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# CLINICAL BIOCHEMISTRY (INCLUDING IMMUNOLOGY) USER GUIDE

**Dear Colleague,**

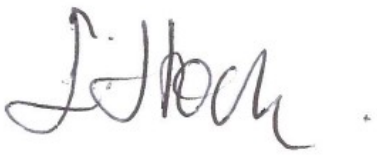
Efficient and appropriate use of the laboratory service is central to the modern practice of medicine. The aim of this user guide is to provide clear guidance on how and when to use our service, which analyses are available and which sample type should be used.

Clinical Biochemistry has laboratories on the three acute Trust sites in East Kent and provides a continuous service to hospitals and local general practitioners. Our specialist immunology service is located at the William Harvey Hospital, Ashford. Clinical Biochemistry (including immunology) is accredited by UKAS to ISO 15189 (laboratory reference 8636).

We process more than 9 million individual biochemistry and immunology tests each year. Analyses are performed using the latest technology by qualified, HCPC registered scientific staff assisted by trained support staff. All processes are rigorously quality controlled and the laboratory participates in external quality assessment programmes and accreditation schemes. Authorised personnel periodically review the examinations provided by the laboratory to ensure that they are clinically appropriate for the requests received.

Clearly, a concise user guide cannot give comprehensive coverage of all aspects of the service we offer. Contact names and telephone numbers of key senior members of staff are given - please contact us whenever you have a query over which investigation is most appropriate, what collection conditions might affect your result and how you should interpret that result. Clinical advice is always available from HCPC registered clinical scientists and is an essential part of the service we offer: effective liaison with us improves our service to you.

We have made every effort to ensure that the information in this user guide is correct at the time of publication. However, information will obviously change as new technologies become available and the service evolves to meet the needs of our users. We welcome any comments or suggestions you would like to make, positive or negative, so that these can be incorporated into future editions.



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**Consultant Clinical Scientist & Head of Service for Clinical Biochemistry and Immunology**

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# 1. INTRODUCTION

This user guide is designed to help you get the most from the clinical biochemistry and immunology services at East Kent Hospitals.

## SERVICE OVERVIEW

The clinical biochemistry and immunology laboratory service, which operates within East Kent Hospitals University NHS Foundation Trust (EKHUFT), covers 5 hospital sites including:

1. William Harvey Hospital (WHH), Ashford – hub blood sciences laboratory, which processes all work from primary care, and provides many specialist tests. Immunology laboratory is located at this site.
2. Kent & Canterbury Hospital (K&CH), Canterbury – cross trained spoke laboratory, provision of some specialist testing
3. Queen Elizabeth the Queen Mother Hospital (QEQMH), Margate – cross trained spoke laboratory
4. Royal Victoria Hospital Folkestone – phlebotomy service only
5. Buckland Hospital, Dover – phlebotomy service only

There is a 24-7 / 365 diagnostic laboratory service offered on sites 1-3 with full clinical biochemistry cover during these times provided by clinical scientists, biomedical scientists and assistant health care scientists. The immunology laboratory at WHH is open Monday – Friday 08:00 - 17:15.

All of our clinical biochemistry (including immunology) laboratories are UKAS ISO 15189; 2012 accredited. Tests listed on our current scope of practice can be found on the UKAS website https://www.ukas.com/ or http://www.ekhuft.nhs.uk/pathology/.

Section 22 of this user guide lists our test repertoire, both tests provided within EKHUFT and those that are referred to other laboratories. The section details reference ranges, sample requirements, turnaround time, referral laboratory (if applicable) and identifies those test that are not UKAS ISO 15189; 2012 accredited.

## GEOGRAPHICAL CATCHMENT

East Kent University Hospitals NHS Foundation Trusts clinical biochemistry and immunology laboratories are spread across a wide geographical area supporting over 110 primary care sites from Margate to the east, Faversham to the north, Tenterden to the west and Romney Marsh to the south.

Our services are reliant upon a specific and robust transport infrastructure in order to effectively support an ever growing population of circa 760,000 within East Kent. These support services are located within equal distance of each other geographically but are constrained by the road network in places. Our services operate from:

1. The William Harvey Hospital, Ashford
2. The Kent & Canterbury Hospital, Canterbury
3. The Queen Elizabeth the Queen Mother Hospital, Margate
4. Royal Victoria Hospital, Folkestone (Phlebotomy Only)
5. Buckland Hospital, Dover (Phlebotomy Only)

The figure below demonstrates the wide geographical spread of East Kent's Pathology services as things stand.

**FIGURE 1 – SPREAD OF MAIN NHS TRUST SITES**


**CLINICAL BIOCHEMISTRY (INCLUDING IMMUNOLOGY) LABORATORY LOCATIONS**

**WHH** laboratory is located on the ground floor in the green zone at the rear of the hospital. Note that phlebotomy facilities at WHH are located near the main entrance, not in Pathology.

**K&CH** laboratory is located in the corridor between Outpatients and Clarke Ward. Phlebotomy services are adjacent to the laboratory.

**QEQMH** laboratory is located in the St Peter's Road wing on the ground floor. Phlebotomy services are adjacent to the laboratory.

# 2. LABORATORY OPENING HOURS/PHLEBOTOMY SERVICES

The laboratories are operational 24-7 / 365 days a year. The immunology laboratory at WHH is open Monday – Friday 08:00 - 17:15.

**CORE LABORATORY HOURS (all sites)**

| | |
|---|---|
| Monday – Friday | 08:00 - 20.00 |
| Saturday | 08:00 - 13:00 |

The laboratory provides a reduced number of investigations outside of these core hours 24 hours a day, every day of the year, though as this service is provided by a limited number of staff, use of this service should be restricted to urgent investigations only. For a list of tests available outside core hours, please refer to section 9.

**PHLEBOTOMY SERVICES**

**Kent and Canterbury Hospital, Canterbury**

| AREA | DAYS | TIMES |
|---|---|---|
| Wards | Monday – Friday | 06.00-08.00 (Limited staff)<br>08.30-12.00 |
| Wards | Saturday | 06.00-09.30 |
| Outpatients | Monday – Friday | 08.30-16.30 |

An outpatient Phlebotomy service is provided for the hospital and GP patients. The service is sited in the foyer of the Pathology block, this is an appointment only system; appointments are booked via the patient portal on the EKHUFT website.

