Competent Interpretation of PM BAC & Use of Alternative Matrices

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Ethanol Case #1

- SF, 38 yo WF, had 3 drinks & meal over 2 hrs
- On drive home failed to negotiate a curve
- Struck a light post, SF ejected (no SB), flew 30 feet into building wall
- Suffered massive thoracoabdominal/head injuries
- Coroner called to scene, DOA, examined body
- Collected PM specimens, released to FH
Ethanol Case #1

- PM alcohol 0.268g% by State Police Crime Lab
- Family brings Dram shop lawsuit vs. bar owner
  - Alleged improperly served her too much alcohol
  - Proximate cause of her death
- Bartender testifies served 3 standard rum & cokes (one shot, i.e. 1.25 oz rum per drink)
- Pt weight (145 lb), and 3 standard drinks over 2 hrs does not seem to correlate
Ethanol Case #2

- AJ, 47 yo male, motorcycle accident ~ 6/17/05 in south Texas, missing for 3+ days
- Body and cycle found by squirrel hunters down roadside embankment 6/20/05
- Autopsy performed 6/21/05
Ethanol Case #2

- Body extremely bloated, Severe decompositional Δ’s:
  - blisters, green-tan skin discoloration, extensive skin slippage & sloughing
  - All cavities contain gas and decomposition fluid & severe decomposition odor
  - All organs show extensive decomposition, but no other abnormalities

- Fx neck C1-2

- Cause of death: C-spine fx & spinal cord transection

- Manner of death: accident
Case #2 Toxicology

- Specimens sent to forensic lab
- Lab report: Heart blood specimen
  - Ethanol 0.09g/dL
  - Methanol ND
  - N-propanol +
  - Acetone +
  - Drugs of abuse ND
- No urine or vitreous sampling done
Case #3: Alcohol

- DS, 38 yo male went fishing alone in a small boat spring 2006 in Minnesota.
- Empty boat washed up on a nearby shore a day later.
- Body was found (no life vest) by dredging the lake, and was promptly refrigerated.
- Autopsy revealed a COD: drowning; MOD: accident
Case #3: Alcohol

- Peripheral BAC of 0.20 g%, other volatiles were negative;
- Vitreous ethanol 0.24g%;
- Urine ethanol 0.24 g%.
- Insurance death benefits denied due to alcohol intoxication; family appeals the decision, claiming he does not drink alcohol, and post-mortem alcohol production was the cause.
PMR and/or quality of results also depends on:

- Manner of death - trauma
- Stomach contents
- Conditions of storage of body - refrigeration
- Amount of decomposition/putrefaction
- Storage of blood: temp., preserv (NaF), time
- Type of blood tube (Li)
- Site of blood sample - C vs. P; ligated?
- Method of blood sampling (i.e. blind stick)
- Interpretation depends on type of blood tested: serum (plasma) v whole blood
Post-Mortem Ethanol Production

- Ethanol produced from fermentation of blood glucose & lactate
- Begins only after at least 2 days of decomposition through ≈ day 10
- Bacteria, yeast, Candida all can ferment
- Generally levels produced are < 50mg/dL (0.05gm%)
  - Although levels of 200mg% (0.20gm%) have been reported
Post-Mortem Ethanol Production

- When fermentation does occur, other volatiles are also produced:
  - Methanol, \( n \)-propanol, acetaldehyde, acetone
- Simultaneous urine, VH testing can distinguish
  - VH [EtOH] lags behind BAC, avg. 0.9-1.3 x BAC
  - Caveat: urine in DM can have higher PM EtOH production
- Cocaethylene NOT produced via this mechanism
- Ethyl glucuronide (ETG)
  - Used to monitor abstinence, present for 4-5 days post-ingestion
  - NOT produced by fermentation
  - Quandry: is +ETG due to acute intoxication, or just recent use
Method of sampling

