Rational use and interpretation of Toxicology tests

Dr SH Tsui, Toxicology Subcommittee
JCM May 2012
Ten principles (commandments) on use of ancillary tests in Toxicology

To Illustrate by real cases

ECG not included in this talk
Commandment 1

- Rely on your clinical judgment; perform a test only when it is indicated

- Emergency Physicians: The last fortress to practice ‘Clinical’ Medicine?
Case

- F 3y.o.
- Witnessed by grandma to have overdosed ~ 30ml of Chlorpheniramine (piriton)
- Patient was sleepy on arrival
- Attempted to take blood for paracetamol, salicylates and ethanol levels; but with great difficulty.....
Is blood test indicated in this case?

- Screening for paracetamol, salicylates and ethanol levels only advocated for suicidal patients who may hide or unable to give a reliable history
- Or unexplained liver toxicity, renal toxicity or acidosis
- May pick up potentially treatable poisoning

Acetaminophen and Salicylate Serum Levels in Patients With Suicidal Ingestion or Altered Mental Status

KARL A. SPORER, MD,* HASSAN KHAYAM-BASHI, PhD†

AMERICAN JOURNAL OF EMERGENCY MEDICINE ■ Volume 14, Number 5 ■ September 1996
Case

- M51, good past health
- Hit by a private van at unknown speed while pushing a cart (working)
- BP 175/91, P 98 bpm, T 35.9C
- RR 16/min, SpO₂ 100%
- GCS: E3 V2 M5
- ‘Confused’
- Pupils 4mm E&R
Case

- Left frontal wound
- Glucose 8.4, Hb 14
- Trauma series: No #
- FAST: -ve
- ECG: SR

- Urine ACON…. Faint line next to ketamine
- Any comment?
Cause of confusion
Commandment 2

- Know the implications and limitations of the tests concerned

- Point-of-care urine test for substance of abuse (ACON®)

- Laboratory Toxicology screening test
Case

- M/ 24, good PH
- Quarreled with girlfriend recent 1 week
- Had dinner with GF and returned home
- Found confused the next morning by relatives
- 2 empty bottles found alongside: ~ 200 tabs of sleeping pills containing valerian and cyproheptadine
Case on arrival

- GCS E4M5V2 (11/15),
- BP 150/97, P 104
- SpO2 100% (High flow O2), RR 22
- Temp 36.1 °C, dry skin
- Pupil 3mm, reactive
- Power 3/5
- Bladder distended
Case

- Glucose 5.6, i-stat normal
- ECG: SR 100/min, QRS 100ms, QTc 412ms
- Foley inserted
- Urine ACON test
  - To do or not to do?
- Urine ACON test: +ve
  - Are you concerned?
  - Will you give physostigmine?
ACON® DOA Kits

- Lateral flow chromatographic immunoassay
- For **qualitative** detection of multiple drugs and its metabolites
- Fast and easy to use
- Presence of drug above cut-off conc:
  - Saturate all the binding sites of Ab
  - No labeled Ab retained in captured zone
  - **No colored line** → +ve
Control (C):

- A colored line will always appear at the control line region
- Indicating sufficient specimen volume, adequate membrane wicking and correct procedure technique

Make sure the Control line appear before you accept the result
- How to interpret this result?

- Only positive or negative

- **Weakly positive NOT exist!!**

- Faint line means negative
<table>
<thead>
<tr>
<th>Test</th>
<th>Calibrator</th>
<th>Cut-off (ng/ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amphetamine (AMP)</td>
<td>D-Amphetamine (P)</td>
<td>1000</td>
</tr>
<tr>
<td>Barbiturates (BAR)</td>
<td>Secobarbital (M)</td>
<td>300</td>
</tr>
<tr>
<td>Benzodiazepines (BZO)</td>
<td>Oxazepam (M)</td>
<td>300</td>
</tr>
<tr>
<td>Cannabinoid (THC)</td>
<td>11-nor-THC-9 COOH (P)</td>
<td>50</td>
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<tr>
<td>Cocaine (COC)</td>
<td>Benzoylecgonine (M)</td>
<td>300</td>
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<tr>
<td>Ketamine (KET)</td>
<td>Ketamine (P)</td>
<td>1000</td>
</tr>
<tr>
<td>Methadone (MTD)</td>
<td>Methadone (P)</td>
<td>300</td>
</tr>
<tr>
<td>Methylenedioxymethamphetamine (MDMA)</td>
<td>D,L Methylenedioxy-Methamphetamine (P)</td>
<td>500</td>
</tr>
<tr>
<td>Methamphetamine (MET)</td>
<td>D-Methamphetamine (P)</td>
<td>1000</td>
</tr>
<tr>
<td>Opioids/Morphine (MOP)</td>
<td>Morphine (P,M)</td>
<td>300</td>
</tr>
<tr>
<td>Tricyclic Antidepressants (TCA)</td>
<td>Nortriptyline (P,M)</td>
<td>1000</td>
</tr>
</tbody>
</table>