**Queen Elizabeth the Queen Mother Hospital, Margate**

| AREA | DAYS | TIMES |
|---|---|---|
| Wards | Monday – Friday | 08.30-12.00<br>13.00-14:30 |
| Wards | Saturday | 07.30-10.30 (Limited Staff) |
| Outpatients | Monday – Friday | 08.30-16.30 |

An outpatient Phlebotomy service is provided for the hospital and GP patients. This is sited next to the Pathology department. This is an appointment only system, appointments are booked via the patient portal on the EKHUFT website. Glucose tolerance tests (GTT) require an appointment. Booking number 01843 235000.

**William Harvey Hospital, Ashford**

| AREA | DAYS | TIMES |
|---|---|---|
| Wards | Monday – Friday | 07.00-13.00<br>14.00-16.30 |
| Wards | Saturday<br>Sundays | 07.00-12.00 (limited staff)<br>08.00-12.00 (limited staff) |
| Main Foyer of Hospital | Monday - Friday | 08.30-17.00 |

**Royal Victoria Hospital, Folkestone**

| AREA | DAYS | TIMES |
|---|---|---|
| Outpatients | Monday – Friday | 08.30-16.00 |
| Outpatients | Saturdays | 09.00-12.00 |

All patients are seen via an appointment system, appointments are booked via the patient portal on the EKHUFT website.

**Buckland Hospital, Dover**

| AREA | DAYS | TIMES |
|---|---|---|
| Outpatients | Monday – Friday | 08.00-15.45 |

All patients seen via an appointment system. Appointments are booked via the patient portal on the EKHUFT website.

Appointments required for Glucose Tolerance Tests (GTT) only. Booking number 01304 222552

# 3. CONTACT NUMBERS AND KEY PERSONNEL

The main hospital switchboard number is: 01227 766877

If calling from outside the hospital, dial the main switchboard number and then once prompted add the appropriate extension number as below.

If calling from within the hospital then dial the extension number directly.

Alternatively, use the automated answering system on 01233 616060 and select the appropriate option when prompted

**The following prefixes apply: WHH (723) K&CH (722) QEQMH (725)**

| Contact | Position | Extension Number |
|---|---|---|
| **Clinical biochemistry laboratory** | | |
| WHH | Main Laboratory<br><br>Results (please try computer terminals first) | **723 8056**<br><br>**723 6060** |
| K&CH | Main Laboratory<br><br>Results (please try computer terminals first) | **722 3174**<br><br>**723 6060** |
| QEQMH | Main Laboratory<br><br>Results (please try computer terminals first) | **725 4428**<br><br>**723 6060** |
| Duty Biochemist (clinical enquires) | ekhuft.biochemistryekhuft@nhs.net | **723 6287**<br>**01233 616287 (direct line)** |
| **Immunology laboratory** | | |
| WHH | Main Laboratory | **723 6716** |
| **Senior personnel** | | |
| Dr Sally Stock | Consultant Clinical Scientist and Head of Service | **723 6025**<br>**01233 616025 (direct)** |
| Dr Edmund Lamb | Consultant Clinical Scientist and Clinical Director of Pathology | **722 4112** |
| Dr Joanna Sheldon | Visiting Consultant Clinical Scientist (Immunology) | **723 6716** |
| Miss Elizabeth Hall | Principal Clinical Scientist | **722 2868** |
| Dr Helen Holt | Principal Clinical Scientist and Quality Lead | **723 6288** |
| Dr Danni Fan | Principal Clinical Scientist | **723 6165** |

| Contact | Position | Extension Number |
|---|---|---|
| | | |
| Mrs Gifty George | Senior Clinical Scientist | **723 6165** |
| Miss Ellen Bealing | Senior Clinical Scientist | **723 6165** |
| Phil Bates | Head Biomedical Scientist | **722 4368**<br>**01227 864 368 (direct line)** |
| Heidi Luck | Chief Biomedical Scientist (K&CH and QEQMH) | **722 5064 (K&CH)**<br>**725 3630 (QEQMH)** |
| Tracy Clawson | Acting Chief Biomedical Scientist (WHH) | **723 6130** |
| Lorna Miller | Chief Biomedical Scientist and Clinical Scientist (Immunology) | **723 6716** |
| Joan Butler | Specimen Reception Manager WHH | **723 6130** |
| **Pathology management** | | |
| Mr Marcus Coales | General Manager | **723 8400** |
| Mrs Emma Sutton | Head of Quality, Governance and Risk Management | **723 4204** |
| Chris Christodoulou-Smith | Operations Manager | **723 6133** |
| **Point of care testing** | | |
| Mr Phil Bates | POCT Co-ordinator | **722 4368** |

## 4. CLINICAL INFORMATION

It is particularly helpful to us to receive as much clinical information as possible alongside the laboratory test request(s) as this ensures that the appropriate diagnostic tests are performed on your behalf. Some laboratory tests are vetted prior to being processed and will only be processed if supported by relevant clinical information.

## 5. CLINICAL ADVICE AND INTERPRETATION

Clinical advice and interpretation is available from the duty biochemist, on extension 723 6287 or 01233 616287. They can also be contacted by email ekhuft.biochemistryekhuft@nhs.net

Interpretative comments are added to some test results by a HCPC registered clinical scientist.

Out of hours clinical advice is available by contacting the on call duty biochemist via switchboard.

# 6. SPECIMEN AND REQUEST FORM LABELLING

- Requests made in primary care must be made via DartOCM
- Requests made in secondary care must be made via Sunrise.

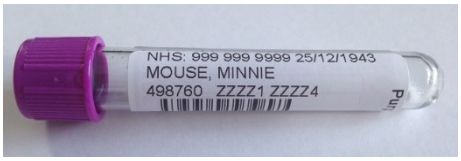
## How to apply sunrise/Dart printed labels to specimen containers

As with all phlebotomy/sample collection processes it is essential that correct positive patient ID is performed and that all samples are labelled with the correct patient information.

When placing printed sample labels on the containers, it is essential they are placed in the correct position and orientation and on the correct sample for the tests required. If the labels are not applied correctly, the analysers are not able to read the barcodes. This may cause delay in issuing results.

## Example of a correctly labelled sample

- Note how the label is perfectly centred and straight, clearly printed and aligned on the tube with the coloured lid on the left.
-



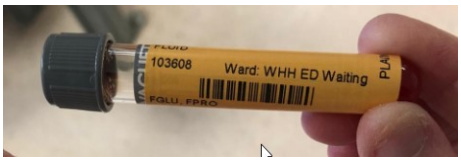

## Examples of incorrectly labelled samples

- This label has been wrapped around the tube sideways. The analysers are unable to see/read the entire barcode.

- Try to ensure the label is placed on the tube as straight as possible. Crooked, crumpled or torn labels will need reprinting.

