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## Clumsy Coagulation Communication
## Let's Blame the Lab!

George A Fritsma MS, MLS
The Fritsma Factor, Your interactive Hemostasis Resource℠
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## Lab–Clinician Communication

- Barriers and opportunities
- Where are the errors made?
- How do we enhance patient experience?


"This concludes my lecture on non-verbal communication. Any comments or questions?"



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## Total Testing Process

| Lab Consult | Lab Consult | Lab | Lab Consult | Lab Consult |
|---|---|---|---|---|
| **"Pre-pre" Analytical** | **Pre-Analytical** | **Analytical** | **Post-analytical** | **"Post-post" Analytical** |
| Pt visits Dr with specific complaint | Collector addresses Pt, collects spec | MLT/S performs assay | Lab personnel publish and deliver report | Dr & staff interpret results |
| Dr & staff select and order "labs" | Select tube, fill, invert, ID, manage spec | Validate, internal and external QC | Narrative, direct to electronic health record | Dr & staff treat Pt |

- Ward-Cook KM, Lehmann CA, Schoeff LE, Williams RH. Clinical Diagnostic Technology—The Total Testing Process, 2004, AACC Press
- Laposata M. Clin Chem Lab Med 2007;45:712–9



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## IOM: Quality Domains

- Patient-centered
- Equitable
- Effective
- Efficient
- Timely
- Safe

Institute of Medicine: Crossing the quality chasm: a new health care system tor the 21st century. Washington, DC: National Academy Press. 2001.


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## Quality Assurance in the 1990s

- 1996–7: CAP error rate improvements
  - Improved internal and external QC approaches
  - Automation reduced errors
- Plebani; 1997 error rates, confirmed 2007: pre, 68%; analytical,13%; post,19%
  - "The evil is in the boundaries," interface of lab and clinic
  - Poor *extra-analytical* error rate attention & documentation
  - Pre-analytical: ID errors, poor tube-filling, blood/AC ratio
  - Post-analytical: gaps in data *receipt, reading, interpreting, usage*
  - No assay interpretation and no consultation
  - Indiscriminate POC test adoption

Plebani M. Exploring the iceberg of errors in laboratory medicine. Clinica Chimica Acta 2009; 404: 16–23.



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## Quality Improvement in the 1990s

- QI initiatives address extra-analytical errors
- Reliable patient ID
  - Bar codes, requirement of two data pieces
- Quality criteria for specimen acceptance
- 1998: "patient-centered" clinical consults
  - Define: ID defects that can have negative patient impact
  - The "brain-to-brain loop"

Lundberg GD. The need for an outcome research agenda for clinical laboratory testing. JAMA 1998;280:565–6.

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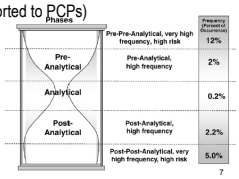
## Quality Assurance in the 2000s

- Hazard Analysis and Critical Control
  - Stroobants: "Pre-pre" error rate 12%, "post-post" 5%
- Primary care physician errors: Hickner
  - Test ordering: 12.9%
  - Results returned to clinician: 24.6%
  - Misfiling and poor chart availability: 17.6%
  - Analytical errors: 0 (not reported to PCPs)

Stroobants AK. Goldschmidt HM, Piebani M. Error budget calculations in laboratory medicine: linking the concepts of biological variation and allowable medical errors. Clin Chim Acta 2003;333:169–76.
Hickner J, Graham DG, Elder NC, et al. Testing practices: a study of the American Academy of Family Physicians National Research Network. Qual Saf Health Care 2008;17:194–200



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## A Personal Experience

| CBC | Patient | RI |
|---|---|---|
| MCV | 104 fL | 80–100 fL |
| MCH | 33 pg | 26–32 pg |
| MCHC | 34% | 32–36% |
| Urinalysis | 1+ bili | No bili |

CBC, UA, chem panel, lipids WNL
Repeated after 4 weeks, identical results.
Would you follow up?