P: parent compound, M: metabolites
Bedside drug screening

Specific Limitations:

- False positive (cross reactivity)
- False negative
The Good: Cocaine, Cannabinoid, Barbituates, Methadone

The Bad: Amphetamine, MDMA, Opioids, Benzo, PCP

The Ugly: TCA
General Limitations

- Negative ACON test does not rule out poisoning, it only covers a number of abusive drugs.

- True positive only indicates exposure, not necessarily poisoning; and may not be even recent exposure.

- Technical error: adulteration of urine by dilution, addition of acids, bases, oxidizing agents (bleach, nitrite, peroxide, peroxidase) etc. may produce erroneous results.
Laboratory Toxicology Screening Test

- Usually works on urine, blood and gastric aspirates
- By employing multiple analytic methods: Immunoassay, HPLC, GC, GC/MS, LC/MS/MS
- More comprehensive but still not exclusive
- Panels established by individual laboratory varies and performance also varies
+ve and –ve predictive values of two hypothetical toxicology screens
Laboratory Toxicology Screening Test

Applications

- May provide additional information to confirm an episode of poisoning
- Sometimes may give unexpected results and shine light on difficult cases
- But most of the time NO ONE is paying attention to the result when it comes back few days later
- Role of A&E Toxicology Team
Case

- M/51
- Caucasian living with friend in Central
- Occupation: pilot
- Good past health
- Found vomiting with altered consciousness at home by his friend
- ? Limb twitching
- His friend claimed that patient had gone out to a pub in Wan Chai tonight; unsure if he had taken alcohol or not
Vital sign and P/E on arrival to AED

- BP 167/87mmHg, P 46 bpm
- Temp 35.7°C (rectal)
- RR 16
- GCS E1V1M6 (total 8/15)
- SpO2 97% on RA
- Pupil size 3mm bilaterally, reactive
- Resp and CVS: unremarkable
- Abd: soft
- neck soft
- Neurological exam: unremarkable
- small area of abrasion at right forehead
A typical clinical course follows

- You suspect GHB poisoning
- Urine sent to laboratory for Toxicology screening
Here is the result

Date Collected: 09/11/08 01:45

Clinical Details: AGITATED

<table>
<thead>
<tr>
<th>pH</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ketones</td>
<td>Negative</td>
</tr>
<tr>
<td>Glucose</td>
<td>Negative</td>
</tr>
</tbody>
</table>

Toxicology screening (Urine):
None of the compounds on the following list are detected.

The following drugs (if present) can be identified by this laboratory:

<table>
<thead>
<tr>
<th>ANALGESICS</th>
<th>ANTIDEPRESSANTS</th>
<th>ANTIHISTAMINES</th>
<th>Carbazepine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mefenamic acid</td>
<td>Amitriptyline</td>
<td>Diphenhydramine</td>
<td></td>
</tr>
<tr>
<td>Meperidine</td>
<td>Amoxapine</td>
<td>Pheniramine</td>
<td></td>
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<tr>
<td>Naproxen</td>
<td>Desipramine</td>
<td></td>
<td></td>
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<tr>
<td>Paracetamol</td>
<td>Dexamethasone</td>
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<tr>
<td>Propoxyphene</td>
<td>Imipramine</td>
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<tr>
<td>Salicylate</td>
<td>Lorazepam</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BARBITURATES</td>
<td>Trazodone</td>
<td>Phentermine</td>
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<tr>
<td>Amobarbital</td>
<td>Trimepramine</td>
<td>Phenylpropanolamine</td>
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<tr>
<td>Aprobarbital</td>
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</tr>
<tr>
<td>Barbital</td>
<td>Hypnotics</td>
<td>Narcoic</td>
<td>Propranolol</td>
</tr>
<tr>
<td>Butobarbital</td>
<td>glutethimide</td>
<td>Benzoylcocholine/cocaine</td>
<td>Quinine/Quinidine</td>
</tr>
<tr>
<td>Pentobarbital</td>
<td>Methaqualone</td>
<td>Codeine</td>
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<tr>
<td>Phenobarbital</td>
<td>Methadone</td>
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<tr>
<td>Secobarbital</td>
<td>BZKOTDIAZEPINES</td>
<td>Morphine</td>
<td></td>
</tr>
</tbody>
</table>
3. Has a fair idea what tests are provided by your hospital laboratory, cluster laboratory and Toxicology Reference Laboratory