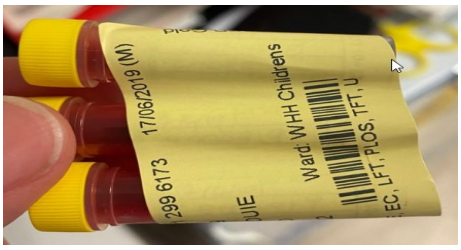
- All Sunrise labels have the correct container information printed on them which relates to the tests requested/collected. The above tests were routine blood chemistry tests that should have been put in a yellow (gold) topped tube.


- All Sunrise labels have the correct container information printed on them which relates to the tests requested/collected. The above tests were CSF tests that should have been put into a plain bottle and not grey topped.




- All labels will fit onto adult blood tubes so there is no need to let them wrap over the bottom of the sample container.


- This is an example of why we are asking for request forms for paediatric samples – our labels are too large for paediatric sample containers. If you require more than 1 tube for tests then either Sunrise will print the correct number of labels or you should reprint labels but please ensure that you reprint the correct




**NOTE: THE BARCODE MUST BE CLEAR AND IN SHARP DEFINITION. IF THE LABEL IS SMUDGED, PLEASE CLEAN THE PRINTER WITH AN ALCOHOL WIPE AND REPRINT THE LABEL.**

## When and when not to collect samples using Sunrise

*NOTE:* The sample collection process in Sunrise **must not** be used for:

- Any paediatric requests (patients of less than 18 years of age)
- Any Blood Transfusion requests
- Outpatient clinics; *if* the patient is leaving to have sample collected at a later date/different location.

In the above scenarios we require a request form to be printed at the time of request and the pre-existing label on the container to be filled in by hand and sent to the laboratory together.

Any handwritten samples and manually completed (paper) request forms must be clearly labelled in accordance with the Department of Pathology's specimen acceptance policy. Label specimens clearly with a minimum of surname, forename, NHS/hospital number and date of birth. Requests for biochemistry tests must include the following information:

- patient demographic details
- whether the patient is NHS or private
- nature of specimen and date of collection
- the requesting doctor, with bleep number (junior doctors)
- return destination for the report
- brief, relevant clinical details (including medication)
- the analyses you require: if the test you require is not listed in this user guide please contact the laboratory prior to collection of the sample

**Any samples not meeting current guidelines as shown in the Pathology specimen and request form acceptance policy will not be processed.**

# 7. SAMPLE REQUIREMENTS

**Please**

- ask about tests; how to arrange them and how to interpret them.
- be prepared to bring urgent specimens to the laboratory.
- ensure that specimens and request forms are correctly labelled and completed as described in this user guide: specimens must be sent in the appropriate sealed container with the correct request form attached (if appropriate).

**Please avoid**

- sending leaking specimens
- sending unlabelled samples
- asking for tests to be performed urgently/results telephoned unless there is a clear clinical need

## BLOOD SAMPLES

Several types of evacuated tubes for blood collection are in use for adults. The following list is not exhaustive: for certain specialist tests there are particular collection conditions which must be strictly adhered to. Please contact the laboratory for further information if you have any doubt about which tube should be used or whether special collection conditions apply.

- **Plain clotted** (red) for therapeutic drug analyses.
- **Gel separator tube** (gold) for majority of biochemistry and immunology tests.
- **Lithium heparin** (green) for ammonia (adult samples) and for certain specialist assays.
- **EDTA** (lavender/purple) for $HbA_{1c}$, PTH, troponin, NT-proBNP, ammonia, tacrolimus and ciclosporin.
- **Fluoride oxalate** (grey) for glucose, lactate and alcohol.
- **Cryoglobulin** collection flask and tubes available from the laboratory by arrangement.

**Note**: tubes are labelled with a line indicating the amount of blood which should be placed in them. Please attempt to put the correct amount of blood in the tubes and ensure that any anticoagulants or preservatives are mixed into the blood by gentle inversion of the tubes once they have been filled.

For paediatric use, a supply of smaller containers with the same colour coding as adult tubes is available. However, other types of paediatric tubes are also in circulation. Please ensure the correct lids are re-fitted to these tubes after collection.

### Order of filling of evacuated tubes

1 - Citrate tubes (for clotting studies/INR)
2 - Dry tubes with clot activator for tests on serum (red)
3 - Gel separator tubes with clot activator for tests on serum (gold/yellow)
4 - Lithium heparin tubes (green)
5 - EDTA tubes (lavender)
6 - Fluoride oxalate tubes (grey)

It is essential that the above sequence is adhered to otherwise cross contamination may occur leading to erroneous results.

## URINE SAMPLES

Random urines should be collected into a 60 mL white-top (or silver-top) universal container. Do **not** use the red-top (Boricon) microbiology pots. Patient information leaflets describing the collection procedure are available (see section 21)

24 h urine containers are issued by the laboratory. The Pathology reception staff are responsible for ensuring that the correct container and collection details are issued, either directly to the patient or to the ward or clinic staff. Urine containers for trace metal (e.g. copper) analysis are acid-washed. Patient information leaflets describing the collection procedure are available (see section 21).

## CSF SAMPLES

A plain universal or 2 mL sterile tube must be used for total protein or oligoclonal bands and a fluoride oxalate sample for glucose. When investigating suspected meningitis, the CSF glucose request must be accompanied by a plasma glucose request/sample. When investigating suspected multiple sclerosis, the request for CSF oligoclonal bands must be accompanied by a clotted (red or gel separator tube) blood sample. CSF specimens contaminated with blood will not be analysed. For xanthochromia testing see section 21.

## FAECAL SAMPLES

Faecal specimens for measurement of porphyrins, calprotectin and elastase must be collected into sterile faeces pots. Specimens for porphyrins **MUST** be protected from light. Patient information leaflets describing the collection procedure are available (see section 21).

## STORING SAMPLES

The storage of whole blood specimens in a refrigerator at 4$^{o}$C prior to sending to the laboratory is not suitable for the vast majority of analytes. Notably serum potassium, phosphate and magnesium will be falsely elevated due to leakage from the red blood cells and the bicarbonate may be falsely decreased. **Do not store specimens in the freezer! Do not stand specimens on radiators or other very hot places!** If in doubt, contact the laboratory.

Some samples must be brought to the laboratory immediately (e.g. ammonia, lactate, ACTH, gut hormones, renin, aldosterone, and plasma metanephrines). Samples for these tests cannot be collected in primary care (see section 10). Please contact the duty biochemist if you wish to discuss sample requirements, or make the laboratory aware that an unstable sample is being sent.