- Liver enzymes normal
- Repeat CBC, same results, no blood film exam
- B12 and folate specimen neglected and discarded



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## Quality Assurance in the 2000s McGlynn Study

- 6712 adults in 12 metropolitan areas
- 439 quality care indicators
- 61% had the correct laboratory test ordered
- 55% received lab-recommended care

McGlynn EA, et al. N Eng J Med 2003; 348:2635–45


"What's the opposite of 'Eureka!'?"



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## Primary Care Practice Errors Malpractice Claim Review

- Adverse consequences of errors
  - No consequences, 26%; delay in care, 24%; financial loss, 22%; pain and suffering, 11%; other, 17%
- Malpractice claims of lab & imaging errors
  - Adverse physical outcomes, 58%; death, 30%
  - Missed diagnosis: cancer, 59%; infections, 5%; fractures, 4%, acute myocardial infarction (AMI), 4%
  - Failure to order appropriate test, 55%; ordered but not performed, 9%; lab performed incorrectly, 8%; PCP did not receive results, 12%; incorrect interpretation, 37%
- PCPs who monitor error reduce errors by 50%

Gandhi TK, Kachalia A, Thomas EJ, et al. Missed and delayed diagnoses in the ambulatory setting: a study of closed malpractice claims. Ann Intern Med 2006;145: 488–96.



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## PCP Post-post Analytical Errors

- Diagnostic errors more frequent & cause more harm than Rx errors
- Types of post-post errors
  - Incorrect interpretation, 37%; inappropriate or inadequate follow-up, 45%; failure to refer, 26%
- Factors contributing to errors
  - Inadequate judgment, 70%; vigilance or memory, 59%; knowledge, 48%; patient-related, 46%; handoffs, 20%
  - Multifactorial: 54% of errors involve 3 process breakdowns; 29%, 4 or more
  - Multi-clinician: 43% of errors involve 2 or more physicians; 16% 3 or more



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## Post-post Analytical Errors

- Duplicate health records
  - 400,000 HRs, 17,000 duplicates (4%), often single-entry
  - Labs: HGB A1c, TSH, LDL, vitamin $B_{12}$
  - Missed abnormal laboratory results, overall, 35%
  - 38% missed duplicate records compared to 28% in single
  - 18% abnormal results in secondary record
  - Odds ratio 1.44 of missing abnormal lab results in duplicated records
- Other reasons for missed lab results
  - Mass screening: OR 2.22
  - Old age: OR rises 1.15 per decade

Joffe E, Bearden CF, Byrne MJ, Bernstam EV. Duplicate patient records—implication for missed laboratory results. AMIA Annu Symp Proc. 2012; 2012: 1269–75.

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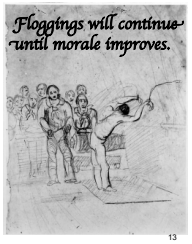
## Reducing Diagnostic Errors

- Resolve error and educate, don't punish
  - Disseminate practice guidelines & standards; provide clinical trial results coupled with expert opinions
  - Enhance clinician knowledge of lab tests
  - Audit errors
- Improve systems
  - Modify laboratory test reqs for easy reading
  - Formulate *clinical queries* in place of test requests
  - Computerize order entry, check redundancy, duplicate records
  - Computerize decision-making strategies



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## Cleveland Clinic Test Utilization Committee Order Duplication Review

- In 2010, of 4,326,387 selected inpatient tests, 27,549 (0.64%) were ordered more than once a day
- K. Marchant created list of tests that shouldn't be ordered more than once a day, confirmed with medical staff
- Implemented "hard stops" for attempted duplicate orders
- Means for the caregiver to still order the test, but with documentation and lab approval

Marchant K, Procop G; Test Utilization Committee



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## Cleveland Clinic Test Utilization Committee "Hard Stop" Assays

- Quantitative transplant viruses: CMV, EBV, BKV
- Molecular thrombosis markers: FVL, FII 20210
- Total cholesterol, HDL, LDL, triglyceride
- *Clostridium difficile* EIA
- Thrombophilia panel
- Reticulocyte count
- CRP, HGB A1C
- Hepatitis panel
- Iron and TIBC