4. Maintain good communication with your laboratory counterparts
Every laboratory is different

- Some tests are routinely done
- Some tests cannot be done
- Some tests can be done on special request

TABLE 6-5. Xenobiotics of Concern that are Often not Detected by Toxicology Screens

<table>
<thead>
<tr>
<th>Antidyssrhythmic</th>
<th>γ-Hydroxybutyrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anticholinergics</td>
<td>Herbal preparations</td>
</tr>
<tr>
<td>Anticoagulants</td>
<td>Hypoglycemics</td>
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<tr>
<td>Anticonvulsants</td>
<td>Iron</td>
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<tr>
<td>Antipsychotics</td>
<td>Isopropanol</td>
</tr>
<tr>
<td>β-Adrenergic agonists and antagonists</td>
<td>Ketamine</td>
</tr>
<tr>
<td>Calcium channel blockers</td>
<td>Lithium</td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>Lysergic acid diethylamide</td>
</tr>
<tr>
<td>Clonidine</td>
<td>Methylene dioxyamphetamine</td>
</tr>
<tr>
<td>Cyanide</td>
<td>Methylene dioxymethamphetamine</td>
</tr>
<tr>
<td>“Designer drugs”</td>
<td>Metals</td>
</tr>
<tr>
<td>Digoxin</td>
<td>Methanol</td>
</tr>
<tr>
<td>Diphenhydramine</td>
<td>Methemoglobin</td>
</tr>
<tr>
<td>Ethylene glycol</td>
<td>Solvents</td>
</tr>
<tr>
<td>Fentanyl</td>
<td>Serotonin reuptake inhibitors</td>
</tr>
<tr>
<td></td>
<td>Strychnine</td>
</tr>
</tbody>
</table>

Goldfrank’s 9th
What is meant by good communication?

- Input important **clinical information** into the laboratory request form; esp Toxidrome, suspected culprit drug or class of drugs

- **Electronic poisoning form** in CMS

- **Direct discussion** with laboratory counterparts concerning your worry and see what helps they can offer
AED Poisoning Case Management Form

Hospital Authority
Queen Mary Hospital

Sex: F Age: 32y
Ward: AE01 Spec: A&E

Chief complaints:
DO Stilnox of 30 tabs from MN to 4 am
Presented with decrease in responsiveness

Medical history:
Bipolar disorder FU private

Poison details:
Poison name: Zopidem
Category: Pharmaceutical
Dose: 30 tablet Route: Oral
Start from: 19/04/2012 to 19/04/2012 04:00
Reason of exposure: Intentional
Place of exposure type: Self-harm Category of exposure place: Home
Exposure address: --
Exposure district: --
AED Poisoning Case Management Form

Vital sign:
Body temp: 36.3°C  BP: 94/53 mmHg  Pulse: 74 b/min
Respiration rate: 16 per min  SpO2: 96% on room air
COHb: --%  MethHb: --%
GCS score: 13/15 (E: 3  V: 4  M: 6)
Pupils size: Right 5 mm (Reactive to light, -)
Left 5 mm (Reactive to light, -)

Clinical findings:
Sleepy

Bedside Investigations:
ECG normal
QRS: 92ms, Qtc: 429ms
ECG findings: Rate 65

Laboratory investigations:
Request submitted to Toxicology Reference Laboratory: No

Laboratory test requested

For professional communication only.
What is meant by good communication?