If samples are not delivered to the laboratory within 4 hours after collection, they must be centrifuged (2000 g for 10 minutes) at source (within 8 hours of collection) and stored at 2 – 8 degrees before transportation, to preserve sample integrity and to ensure that they are not rejected upon arrival at EKHUFT. The laboratory must be informed that this procedure is in place, and it must be agreed in writing.

## UNSUITABLE SAMPLES

Under certain circumstances results of some tests will not be reported due to the receipt of a compromised sample (e.g. many analytes will not be reported on haemolysed or lipaemic samples). This is done to ensure that the results you receive are clinically meaningful and accurate: please do not ask laboratory staff to release results in these situations.

**SAMPLE VOLUMES AND PROFILES**

The laboratory offers several test profiles. Their basic constituent tests are:

**Electrolytes and creatinine (ECR);** sodium, potassium, creatinine
**Liver function test (LFT);** total bilirubin, albumin, alanine transaminase, alkaline phosphatase
**Lipid profile;** total cholesterol, HDL-cholesterol, LDL-cholesterol (calculated), non HDL cholesterol (calculated), triglyceride
**Thyroid function test (TFT):** thyroid stimulating hormone (TSH), free thyroxine (FT4)

No other profiles are in use – please always specify in other cases exactly which tests you require. The laboratory will always undertake to do as many of the requested tests as possible on the sample provided. In general, all of the above tests can be done upon receipt of a single filled 4 mL gel separator tube. Some more specialised tests, in particular those which we send to referral laboratories, may require larger sample volumes. Please contact the laboratory to discuss sample requirements for specialised tests.

**Some tests require special attention and must be delivered to the laboratory in a specific timeframe or under certain conditions. Please pay attention to any messages displayed in Sunrise or DartOCM. Detailed information can be obtained from laboratory upon request, or can be found in BIO NO 026.**

## 8. REQUESTING ADDITIONAL TESTS

- The laboratory will generally consider requests for additional tests on samples up to 3 days after receipt of the sample in the laboratory. In some cases, samples are stored for longer than this and we will be happy to undertake additional tests beyond this period.
- There are analytes for which the sample integrity cannot be guaranteed after laboratory storage of varying times and in these situations, we will decline to undertake further investigations.
- If additional requests are required once the request has been placed and the samples sent to the laboratory, please request additional tests via Sunrise (secondary care) and send the relevant request form to the laboratory clearly stating that the sample is in the laboratory. Any add on requests from primary care should be made by telephone.
- Samples for autoantibody investigations are stored for one month and allergy investigations for two months. Additional tests can be added by telephoning the immunology laboratory.

# 9. URGENT AND OUT OF HOURS REQUESTS

- Please request tests to be performed urgently only when it is clinically essential.
- All of our work is processed rapidly and the results are available in a timely manner. The agreed non-urgent turnaround times for each test are published within this user guide (see section 22).
- Urgent requests from primary care should be clearly marked "URGENT", placed in the designated large, zip-topped plastic envelopes & then either placed in the blue transport boxes or given to the driver to be placed in the yellow transport box that is in the van. These samples will be given priority on arrival in the laboratory.

Outside of the core laboratory hours and on public holidays an urgent clinical biochemistry service operates. The following repertoire of tests (blood tests unless stated otherwise) is available: however, **tests should only be requested when there is an urgent clinical need and the result is going to make an immediate difference to the management/treatment of the patient**. Other tests may be available following approval. Clinical advice is always available by contacting the on call clinical biochemist via switchboard.

Results are generally available via computer terminals on all wards. Laboratory staff should not be routinely telephoned for results.

| **General biochemistry** | **Suspected toxicity** |
|---|---|
| Albumin | Valproate |
| Alkaline phosphatase | Theophylline |
| Ammonia | Salicylate |
| Amylase | Phenytoin |
| AST | Paracetamol ( > 4 hours post overdose |
| ALT | Lithium |
| Bilirubin | Iron |
| Carboxyhaemoglobin (use ward based blood gas instruments) | Ethanol |
| Chloride | Digoxin |
| CRP | Carbamazepine (following requesting consultant and duty biochemist discussion) |
| Creatine kinase (CK) | |
| Creatinine | |
| Glucose | **Urine** |
| HCG (according to protocol) | Sodium |
| Lactate | Potassium |
| Magnesium | Osmolality |
| Osmolality | |
| Phosphate | **CSF** |
| Potassium | Glucose |
| Sodium | Total protein |
| Total protein | |
| Troponin | |
| Urate (pre-eclampsia) | |
| Urea | |

# 10. TESTS THAT CANNOT BE COLLECTED AT THE GP SURGERY

There are certain tests that are unsuitable for collection outside the hospital setting. Often these are tests requested by a secondary care physician. There are several reasons for this including:

- the sample is unstable and must reach the laboratory quickly
- there are funding restrictions around the use of the test
- testing will only be carried out following prior discussion with the laboratory

Samples that cannot be tested will be rejected which frustrates doctors and any repeat testing worries patients. Please share the table below with your practice phlebotomists so that we can reduce unnecessary repeat testing and worry.

| Tests | Reason for unavailability |
|---|---|
| Blood adrenocorticotrophic hormone (ACTH), aldosterone, ammonia, biotinidase, calcitonin, chromogranin A and B, cold agglutinins, C-peptide, cryoglobulins, free fatty acids, gastrin, glucagon, gut hormone profile, insulin, pancreatic polypeptide, plasma metanephrines, renin, somatostatin, vasoactive intestinal polypeptide (VIP), white cell enzymes | Analyte unstable<br>Must be taken at K&CH, QEQMH or WHH |
| Urine bilirubin, urobilinogen, glucose, ketones | Analyte unstable<br>Test using reagent strip analysis on a fresh urine sample at the surgery |
| Anti-mullerian hormone (AMH) | Test not funded for primary care |
| Citrullinated cyclic peptide (CCP) antibodies | Test not funded for primary care |
| Chromium, cobalt, manganese | Risk of sample contamination<br>Must be taken at K&CH, QEQMH or WHH |
| Clozapine | Sample must be sent directly to Clozaril Monitoring Service<br>May be taken and posted from GP surgery |
| Carnitine and acyl carnitine profile | May be taken on children's wards |
| Troponin | Patients with chest pain should attend A&E or Emergency Care Centre<br>Other requests MUST be arranged with the Duty Biochemist 01233 616060 and relevant clinical details included with the request |

# 11. HIGH RISK SAMPLES

The laboratory operates a policy of universal safety precautions for all samples and we recommend that you regard all blood as being potentially infectious. High risk labelling of samples is **not required**.

