tr>
<th>Hair treatment step</th>
<th>Total cocaine on hair (ng/10 mg hair)</th>
<th>Analytical results after washing (ng/10 mg hair)</th>
<th>Interpretive result*</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Cocaine</td>
<td>BE</td>
</tr>
<tr>
<td>Sample 1</td>
<td></td>
<td></td>
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<tr>
<td>Pre-Sweat</td>
<td>555</td>
<td>7.5</td>
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<tr>
<td></td>
<td>669</td>
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<tr>
<td></td>
<td>443</td>
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</tr>
<tr>
<td></td>
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<td>Lab accident</td>
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<tr>
<td>Plus Sweat, 1 week</td>
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<tr>
<td></td>
<td>225</td>
<td>6.5</td>
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</tr>
<tr>
<td></td>
<td>225</td>
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<td>0.2</td>
</tr>
<tr>
<td>Plus Sweat, 2 weeks</td>
<td>35</td>
<td>5.3</td>
<td>0.27</td>
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<tr>
<td></td>
<td>29</td>
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<td>0.21</td>
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<td></td>
<td>32</td>
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<td>0.17</td>
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<td>Plus Sweat, 3 weeks</td>
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<td>78.7</td>
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<td>Plus Sweat, 4 weeks</td>
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<td>25.6</td>
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<td>Pre-Sweat</td>
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<td>191</td>
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<tr>
<td>Plus Sweat, 1 week</td>
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<td>Plus Sweat, 2 weeks</td>
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<tr>
<td></td>
<td>5.8</td>
<td>2.4</td>
<td>0</td>
</tr>
</tbody>
</table>

* Hair shampooed every week day.

LW: Last Wash.

Cocaine must be present at ≥5 ng/10 mg hair. BE must be present at ≥0.5 ng/10 mg hair and ≥5% of cocaine. Wash criterion: Hair minus (5 × LW) must = ≥5 ng cocaine/10 mg hair.
External Contamination Issue in Hair: Observations

- Hair may be an ideal matrix to test for exposure of drugs in children; Distinguishing exposure and ingestion proves difficult in studies reviewed.

- Exposure to Drugs by Narcotic Officers: Real concern: Able to distinguish Use v. Exposure

- THC Exposure in Hair: Little Argument: THCA detection appears to be evidence of Use
External Contamination Issue in Hair: Observations

- Wash Procedures and Wash Criterion appear to be effective for distinguishing Contamination V. Use based on Studies

- Past Proposed Unique Biomarkers for Cocaine Use not unique –Search continues

- *In Vitro* Studies appear contradictory to Lab Procedure *In Vitro* Studies to distinguish Cocaine Exposure v. Use
Questions?