- Input important **clinical information** into the laboratory request form; esp Toxidrome, suspected culprit drug or class of drugs

- **Electronic poisoning form** in CMS

- **Direct communication** with laboratory counterparts concerning your worry and see if what helps they can offer
GHB

- rapidly absorbed and metabolized
- Mean elimination half-life is 30 to 50 minutes
- Detection period:
  - <6-8 hrs in plasma
  - <10-12 hrs in urine
- Preferred specimen: first catch urine
In QMH: Targeted analysis with GC-MS is necessary for detection of GHB and **must be specifically requested**.

In our case: **Marked excretion of GHB was detected in the urine and diagnosis was confirmed**.
Commandment 5

- Toxicology tests should be performed and interpreted timely

- Have you got some examples in your mind?
Paracetamol poisoning

- F25, DO of paracetamol 20 tabs 5 hours ago before presentation to A&E
- Together with beer, vomited twice
- Paracetamol level checked in A&E (6 hours post ingestion)
- Patient admitted EMW but

- No one remember to trace the result…
Paracetamol normogram

![Diagram showing Acetaminophen plasma concentration vs. hours post-ingestion]

**Treatment window**

Unit conversion: 1 mg/L (or µg/ml) = 6.6 µmol/L
Rat poison ingestion

- Warfarin or superwarfarin: expected delay for prolongation of INR:
  1. Time needed to deplete the existing store of Vit K
  2. Time needed to deplete the existing coagulating factors (VII)

- $\sim 3 \times T_{1/2}$ of Factor VII = 15 hours
For acute accidental ingestion and symptomatic: repeat INR at 48 hours to clear patient

For intentional overdose: check baseline, then every 12 hours to identify coagulopathy. Increase frequency of monitoring if INR prolongation occurs
Case

- F/45, asthma FU QMH
- Depression FU Western Psychiatric Centre
  - Venlafaxine
  - Zolpidem
- C/O: Dizziness, vomiting and generalised weakness for 1/7
- BP 111/53 mmHg, P 117 bpm
- Temp 36°C
- RR 16/min, SpO₂ 98% R.A.
- Noticed to have intermittent limb twitching in cubicle
- GCS 15/15 all along, restless\(^+\), agitated\(^+\)
- CVS: tachycardia, irregular pulse\(^+\), no murmur
- Resp: unremarkable except tachypnoea
- CNS:
  - Tone normal at rest
  - Intermittent 4 limbs twitching and spasm
  - Power full over 4 limbs
  - No neck rigidity, pupils E/R bilaterally
- Abdomen: NAD
- CXR: normal findings
- H’stix = 15.3 mmol/L
- Serum ketone = 0.8 (low)
- Urine tests
  - Acon test all –ve
  - WBC –
  - RBC –
  - Glucose +++
  - Albumen –
  - Ketone +++
Causes to consider

- Metabolic cause
  - DKA
  - Thyroid storm
- Cardiovascular cause
  - Myocarditis
  - Cardiomyopathy
- Sepsis
- CNS disease
  - ICH

Poisoning to be considered
- Theophylline
- Salicylates

But patient strongly denies DO
Progress

- Urgent theophylline level arranged with Clinical Biochemist
- They can give us the result in half hour!
Commandment 6

- One should know which drug/toxin levels have to be done; which really affect patient management
### Drug/Toxin levels that affects management

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>COHb, MetHb</td>
<td>Paracetamol</td>
</tr>
<tr>
<td>Digoxin</td>
<td>Salicylate</td>
</tr>
<tr>
<td>Ethanol</td>
<td>Theophylline</td>
</tr>
<tr>
<td>Iron</td>
<td>Valproate</td>
</tr>
<tr>
<td>Lithium</td>
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</tbody>
</table>

- Recommended by COC (Path) to be available round the clock
Ethanol level

- Should we routinely check ethanol level in drunk patients?
- From time to time there are drunk patients dead in A&E because of complications or other missed diagnosis
- Some clinicians recommend checking ethanol levels for all drunk patients
- Practical difficulty in situation in HK
- Patient in deep coma

- Patient with prolonged depression of conscious level with no improvement upon observation

- Patient with atypical presentation
Many more drug levels are not useful in patient management.