# 12. INFORMED CONSENT

When a patient presents to a GP surgery or clinic and submits to a collecting procedure, consent is inferred. The EKHUFT policy; Patient Information and Consent to Examination or Treatment is available via the staff zone of the intranet, and for patients there is a web link to the DH web site regarding medical consent.

# 13. TRANSPORT OF SPECIMENS TO THE LABORATORY

The Pathology department holds an SLA with EKHUFT transport services in order to cover all of the primary care sites in our catchment on a daily basis and provide assurance that samples will be delivered to pathology within 4 hours of collection. The pattern of delivery from GP surgery to laboratory will be dependent upon locality and based upon distance to the local hospital Pathology service laboratories in order to ensure optimum turnaround times and efficiency.

**INTERNAL LOGISITICS**
Some pathology specimens are transferred to other sites within EKHUFT in order to be processed or to be collated centrally and sent off site to external pathology providers for analysis.

**TRANSPORT WITHIN THE HOSPITAL**
All specimens should be placed in the appropriate combined request form and specimen transport bag: transport bags must not be used more than once.

Specimens can be transported to the laboratory using one of the following methods:

1. In person from ward to laboratory reception
2. Through use of the Trusts pneumatic tube system within a secure air-pod - where this option exists
3. Through the hospital porters

**TRANSPORT OUTSIDE THE HOSPITAL (OTHER THAN BY POST e.g. TAXI)**
The laboratory can provide advice to users on where to obtain containers, labels and transport boxes. Specimens must be transported in specially provided transport boxes. Unless all specimens are in individual transport bags, the carrier box or tray must be designed to ensure that specimens are kept upright and secure. Specimen transport boxes or trays should not be used for any purpose other than carrying specimens.

# 14. ACCESS TO RESULTS

All results are available electronically through Sunrise and/or DART OCM shortly after they are verified in the laboratory. All clinical staff who are required to access patient results should obtain logins and passwords and appropriate training for both Sunrise and/or DART OCM.

**Please attempt to find patient results on the computer terminals (Sunrise and/or DART OCM) before telephoning the laboratory. You are reminded that it is a breach of the Data Protection Act to access any computer using someone else's password.**

# 15. COMMUNICATION OF CRITICAL AND UNEXPECTED RESULTS

It is our policy to telephone **apparently unexpected** critical results which may immediately affect patient management following the limits in the table below. The BMS or Clinical Scientist can telephone any abnormal result at their discretion e.g. this may be considered if there has been a significant change from previous results.

Please note it may not be possible to communicate critical results on GUM patients out of hours if the only patient identifier is the GUM reference. Such results must be communicated at the first available opportunity.

We are required to log telephoned results. Therefore, you will be asked to confirm the patients name, date of birth and hospital number and to give your name and grade. You will also be asked to read back the results transmitted to you to ensure they have been transcribed correctly. **All telephoned results should be written in the ward results diary (or telephone result pads) or in the patient's notes; not on a loose scrap of paper. Telephoned results must be relayed as a matter of priority to the clinician responsible for the patients care.**

For A&E (Emergency Department, ED) there is generally no need to telephone certain critical results (those highlighted blue in the tables below): critical results will be displayed on the PTL/whiteboards within A&E as soon as they are released from the laboratory, and will flash to highlight them to A&E staff. However should the PTL become unavailable (e.g. due to a service interruption) or a software fault within the laboratory's IT systems prevents transmission of results, then it will be necessary to telephone critical results to A&E as per other clinical areas. The A&E staff will inform the laboratory should a PTL failure occur.

| Lower phoning limit (phone if less than or equal to) | Analyte | Upper phoning limit (phone if greater than or equal to) |
|---|---|---|
| n/a | **AKI *** | AKI-3 |
| n/a | **AKI *** | AKI-2 (GP B see note) * |
| n/a | **ALT (U/L)** | 900 (unexpected inpatient/GP/out-patients) |
| n/a | **Amikacin (mg/L)** | 5.0 |
| n/a | **Ammonia (µmol/L)** | 100 (paediatric <16 y only) |
| n/a | **Amylase (U/L)** | 625 (GP/out-patients only) |
| n/a | **AST (U/L)** | 750 (unexpected inpatient/GP/out-patients) |
| 10 | **Bicarbonate (mmol/L)** | n/a |
| n/a | **Bile acids (umol/L)** | 40 |
| n/a | **Bilirubin, total (µmol/L)** | 300 (paediatric <16 y only) |
| n/a | **Bilirubin, conjugated (µmol/L)** | 25 (paediatric only) |
| 1.8 (GP B see note) | **Calcium (adjusted) (mmol/L)** | 3.2 |
| n/a | **Carbamazepine (mg/L)** | 25 |
| 50 | **Ciclosporin (µg/L)**** | 250 |
| n/a | **CK (U/L)** | 5000 |
| 50 (unless post-dex.)<br>200 (if post-synacthen) | **Cortisol (nmol/L)** | n/a |
| n/a | **Creatinine (umol/L)** | 350 (200 if less than 16 years old and adults with no previous result or no result in the previous year) |
| n/a | **CRP** | 200 (GP only) |
| n/a | **Digoxin (g/L)** | 2.5 (GP B see note) |
| n/a | **Ethanol (mg/L)** | 4000 |
| n/a | **Gentamicin (mg/L)** | 2.0 |

| | | |
|---|---|---|
| 2.0 | **Glucose (CSF) (mmol/L)** | n/a |
| 2.5 | **Glucose (mmol/L)** | 15.0 (in children <16 y)<br>25.0 (adult not known to be DM)<br>30.0 (adult known to be DM) |
| n/a | **Lithium (mmol/L)** | 1.5 (GP B see note) |
| 0.40 | **Magnesium (mmol/L)** | 4.00 |
| 260 (unexplained) | **Osmolality (serum)(mOsm/Kg $H_2O$)** | 305 (unexplained) |
| n/a | **Paracetamol (mg/L)** | 30 |
| n/a | **Phenobarbital (mg/L)** | 70 (adults), 40 (paediatrics) |
| n/a | **Phenytoin (mg/L)** | 25 (GP B see note) |
| 0.30 | **Phosphate (mmol/L)** | n/a |
| 2.5 | **Potassium (mmol/L)** | 6.0 (only if AKI)<br>6.5 (all except neonates and pre-dialysis)<br>7.0 (all) |
| n/a | **Salicylate (mg/L)** | 300 |
| 2 | **Sirolimus (µg/L)**** | 10 |
| 130 (paediatric only)<br>120 (unexpected inpatient results/all out-patients & GP's) | **Sodium (mmol/L)** | 150 (unexpected inpatient results/all out-patients & GP's) |
| n/a | **Sweat chloride** | All positive tests |
| 3 | **Tacrolimus (FK506) (µg/L)**** | 14 |
| n/a | **Theophylline (mg/L)** | 25 (GP B see note) |
| n/a | **Thyroid stimulating hormone** | 100 (GP only)<br>50 (when unexpected, GP only) |
| n/a | **Thyroxine (T4, free)** | 50 (when unexpected, GP only) |
| n/a | **Tobramycin (mg/mL)** | 2.0 |
| n/a | **Triglycerides** | 20.0 (when unexpected, GP only) |
| n/a | **Vancomycin (mg/L)** | 25.0 (pre dose)<br>80 .0 (post dose) |
| n/a | **MPO, PR3, GBM antibodies** | New positives |
| n/a | **Paraproteins** | New cases at discretion of clinical scientist |