Kandice Marchant, MD



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## CC Cost Savings Through 2013

| Intervention | Number | Savings |
|---|---|---|
| Hard stops | 18, 160 | $295,507 |
| Restricted use | 273 | $711, 026 |
| Genetics counselor required | 261 | $820,887 |
| Regional smart alert | 5625 | $46,031 |
| Expensive test notification | 66 | $91,828 |
| Total | 24,385 | $1,965,279 |

Procop G. Strategies for Appropriate Test Utilization—The Right Test for the Right Patient at the Right Time



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## Improvements in the 2000s

- Improving lab interest in patient safety, focus on how lab errors cause adverse patient events
- Improving failure analysis, error definitions
- Collecting evidence for "extra-analytical" errors
- Applied patient safety incentives, redundancy, and data backups to insure clinician response
- Recognize that IT alone can't improve error rate
  - Computerized entry systems can actually raise error rate
- Developing lab-clinician interface
  - Emphasis on evidence-based practice: clinical trial data, standards
  - The diagnostic management team (DMT), M. Laposata, UTMB Galveston
  - Improve test selection, eliminate obsolete tests
  - Control POC testing



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## Challenges in the 2000s

- Laboratory service consolidation
  - Commoditization and outsourcing
  - Less emphasis on extra-analytical variation
  - Specimen management confounded by transport, storage, time
- Professional staff reduction
  - Reduced retention, increased turnover, need to educate staff
  - Workload redirects staff attention from extra-analytical error
  - Adoption of lower-level staff in less demanding positions
  - Easy-to-use instruments don't improve error rate
  - Phlebotomist not responsible for the lab assay
  - Outcome: slow deterioration of service
- Balance cost-per-test with patient care value

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## Factors Driving Complexity

- Information explosion
  - 20,000 medical journals, thousands of DRGs
  - Increasing number of drugs, "designer" drugs
- Health care reform
  - Millions of additional health care consumers
  - Focus on value: benefit/cost
- USA Today 9.24.12: "Accountable Care Organizations Experience Record Profits"
  - Accountable care measures: team coordination, reduced blood usage, early intervention, reduced redundancy, life style
  - Electronic health records with hand-held devices
- Laboratory provides best benefit/cost
  - Laboratory supports 70% of medical decisions
  - Laboratory spends 2% of CMS charges



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## Lab-centered Enhancements

- Test order is made by clinical query
- Test profile algorithms
- Label verified by patient after collection
- Simple SOPs for specimen management
- Evidence-based specimen acceptance criteria: is hemolysis really so bad?
- Reliable information technology
- Rapid transmission of critical results with read-back protocols, especially to ER
- Narrative interpretations



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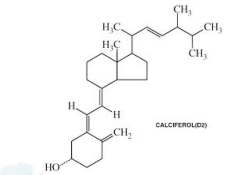
## Pre-pre: Test Ordering

An order arrives with a serum-separator tube requesting "Vitamin D." How do you log it?






- Kleerekoper M, Schleicher RL, Eisman J, et al. Clinical applications for vitamin D assays: what is known and what is wished for. Clin Chem 2011;57:1227–32.
- Passiment E, Meisel JL, Fontanisei J, Fritsma GA, Aleryani S, Marques, M. Decoding laboratory test names: a major challenge to appropriate patient care. J Gen Intern Med DOI 10.1007/s11606-012-2253-8

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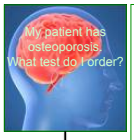
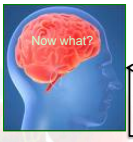
## "Pre-pre" Analytical Error: Test Selection