Metformin-Associated Lactic Acidosis in Chinese Patients with Type II Diabetes

Chun Wing Yeung\textsuperscript{a}, Ho Yin Chung\textsuperscript{b}, Bonnie Mei Wah Fong\textsuperscript{a}, Nga Wing Tsai\textsuperscript{c}, Wai Ming Chan\textsuperscript{c}, Tak Shing Siu\textsuperscript{a}, Sidney Tam\textsuperscript{a}, Sik Hon Tsui\textsuperscript{b}

\textsuperscript{a}Division of Clinical Biochemistry, \textsuperscript{b}Department of Accident and Emergency, and \textsuperscript{c}Adult Intensive Care Unit, Queen Mary Hospital, Hong Kong, SAR, China

Risk factors of mortality were identified as shock and high plasma lactate levels. The majority of patients were found to have significantly raised creatinine versus a normal baseline value before the acute illness. Concomitant illnesses taking place alongside MALA were common. With a high utility rate of renal replacement therapy (82.6\%) in the study group, the mortality rate was 30.4\%.
Case

- F / 91yo
- HT, AF with VVIR, dementia
- Accidentally took 8 times the normal dose of medications
  - Aspirin (x80mg)
  - Digoxin (x62.5mcg)
  - Lisinopril (x2.5mg)
  - Adalat Retard (x20mg)
- Last dose 30min before admission
Case

- Alert
- BP 79/39 P 89
- Temp. 36.1°C
- GCS 15/15
- Glucose 8.4
- Hb 10.9
- Na/K 140/4.1
Calcium and IV fluid given

<table>
<thead>
<tr>
<th>BP</th>
<th>Pulse</th>
<th>0850</th>
<th>0807</th>
<th>0819</th>
<th>0847</th>
<th>0914</th>
<th>0937</th>
<th>0942</th>
<th>0950</th>
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</tbody>
</table>
■ Digoxin level came back soon: **11.2 nmol/L**
■ Reference level: 1.3 – 2.6 nmol/L
■ Digitalis antibody was given

■ Was the treatment indicated?
Patient was stable at that juncture; no clinical indication

Action level quoted by HKPIC was >12nmol/L for acute toxicity

However it refers to post distribution, i.e. >6 hours post ingestion
Commandment 7

- Treat the patient, not the laboratory result

- Be careful with the Units (Conventional vs SI) for laboratory results and take reference to individual laboratory reference levels when making clinical decisions
Paracetamol normogram
Nomogram for Paracetamol Poisoning

Plasma Paracetamol Concentration

µg/mL

µmol/L

Potential for Toxicity

Toxicity Unlikely

Recommend treatment if level is above broken line

Hours Post-Ingestion

Unit conversion: 1mg/L (or µg/mL) = 6.6 µmol/L

(adapted from the HKPIC Nomogram)
Commandment 8

- Be familiar with the use and interpretation of common tests that are very useful for poisoning diagnosis and management.
Examples include

- COHb, MetHb levels
- RFT
- Blood gas analysis
- Lactate
- Anion Gap
- Osmolar Gap (serum osmolarity)
Case

- M/45, chronic alcoholic
- c/o palpitation, chest & epigastric discomfort, SOB for 1/52
- Poor oral intake, vomiting +
- GCS 15, BP 115/73, P 141, RR 28, SpO₂ 100% in RA, Temp 36.7C
- P/E: mild dehydration, chest clear, no abd. sign
Case

<table>
<thead>
<tr>
<th>Test</th>
<th>Result</th>
<th>Reference Range</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood pH</td>
<td>7.09 L</td>
<td>7.35 - 7.45</td>
<td>kPa</td>
</tr>
<tr>
<td>Blood pCO2</td>
<td>1.42 L</td>
<td>4.70 - 6.00</td>
<td>kPa</td>
</tr>
<tr>
<td>Blood pO2</td>
<td>18.25 H</td>
<td>10.60 - 13.30$</td>
<td>kPa</td>
</tr>
<tr>
<td>Base Excess (vt)</td>
<td>-24.3 L</td>
<td>-3.0 - 3.0</td>
<td>mmol/L</td>
</tr>
<tr>
<td>Bicarbonate (act)</td>
<td>3.1 L</td>
<td>20.0 - 26.0</td>
<td>mmol/L</td>
</tr>
<tr>
<td>O2 Saturation</td>
<td>98</td>
<td>&gt;95</td>
<td>%</td>
</tr>
</tbody>
</table>