*It is not necessary to telephone AKI scores for patients on dialysis. AKI (or other) critical alerts relating to radiology patients awaiting or following contrast injection for CT must be telephoned to the duty radiologist (via the X-ray viewing extension 722-2829 between 08:00 and 17:00 Monday to Friday, or via switchboard between 17:00 and 20:00 Monday to Friday and between 08:00 to 20:00 at weekends and on public holidays). Outside of these hours such results must be telephoned to the on call medical registrar.

**Telephone all critical immunosuppressant results to the renal transplant office (extn. 722-6443) in addition to the requesting location if not a renal ward/renal unit.

**Note GP B: if primary care and out of surgery hours then telephone the GP the next day unless the next day is a Saturday, Sunday or Public Holiday in which case telephone the out of hours service**

**Note: tests in cells with blue shading do not need to be telephoned to A&E (Emergency Department, ED), unless the laboratory has been informed that the PTL is out of operation.**

# 16. INTERPRETATION OF RESULTS/UNCERTAINTY OF MEASUREMENT

**Physiological factors affecting test results**

- Many factors other than disease affect the value and the interpretation of a variety of tests. Common factors (i.e. age, gender) are often accounted for with the use of appropriate reference ranges.
- Parameters such as the time of sampling (e.g. serum cortisol results will be highest at approximately 9 a.m. in the morning and will reach a nadir at midnight).
- Sample handling may also affect analytes (e.g. bilirubin and porphyrins may be destroyed by exposure to light; bicarbonate may be lost to the atmosphere; haemolysis will increase plasma potassium and phosphate concentrations.)
- Drugs may have effects in vivo on the measurands of interest (e.g. phenytoin and phenobarbitone induce gamma glutamyl transferase and alkaline phosphatase synthesis; oral contraceptives will induce alpha-1 antitrypsin synthesis.)
- Interpretation of results should take into account biological differences between individuals. For example, serum creatinine concentration is higher in African-Caribbeans than Caucasians for the same level of glomerular filtration rate; in pregnancy serum alkaline phosphatase activity is increased and serum urea concentration decreased.

**Pre analytical factors affecting test results**

Common analytical factors that are known to affect the performance of a test or the interpretation of results are described below:

| Factors | Precautions |
|---|---|
| **Mixing** | Thorough but gentle mixing of blood with anti-coagulant must be carried out by gently inverting the tube at least three times, immediately on collection. |
| **Haemolysis** | Avoid mechanical trauma to red cells. Never inject blood through a syringe needle into a specimen collection tube. Avoid extremes of temperature. |
| **Contamination** | Do not take blood from the same limb being used for infusion of fluids or decant blood from one container to another. Always follow the correct order of drawn, taking blood into a purple top (EDTA) tube last. |
| **Venous constriction** | It is essential that there should be no venous constriction (tourniquet) or active muscle movement during the collection of blood for the estimation of such constituents as calcium, protein, lactate and electrolytes, as this can lead to considerable alteration in levels. If avoidance of constriction is not practicable, its duration must be kept to an absolute minimum. |

| | |
|---|---|
| **Delay in transport of specimens to laboratory** | Considerable changes in the concentration of some blood constituents may occur if the blood is allowed to stand for any length of time before analysis begins, or separation of serum or plasma occurs. Samples must be transported to the laboratory in a timely fashion and are not stored prior to delivery. All samples must reach the laboratory within 4 hours. |
| **Interfering substances** | Previous administration of a substance or drug may cause interference in analysis. It is impossible to list all such potential interferences and advice should be sought from the duty biochemist if required. |

**Uncertainty of measurement**

When interpreting any laboratory result factors such as those discussed above should be considered. When monitoring a patient's status or disease it is important to consider how big a change in result is required before it can be considered significant. This value is known as the reference change value, and can be derived from knowledge of analytical and biological variation. For example, for serum sodium two results should differ by more than 4% before they can be said to have significantly changed; for serum creatinine the value is approximately 13%.

All biochemical results are subject to a degree of uncertainty of measurement. This may be due to a range of factors, including:

- Biological variation within individuals
- Analytical measurement imprecision
- Pre-analytical factors

If you require more information regarding the effects of these factors on the outcome of an individual test result please contact the Duty Biochemist on 01233 616287 (723-6287)

## 17. MANAGEMENT OF DATA AND INFORMATION

The proper management of data and information in the laboratory is essential for the provision of the service. Clinical Biochemistry and Immunology is committed to meeting its information security obligations to meet the needs of users, clients, patients and staff with respect to confidentiality, integrity and availability, which are defined as follows:

Confidentiality: protecting information from unauthorised disclosure

Integrity: safeguarding the accuracy and completeness of information and software

Availability: ensuring information and vital services are available to users when required

**DIR-MP-Q107** The Management of Data and Information describes the department's adherence to this standard.

Results cannot be given directly to patients. All test results must be obtained from the clinical requestor.

## 18. SERVICE COMPLIMENTS AND COMPLAINTS

Should your experience of our services not reach the very high expectations we set out to achieve then we would appreciate you contacting a senior member of staff (see below) to discuss your complaint/concern:

**For Informal Complaints**

Please contact:

Pathology Operations Manager (Chris Christodoulou-Smith) c.christodoulou1@nhs.net or Ext 723-6133

Head Biomedical Scientist (Mr Phil Bates) philipbates@nhs.net or Ext 722-4368

Head of Service (Dr Sally Stock) sally.stock@nhs.net or Ext 723-6025

**For Formal Complaints**

Please use the following contact:

**Patient Experience Team (PET)**

Email: ekh-tr.patientexperienceteam@nhs.net#

Telephone Number: 01233 633 331

Extension: 722-3145

## 19. RESEARCH, DEVELOPMENT AND TEACHING

The laboratory has an active research and development program. We are always interested in participating in research projects being undertaken by our clinical users. The laboratory actively participates in postgraduate teaching on all sites. We are always happy to talk to primary and secondary care user groups on specific topics. Enquiries should be directed to Dr Sally Stock, head of service (sally.stock@nhs.net).