**Experts identify multiple vitamin D forms with no naming consensus:**

- calciferol
- cholecalciferol
- 1,25 dihydroxycholecalciferol
- ergosterol
- vitamin D
- vitamin D2
- vitamin D3
- 25-0H vitamin D*
- 25-0H vitamin D2
- 25-0H vitamin D3
- 25 hydroxy vitamin D
- 25 hydroxy vitamin D2
- 25 hydroxy vitamin D3
- 1,25 $(OH)_2$ vitamin D
- 1,25 $(OH)_2$ vitamin D2
- 1,25 $(OH)_2$ vitamin D3
- 1,25 dihydroxy vitamin D
- 1,25 dihydroxy vitamin D2
- 1,25 dihydroxy vitamin D3

**Which is correct?**




**Lab director coins arbitrary assay names, IT director creates arbitrary LIS mnemonics:**

- Vitamin D, VITD
- 25-0H vitamin D, 25-OH VITD

**Result:** 60 ng/mL



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## Pre-pre Naming Problems What's in a name?




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## Pre-pre Issues, Not Name-related

- PTT ordered for LMWH or fondaparinux?
- PTT interpretation in UFH Rx: 1.5–2.5 X MRI?
- Interpret PT and PTT when LA present?
- Lupus anticoagulant: what is it, what do you do?
- What is in a thrombophilia profile?
- How to test for the new direct oral A/Cs?
- What is in a VWD profile?

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## Pre-pre Issue: Pre-op Screen

| Assay | Patient | RI |
|---|---|---|
| HGB | 14.2 g/dL | 13.5–15.6 g/dL |
| PTT | 29 s | 25–35 s |
| PT | 12.4 s | 9.8–12.6 s |
| BT | 16.5 m | 2–9 m |
| PLT count | 310,000/µL | 250–450,000/µL |
| Fibrinogen | 270 mg/dL | 150–400 mg/dL |
| D-dimer | 190 ηg/mL | 110–240 ηg/mL |
| No bleeding Hx, surgeon postpones procedure | | |

**What do you recommend?**



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## Pre-pre Issue: Pre-op Screen

| Assay | Patient | RI |
|---|---|---|
| HGB | 10.2 g/dL | 13.5–15.6 g/dL |
| PTT | 29 s | 25–35 s |
| PT | 12.4 s | 9.8–12.6 s |
| PLT count | 310,000/µL | 250–450,000/µL |
| Fibrinogen | 270 mg/dL | 150–400 mg/dL |
| D-dimer | 160 ηg/mL | 110–240 ηg/mL |
| Hx: Easy bruising, chronic epistaxis, prolonged bleeding after shaving. Surgeon decides to go ahead with procedure. | | |

**What do you recommend?**



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## Pre-pre Issue: Pre-op Screen

| Assay | Patient | RI |
|---|---|---|
| HGB | 14.2 g/dL | 13.5–15.6 g/dL |
| PTT | 59 s | 25–35 s |
| PT | 12.4 s | 9.8–12.6 s |
| PLT count | 310,000/µL | 250–450,000/µL |
| Fibrinogen | 270 mg/dL | 150–400 mg/dL |
| No bleeding Hx, surgeon postpones procedure | | |

**What do you recommend?**



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## Pre-pre: Thrombophilia Screen

| Assay | Patient | RI |
|---|---|---|
| Protein C Activity | 61% | >70% |
| Protein S activity | 69% | >65% |
| Antithrombin activity | 27% | 78–126% |
| Factor VIII | 125% | 50–186% |
| APCR | 2.4 | >1.8 |
| Factor II 20210 | Wild-type | Wild-type |
| PTT-LA | 34 s | 30–40 s |
| Homocysteine | 9 ηmol/L | >18 ηmol/L |
| 50-YO man with DVT on UFH 4 days, physician ordered this thrombophilia profile | | |

**What do you recommend?**



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## Pre-pre: Thrombophilia Screen

| Assay | Patient | RI |
|---|---|---|
| Protein C Activity | 35% | >70% |
| Protein S activity | 39% | >65% |
| Antithrombin activity | 57% | 78–126% |
| Factor VIII | 125% | 50–186% |
| APCR | 2.4 | >1.8 |
| Factor II 20210 | Wild-type | Wild-type |
| PTT-LA | 39 s | 30–40 s |
| Homocysteine | 3.9 ηmol/L | <4.3 ηmol/L |
| 60-YO woman, DVT; on Coumadin 3 w, physician ordered this thrombophilia profile | | |

**What do you recommend?**



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## "Pre" Error: Specimen Management

- A phlebotomist collects a PT/INR specimen using a "tiger-top" tube. The patient, who is on Coumadin, inquires about the cap; when she leaves, he transfers the specimen to a blue-closure tube and makes no note.
- What is in a tiger-top?
- What is the likely consequence?