- How to interpret?
- What additional information do you need?
Analysis

- pH 7.09 → **Acidaemia**
- Acidaemia with low HCO$_3$ level 3.1 (20 – 26) → **metabolic acidosis**
- Metabolic acidosis with low pCO$_2$ 1.42 (4.7 – 6) → **respiratory compensation** occurs
- Is the respiratory compensation appropriate /adequate or in fact hyperventilation occurring?
Winter’s equation

- Predicts the degree of respiratory compensation in the setting of metabolic acidosis

\[ \text{PCO}_2 \text{ (mmHg)} = (1.5 \times \text{HCO}_3) + 8 \pm 2 \]

- In our case: calculated \( \text{PCO}_2 = 1.5 \times 3.1 + 8 \pm 2 = 12.65 \pm 2 \text{ mmHg} \)

- Measured blood \( \text{PCO}_2 = 1.42 \text{ kPa} = 1.42 \times 7.5 = 10.65 \text{ mmHg} \)

- **Conclusion:** Metabolic acidosis with respiratory compensation
A case of severe metabolic acidosis

More information that may help your case analysis

- Na 147, Cl 91
- Glucose 3.3
- Urea 3.3, ethanol level 38
- Serum osmolarity 355
- Serum lactate: 6.3mmol/L (0.5-2.2)
■ Anion gap
  ■ \( \text{Na} – \text{Cl} - \text{HCO}_3^- = 147 – 91 - 3.1 = 52.9 \) (normal 12+/−4)

■ Osmolar gap = Measured osmolality – calculated osmolarity
  ■ Calculated osmolarity
  ■ \( \text{Na} \times 2 + \text{urea} + \text{glucose} + \text{ethanol} \) (all in mmol/L)
  ■ \( 147 \times 2 + 3.3 + 3.3 + 38 = 338.6 \)
  ■ OG = 16.4 (normal -10 to 14)
High AG metabolic acidosis (52.9)

- Lactate: 6.3
- Urine ketostix® negative
- Urine ketones by laboratory (acetoacetate and β-hydroxybutyrate): \(50\text{mg/dL} \, ++\)
- Consider KULT

- Dx: Alcoholic ketoacidosis
Commandment 9

- Do no harm!

- E.g. Multi-panel metal testing on hair or mobilized urine samples

- For children with eczema, autism, hyperactivity, poor academic performance...

- Result bound to be positive for some panels
Case

- F36, good PH
- Paracetamol overdose, claimed 20 tabs
- Delayed presentation at 12 hours
- Epigastric pain and vomiting
- NAC given
### Mx in EMW

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- Paracetamol 240
- Salicylate <0.3 L
- Ethanol <3.0

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**Note:** The image shows a laboratory report with a focus on electrolyte and liver function tests. The report includes dates, times, and values for various parameters such as Na, K, chloride, urea, creatinine, glucose, calcium, and more. The report also highlights abnormal values for Paracetamol, Salicylate, and Ethanol.
## Serial LFT

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Commandment 10

- Don’t hesitate to consult the experts if needed
Suggested Management

- Frequent clinical evaluation and monitoring
- Check prognostic markers: ABG, RFT, PT, Lactate, PO₄, αFP
- Continue NAC
- Monitor LFT
When to stop NAC?

Textbook guideline:

- Asymptomatic
- AST / ALT <1000
- Negligible paracetamol level
When to stop NAC?

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Ref. Range Units

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Request No. : C2161259 C2160120 C2161370 C2162817 C2170735
Remark : panadol panadol panadol panadol panadol
          overdose. overdose. overdose. overdose overdose
          panadol liver liver
          overdose damage damage

Units

76
Expert opinion

- AST (cytosolic and mitochondrial) vs. ALT (cytosolic)
  - AST higher intracellular abundance
  - AST shorter half-life
  - AST initially higher than ALT
  - **AST declines more rapidly due to shorter $T_{1/2}$**

- AST the better marker to gauge the clinical course
1. Rely on your clinical judgment; perform a test only when it is indicated

2. Know the implications and limitations of the tests concerned

3. Have a fair idea what tests are provided by your hospital laboratory, cluster laboratory and Toxicology Reference Laboratory
4. Maintain good communication with your laboratory counterparts

5. Toxicology tests should be performed and interpreted timely

6. Know which drug/toxin levels that will affect your patient management
7. Treat the patient, not the laboratory result; and beware of the units

8. Be familiar with other common tests that are very useful for poisoning management

9. Do no harm!

10. Consult the experts
Thank you!