## 20. POINT OF CARE TESTING

The Department of Pathology has responsibility for point-of-care testing (POCT) throughout EKHUFT. Any proposed developments in this area should be discussed with the relevant head of service, or Trust POCT coordinator.

## 21. CLINICAL GUIDELINES/INFORMATION

All our clinical staff welcome the opportunity to discuss and advise on the appropriate investigation of patients. In addition, we provide guidelines and investigative protocols on a range of conditions. These are developed in collaboration with key clinical users within the Trust. Many of our protocols and guidelines are also available on the clinical biochemistry pages on the Pathology pages of TrustNet at http://www.ekhuft.nhs.uk/pathology

Please also see the 'pathology app' accessed via MicroGuide. This can be downloaded to a smart device if accessing from outside the Trust.

To ensure that the examinations provided by the laboratory are clinically appropriate for the requests received, consistent with national guidelines and meet the requirements of our users, senior personnel periodically review the test repertoire provided by the laboratory.

Conversely clinical staff within the laboratory regularly review requests received to ensure appropriate and effective use of the service: this is done both through real time review of requests and by retrospective clinical audit. Wherever possible we involve key stakeholders in audits. Users should note that requests may be withheld when appropriate clinical details are not provided.

## INSTRUCTIONS FOR COLLECTIONS REQUIRING SPECIFIC PREPARATION

The following patient information sheets are available upon request or may be accessed in the patient area of TrustNet at: http://www.ekhuft.nhs.uk/patients-and-visitors/information-for-patients/patient-information-leaflets/ .

- Collection of a non-acidified 24 hour urine sample
- Collection of an acidified 24 hour urine sample
- Collection of a random urine sample
- Collection of a faecal sample
- Sweat test for diagnosis of cystic fibrosis
- Glucose tolerance test

We would encourage you to discuss any special procedures with the laboratory, prior to embarking upon them. Many of the procedures require special sample collection and storage. If these procedures are not adhered to, the samples may be unsuitable for analysis.

## ANTIBIOTICS

- Antibiotic assays for vancomycin and gentamicin are performed on ALL 3 sites by Clinical Biochemistry. Analysis of samples for tobramycin and amikacin levels is undertaken at the QEQMH site, and samples will be analysed between the hours of 08:00 and 20:00. Samples for tobramycin from paediatric cystic fibrosis patients will be analysed on the same day if they are received before 20:00.

- A clotted specimen (red top or SST, **not heparin**) is acceptable for all antibiotic assays.

- The Medical Microbiologists, antimicrobial pharmacist or ward pharmacist will be available for advice on antibiotic management in relation to these drug concentrations. However, calls to microbiology will only be taken from medical staff**.** Enquiries from nursing staff should be directed to the clinicians responsible for the patient. Clinical scientists in clinical biochemistry will not provide clinical advice on these results.

## ENDOCRINOLOGY

- The laboratory provides a full diagnostic endocrinology service and can advise on a range of dynamic endocrine function tests. Assays are available either in house or via specialised regional laboratories.

- Many tests will only be processed when sufficient, relevant and supportive clinical information is

provided with the request (e.g vitamin D, ACTH, IGF-1, growth hormone). Please ensure that all relevant information is provided.

- All requests for copper, careuloplasmin, thyroglobulin, thyroglobulin antibody, vitamin D, IGF-1, growth hormone, plasma metanephrines and 24hr urine 5HIAA are vetted by the duty biochemist prior to analysis. Clinical guidelines have been developed with users, and vetting is performed against these guidelines. All samples that are not tested will be stored for one month from receipt. If you wish to discuss please contact the duty biochemist.

- The test "TSH (thyroxine monitoring)" should be requested to monitor patients treated with thyroxine for primary hypothyroidism.

## METABOLIC MEDICINE

- **Blood gases**
  Blood gas analysis is available on several ward-based instruments throughout the Trust.

- **Adjusted calcium**
  The following equation is used to adjust total serum calcium for decreases in albumin concentration:

  Adjusted calcium (mmol/L) = calcium (mmol/L) + (0.015 x [41 – albumin (g/L)])

  The equation may not apply in patients with extremes of albumin concentration and/or in patients with acid-base disturbances. We therefore will not report an adjusted calcium concentration in the following situations:
  - when the albumin concentration is > 50 or <20 g/L.
  - In critically ill patients (ITU)
  - In patients < 1 year old

  The following comment will be attached to all calcium requests:
  Please note adjusted calcium results may be unreliable in critically ill patients, neonates and in the presence of jaundice. Consider measurement of ionized calcium and clinical correlation.

  These recommendations are based on the following: Albumin adjusted calcium;a position paper, Association for Clinical Biochemistry and Laboratory Medicine 2015.

- **Diabetes mellitus**
  The laboratory has worked closely with diabetologists in the Trust to develop policies for the diagnosis of diabetes and the assessment of albuminuria. These policies are available on TrustNet (within the Pathology area http://www.ekhuft.nhs.uk/pathology

  As requested by the South East Strategic Clinical Network (SESCN) for NHS Diabetes Prevention Programme and in order to support Primary Care with the identification of pre-diabetic patients we have agreed to provide comments on Fasting Plasma glucose [Fasting = > 8 hours with water only (ADA)]and HbA1C reports. This information will help to identify patients who may be eligible for referral to the National Diabetes Prevention Programme. There are 2 HbA1c test codes available on DART OCM and PAS:

  - HbA1cD – Diagnosis/screening
  - HbA1cM – Monitoring diabetic control

HbA1cM should be used for monitoring diabetic control in patients known to have diabetes. If both are selected, default will be HbA1cM. Please be aware Diagnostic HbA1c and Monitoring HbA1c will generate a different narrative on the report and kindly remember to request the appropriate HbA1c. HbA1cD should be used for diagnosis or screening.

The following comments are issued with reports:

**HbA1c Diagnostic (diagnosis/screening):**

< 42 mmol/mol - normal

42 - 47 mmol/mol - non-diabetic hyperglycaemia (NDH). There is a high risk of progression to type 2 diabetes. Consider referral to National Diabetes Prevention Programme

> 48 mmol/mol - indicative of diabetes. If patient is symptomatic, diagnosis is confirmed. If asymptomatic, repeat testing within 4 weeks is required for confirmation.