## Wrong Anticoagulant?

| Assay | Citrate | EDTA | Heparin | Serum |
|---|---|---|---|---|
| PTT | 29s* | 68s* | >180s | >180s |
| PT | 12.4s* | 23s* | >60s | >60s |
| FVII:Act | 115% | 116% | 77% | 308% |
| FVIII:Act | 141% | 4.5% | <1% | 4.5% |
| FIX:Act | 122% | 115% | <1% | 350% |
| VWF:Ag | 122% | 143% | 70% | 101% |
| VWF:RCo | 114% | 131% | 37% | 74% |
| PC:Act | 111% | 152% | <1% | <1% |
| PS:Act | 96% | 30% | <1% | 21.6% |
| *Means | | | | |

Data courtesy of Dorothy Adcock-Funk, MD, Esoterix Coagulation

Adcock, DM, Hoefner DM, Kottke-Marchant K. Collection, transport, and processing of blood specimens for testing plasma-based coagulation assays and molecular hemostasis assays; Approved Guideline–5th Edition, CLSI H21-A5; 2008.
Adcock-Funk DM, Lippi G, Favaloro EJ. Quality standards for sample processing, transportation, and storage in hemostasis testing. Semin Thromb Hemost 2012; 38: 576–85.

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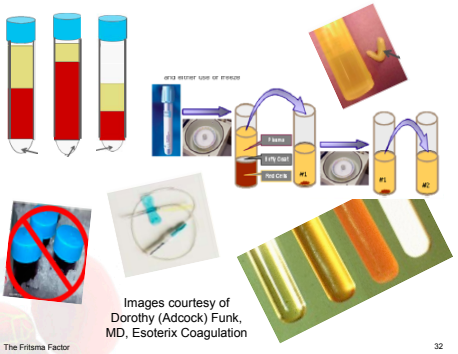
## Pre-Analytical: Specimens



Images courtesy of Dorothy (Adcock) Funk, MD, Esoterix Coagulation

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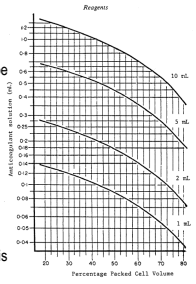
## Pre: Adjust for HCT >55%

- C = 1.85 x $10^{-3}$ (100–HCT%) V
- Where…
  - C = final volume of anticoagulant in tube
  - HCT% = hematocrit
  - V = desired total volume of blood and anticoagulant
- Example, how much AC is needed to collect 2 mL blood from a patient with 70% HCT ?
  - C = 1.85 X $10^{-3}$ (30) x 2 = 0.11 mL
  - Remove 0.09 mL from 2 mL tube (is this possible?)

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## Pre: Specimen Transport, No Ice

| Two samples with originally >70% VWF:Rco, both held 6h at 4°C | | |
|---|---|---|
| Assay | Sample 1 | Sample 2 |
| VWF:Ag | 42% | 68% |
| VWF:RCo | 38% | 30% |
| VWF:CB | 12% | 28% |
| Sample 1: false diagnosis of VWD type 1 in a normal subject<br>Sample 2: false diagnosis of VWD type 2 in a normal subject | | |

- Cold precipitates large VWF multimers
- Cold activates platelets and FVII
- Refrigerate EDTA tubes up to 24 h for hematology to stabilize platelet count and HCT
- In clot tubes for clinical chemistry, cold raises serum $K^+$