- Blind chest stick to obtain blood
  - Most often by local coroners (often morticians, not MD’s)
  - Cardiac blood or great vessels
  - Contaminated with gastric contents, esp. with thoracoabdominal trauma
  - Can markedly elevate ethanol, drug levels if recently ingested
Alternative Matrices: Vitreous Humor Sampling

- VH Essentially 98% water with salt solution
- Very little protein
- Very isolated, not subject to PMR
- Useful when blood is not acceptable or available
  - Severely burned bodies
  - Exsanguinating trauma
  - Extensive decomposition: VH can remain sterile
Vitreous Humor

- Lags behind BAC
- Usually BAC is $< VAC$ since most deaths occur in post-absorptive, metabolizing phase of BAC-time curve
- Occasionally BAC $> VAC$, indicating death occurred during rising arm of BAC-t curve
- Very useful for corroborating BAC values
- Especially useful when blood is not available, or to confirm or dismiss PM fermentation
Urine Alcohol

- Usually 25% higher than BAC (wide variability)
- More prone to PM fermentation than WB, especially DM- EtS & EtG can discriminate
- Useful for corroborating BAC & VHAC values
- Especially useful when blood is not available, or to confirm or dismiss PM fermentation
Cavity Blood Alcohol Testing

- WB collected from hemothorax, hemoperitoneum
- Very prone to dilution, contamination from gastric/intestinal spillage
- Worst possible specimen for PM tox
- Useful only for qualitative
- Should always prompt VH, urine testing
Other Specimens for BAC Testing

- Subdural/Epidural hematoma blood
  - Isolated from general circulation, no metabolism
  - Acts as a snapshot of BAC at time of head trauma
  - Can be tested days later

- Skeletal muscle alcohol
  - Next most preferred/accurate specimen when WB, VH, Urine not available
  - Fair estimate of BAC at time of death
Conclusion of Ethanol Case #1

- 3 drinks in 145 lb would give BAC of 116mg% if 100% absorption, no metabolism
  \[ C_b = \frac{\text{Dose}}{(Vd)(\text{wt in kg})} = \frac{(3\times14)}{(0.55 \times 66)} \]
  \[ \approx 86\text{mg}\% \] if over 2 hrs

- Avg female needs 4 drinks to achieve BAC 0.08g%

- Family alleges bartender lying to protect himself, that drinks with double the alcohol would predict this BAC
  \[ 172-232\text{mg}\% \] if 3 “doubles” were served, with complete absorption, no metabolism

- Any other explanation? Important Issues?
Conclusion of Ethanol Case #1

- Coroners record: blood obtained via transthoracic
- No autopsy; “severely traumatized body”: DOA
- Very possible gastric rupture/spillage
  - 3 drinks, MVA a few minutes after leaving bar
  - Transthoracic specimens notorious for gastric alcohol contamination\(^1\)
- This could explain BAC higher than what was predicted
- Settled out of court, no details on award

Ethanol Case #2 Conclusion

- Due to severe decomposition, PM ethanol fermentation very possible
  - Appropriate temperature, lag time, conditions
  - Positive co-volatiles found:
    - N-propanol, acetone
    - Indicates + PM fermentation
    - Heart blood more susceptible- earlier bacterial contamin.
  - This means fermentation did take place
- Conclusion: Ethanol may be all due to PM fermentation
- Without VH alcohol, unable to conclude DWI
Case #3: Recap:

- Peripheral BAC of 0.20 g%, other volatiles were negative
- Vitreous ethanol 0.24 g%
- Urine ethanol 0.24 g%
Alcohol Case #3

- Body properly handled, stored
- Specimens appropriately obtained & analyzed
- Alcohol in peripheral blood corroborated by levels in VH, urine

Conclusion:
- Acute alcohol intoxication despite family contention that he does not drink


4. Baselt RC *Disposition of Toxic Drugs and Chemicals in Man, 7th ed.*; Biomedical Publications; Foster City, CA 2004


References


References