- Favaloro E. Thromb Haemost 2001;86:1589–90
- Young D. Effects of preanalytical variables on clinical laboratory tests. AACC Press, 1997

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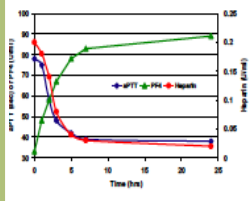
## Pre: Specimen Storage




| PPP stored 24h at 1–4°C | | | |
|---|---|---|---|
| Factor | Fresh | 12h | 24h |
| 1. VIII | 110% | 102% | 71% |
| 2. VIII | 60% | 47% | 39% |
| 3. VIII | 51% | 50% | 33% |
| FV | 94% | 93% | 87% |
| PS | 93% | 97% | 63% |

Adcock D, Kressin D, Marlar RA. The effect of time and temperature variables on routine coagulation tests. Blood Coagul Fibrinolysis 1998;9:463–70.

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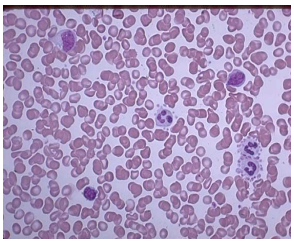
## Pre: Thrombocytopenia

A CBC is collected on a 65-YO man during his annual physical and the PLT count is 59,000/µL. He reports no bleeding and his previous counts are normal. Suspecting ITP, the physician orders a bone marrow examination. What would you recommend?



Zandecki M, Genevieve F, Gerard J, Godon A. Spurious counts and spurious results on haematology analysers: a review. Part II: white blood cells, red blood cells, haemoglobin, red cell indices and reticulocytes. Int J Lab Hematol 2007;29:21-41.

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## Analytical Error: Thrombophilia Screen

| Assay | Patient | RI |
|---|---|---|
| Protein C *antigen* | 73% | >70% |
| Protein S *antigen* | 99% | >65% |
| Antithrombin *antigen* | 93% | 78–126% |
| Factor VIII | 125% | 50–186% |
| APCR | 2.4 | >1.8 |
| Factor II 20210 | Wild-type | Wild-type |
| PTT-LA | 39 s | 30–40 s |
| Homocysteine | 3.9 ηmol/L | <4.3 ηmol/L |
| 45-YO woman, three DVTs in five years | | |

**What do you recommend?**



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## Post-post: Thrombophilia Report

| Assay | Patient | RI |
|---|---|---|
| Protein C activity | 35% | >70% |
| Protein S activity | 39% | >65% |
| Antithrombin activity | 57% | 78–126% |
| Factor VIII | 125% | 50–186% |
| APCR | 2.4 | >1.8 |
| Factor II 20210 | Wild-type | Wild-type |
| PTT-LA | 39 s | 30–40 s |
| Homocysteine | 3.9 ηmol/L | <4.3 ηmol/L |

- Triple heterozygote?
- Terminate pregnancy?
- Increase Coumadin?
- Start heparin?
- Consult with the lab?




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## Post-post: Thrombophilia Report

| Assay | Patient | RI |
|---|---|---|
| Protein C activity | 35% | >70% |
| Protein S activity | 39% | >65% |
| Antithrombin activity | 57% | 78–126% |
| Factor VIII | 125% | 50–186% |
| APCR | 2.4 | >1.8 |
| Factor II 20210 | Wild-type | Wild-type |
| PTT-LA | 39 s | 30–40 s |
| Homocysteine | 3.9 ηmol/L | <4.3 ηmol/L |

Or: "*Protein C, S, and AT appear deficient, probably Coumadin interference, reflex INR = 2.1, suggesting Coumadin is present. Other risk factor assay results are within reference interval. No evidence for thrombotic risk, repeat profile 2 weeks after discontinuing Coumadin.*"



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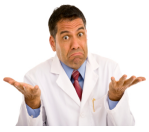
## Post-post Issue: Pre-op Screen

| Assay | Patient | RI |
|---|---|---|
| HGB | 14.2 g/dL | 13.5–15.6 g/dL |
| PTT | 59 s | 25–35 s |
| PT | 12.4 s | 9.8–12.6 s |
| TT | 18.2 s | <21 s |
| PLT count | 310,000/µL | 250–450,000/µL |
| Fibrinogen | 270 mg/dL | 150–400 mg/dL |
| No bleeding Hx, surgeon postpones procedure | | |

- Heparin present?
- Risk: bleeding? Thrombosis?
- Repeat PTT until negative?
- Consult with laboratory?
- Laboratory immediate reflex to…





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## Pre-op Screen: How About This?

| Assay | Patient | RI |
|---|---|---|
| HGB | 14.2 g/dL | 13.5–15.6 g/dL |
| PTT | 59 s | 25–35 s |
| PT | 12.4 s | 9.8–12.6 s |
| TT | 18.2 s | <21 s |
| PLT count | 310,000/µL | 250–450,000/µL |
| Fibrinogen | 270 mg/dL | 150–400 mg/dL |
| No bleeding Hx, surgeon postpones procedure | | |

"*Isolated prolonged PTT may indicate coagulation factor deficiency, coagulation factor inhibitor, or lupus anticoagulant. Normal TT indicates no heparin present. Laboratory reflex to PTT mixing study, results follow.*"



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## Mixing Study: New Specimen, Next Day

| Assay | Result | RI | Comment |
|---|---|---|---|
| PTT | 57 s | 25–35 s | Confirms prior PTT |
| PTT/control 1:1 immediate mix | 38.5 s | Control 27.5 s | Commercial platelet-free normal control plasma |

- Uncorrected?
- Should lab have done incubated mix?
- Do you send this result to the surgeon?
- Continue to delay surgery?
- Consult with laboratory?
- Laboratory immediate reflex to…

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## Mixing Study: How About This?

| Assay | Result | RI | Comment |
|---|---|---|---|
| PTT | 57 s | 25–35 s | Confirms prior PTT |
| PTT/control 1:1 immediate mix | 38.5 s | Control 27.5 s | Commercial platelet-free normal control plasma |

Interim report: "*Patient plasma mixed 1:1 with normal plasma, PTT performed immediately after mix remains prolonged (uncorrected). Presumptive evidence of lupus anticoagulant. LA profile follows.*"

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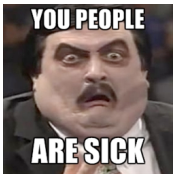
## LA Profile: Third Day of Hospital Stay

| Assay | Result | RI | Comment |
|---|---|---|---|
| PTT-LA | 47.9 s | 30–40 s | Confirms PTT |
| PTT-LA /control 1:1 | 38.5 s | Control 34.5 s | Possible LA |
| Staclot LA kit | 12 s | > 8 s correction | Confirms LA |
| DRVVT | 52.5 s | 35–45 s | Possible LA |
| DRVVT confirm | 1.4 ratio | > 1.2 correction | Confirms LA |

- Send this result to the surgeon w/o comment?
- Delay surgery?
- Consult with laboratory?




The Fritsma Factor 44

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## LA Profile: How About This?

| Assay | Result | RI | Comment |
|---|---|---|---|
| PTT-LA | 47.9 s | 30–40 s | Confirms PTT |
| PTT-LA /control 1:1 | 38.5 s | Control 34.5 s | Possible LA |
| Staclot LA kit | 12 s | > 8s correction | Confirms LA |
| DRVVT | 52.5 s | 35–45 s | Possible LA |
| DRVVT confirm | 1.4 ratio | > 1.2 correction | Confirms LA |

Or: "*Patient plasma tested using LA-sensitive PTT reagent and dilute Russell viper venom reagent, both prolonged, both corrected by high phospholipid neutralization reagent, confirming LA. No bleeding risk, may indicate thrombosis risk if LA is chronic. Repeat after 12 weeks to determine persistence.*"

The Fritsma Factor 45

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## Pre-op Coags: Same as Before

| Assay | Result | RI |
|---|---|---|
| PT | 14.2 s | 12.6–14.6 s |
| PTT | 42.5 s | 25–35 s |
| TT | 17.5 s | < 21 s |
| PLT | 245,000/µL | 150–450,000/µL |

- Heparin present?
- Risk: bleeding? Thrombosis?
- Repeat PTT until negative?
- Consult with laboratory?
- Laboratory reflex to…


The Fritsma Factor 46

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## Pre-op Coags Same as Before How About This?

| Assay | Result | RI |
|---|---|---|
| PT | 14.2 s | 12.6–14.6 s |
| PTT | 42.5 s | 25–35 s |
| TT | 17.5 s | < 21 s |
| PLT | 245,000/µL | 150–450,000/µL |

Or: "*Isolated prolonged PTT may indicate coagulation factor deficiency, coagulation factor inhibitor, or lupus anticoagulant. Normal TT indicates no heparin present. Laboratory reflex to PTT mixing study, results follow.*"

The Fritsma Factor 47

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## Mixing Study: How About This?

| Assay | Result | RI | Comment |
|---|---|---|---|
| PTT | 42.5 s | 25–35 s | Confirms previous PTT |
| PTT/control 1:1 mix immediate | 31.1 s | Control 27.5 s | Commercial platelet-free normal control plasma |
| PTT/control 1:1 mix 2 h at 37°C | 33.4 s | Control 31.3 s | Control is incubated alone and with mix |

- Corrected?
- Send results to surgeon w/o comment?
- Delay surgery?
- Consult with laboratory?
- Laboratory reflex to…

Or: "*Patient plasma was mixed 1:1 with normal plasma, PTT is within 10% of control immediately and after incubation—corrected. Presumptive evidence of factor deficiency, factor assays follow.*"

The Fritsma Factor 48

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## VWD Profile

| Assay | Result | RI | Comment |
|---|---|---|---|
| FVIII | 40% | 50–150% | Mildly decreased |
| VWF:Ag | 37% | | VWD type 1 |
| VWF:RCo | 45% | | |
| VWF:Act | 48% | | |
| VWF:CBA | 37% | | |

- Send this result to the surgeon w/o comment?
- Delay surgery?
- Consult with laboratory?

Or: "*Results indicate von Willebrand disease type 1, risk of mucocutaneous bleeding may require pre-operative corrective therapy.*"



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## Consultative Lab Testing

- "Goal-oriented" clinical query ordering: keyed to condition
- Assess causes for long PT or PTT: Hx of bleeding or thrombosis, interfering drugs, summarize results
- Initial profile with algorithm-based reflex additions
- Reduce cost by selecting correct assays
- Fewer repeat samples, less blood volume
- Conclude on abnormalities efficiently
- Shortened TAT and stay
- Interpret results, indicating cause and significance of the coagulation abnormality, bleeding and thrombotic risk, recommendations for therapy

Kandice Marchant, MD, PhD; Cleveland Clinic; Cleveland, Ohio



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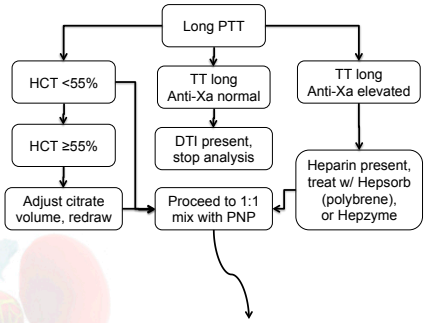
## Prolonged PTT Workup



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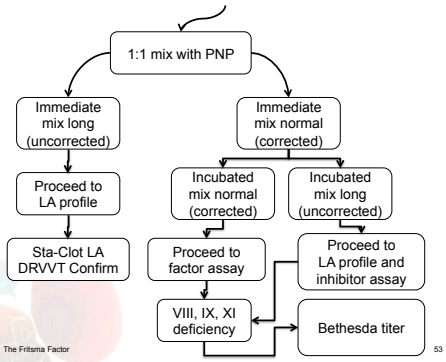
## Mixing Study: Prolonged PTT



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