The following will also be added to all HbA1cD results:

*** HbA1c is accepted for the diagnosis of type 2 diabetes in the UK, but should not be used to diagnose type 1 diabetes or in the following contexts: childhood, pregnancy, renal failure, haemoglobinopathy trait, anaemia, HIV, abnormal red cell turnover or any recent treatment likely to affect glycaemia or red cell turnover ***

**HbA1c Monitoring (monitoring diabetic control):**

The following comment will be added to all HbA1cM results:

Assuming the patient is a known diabetic, individualised targets recommended. Please refer to NICE Guidance [NG28]: Type 2 Diabetes in adults: management / NICE Guidance [NG17]: Type 1 Diabetes in adults- diagnosis and management

https://www.nice.org.uk/guidance/ng28

https://www.nice.org.uk/guidance/ng17

**Fasting Plasma Glucose:**

3.0 – 5.4 mmol/L – normal fasting glucose

≥ 5.5 – 6.9 mmol/L - non-diabetic hyperglycaemia (NDH). There is high risk of progression to type 2 diabetes. Consider referral to National Diabetes Prevention Programme

≥7.0 mmol/L – indicative of diabetes. If patient symptomatic, diagnosis is confirmed. If asymptomatic, repeat testing within 4 weeks is required for confirmation.

- **Kidney disease**

Acute kidney injury

The laboratory reports acute kidney injury (AKI) alerts based on changes in serum creatinine according to a nationally agreed algorithm. Further details can be found at https://www.thinkkidneys.nhs.uk and http://kentakialerts.com

Estimated GFR

An estimated glomerular filtration rate is calculated from serum creatinine to improve the recognition of kidney disease. The laboratory automatically calculates eGFR when we receive a serum creatinine request on samples from adults (≥18 years old). GFR is estimated using the CKD-EPI equation. It should be noted that results should be multiplied by 1.16 if the sample was taken from an African-Caribbean patient and that a GFR between 60-89 mL/min/1.73 $m^2$ does not indicate chronic kidney disease unless there is other laboratory/clinical evidence (e.g. albuminuria). For further information see https://www.nice.org.uk/guidance/cg182

Our standard renal function test profile ("electrolytes and creatinine") consists of sodium, potassium, creatinine and eGFR. The value of urea as a test of kidney function is limited and the historical practice of requesting "urea and electrolytes" is discouraged. Urea is still available as a separately requested test provided that it is specifically indicated on the request form.

Proteinuria and albuminuria

The detection of protein in the urine is one of the cardinal signs of kidney disease. Confirmation has traditionally relied upon the submission of a 24 h urine sample to the laboratory for quantitation of daily protein loss. It is now clear that equivalent information can be obtained from a random (preferably early morning) urine sample and this has been endorsed as a recommendation in the second part of the NSF for kidney disease. We prefer to receive random rather than 24 h urine collections for quantitation of protein loss. The laboratory reports the result as an albumin/creatinine (preferred) or protein/creatinine ratio (mg/mmol).

The international chronic kidney disease staging system considers urine albumin/creatinine ratios ≥3.0 mg/mmol to be positive tests for proteinuria (stage A2, moderately increased), with higher level proteinuria (stage A3, severely increased) being indicated by an albumin/creatinine ratio ≥30 mg/mmol. Positive tests should be followed by exclusion of postural proteinuria, by analysis of an EMU. Patients with two or more positive tests, preferably spaced by 1 to 2 weeks, have persistent proteinuria. Further advice on the interpretation of proteinuria may be accessed at https://www.nice.org.uk/guidance/cg182

- **Lipids**

The laboratory offers analysis of total and HDL cholesterol and triglycerides. In addition we report calculated total cholesterol/HDL ratios, calculated LDL and calculated non-HDL cholesterol. All requests for total cholesterol will receive a HDL cholesterol measurement.

Before starting lipid modification therapy for the primary prevention of CVD, take at least 1 lipid sample to measure a full lipid profile. This should include measurement of total cholesterol, HDL cholesterol, non-HDL cholesterol and triglyceride concentrations. A fasting sample is not needed (NICE CG181).

Results should be interpreted in relation to other coronary risk factors as described in NICE clinical guideline 181, Cardiovascular disease: risk assessment and reduction, including lipid modification, (www.nice.org.uk/cg181) and NICE clinical guideline 71 Familial hypercholesterolaemia: identification and management (www.nice.org.uk/guidance/cg71).

LDL cholesterol measurement can be calculated using Friedwald's equation providing the serum triglyceride concentration is less than 4.5 mmol/L.

LDL Cholesterol = [Total Cholesterol – HDL cholesterol] - [0.46 x triglyceride] (all values are in mmol/L)

Notes:

1. Serum triglycerides are subject to major increases following meals and may also be released (as VLDL) after prolonged fasting: a 12-14 h fast for meaningful triglyceride measurements may be required, in order confirm an elevated non-fasting result.
2. Serum cholesterol concentrations can exhibit a seasonal variation and there may be marked day-to-day variations in certain individuals.
3. Samples for cholesterol measurement during admission for myocardial infarction should be collected within 24 h – if this is not done, assessment of cholesterol status must be postponed to 3 months post-infarction as interim values can be grossly misleading.

- **Porphyria**
  In patients suspected of having an acute neurological porphyria (e.g. abdominal pain, neurological or psychiatric symptoms) the most appropriate first line investigation is a random urine porphobilinogen (PBG). The sample should be collected during or shortly after (within days) of the attack and must be protected from the light after collection and taken promptly to the laboratory. If this test is negative then no further investigations are normally undertaken. Blood porphyrin measurements are not informative in this situation.

  The investigation of patients with suspected dermatological porphyrias (e.g. photosensitivity or skin lesions) is more complex - please contact the duty biochemist for advice.

  Please provide full clinical details when sending samples for porphyrin analysis (e.g. time of acute attack, nature of skin lesions).

- **Urinary stone risk assessment**
  The following investigations should be undertaken in renal stone formers.

  Serum sodium, potassium, chloride, bicarbonate, urea, creatinine, calcium, phosphate, albumin, ALP, urate and urinary (24 h) calcium, magnesium, oxalate, citrate, urate, creatinine, cystine (screening test), sodium, pH and volume

  Patients should be on their normal diet and at least two weeks should have elapsed since any episode of renal colic.

# PAEDIATRIC BIOCHEMISTRY

The provision of a biochemistry service to infants and children obviously has special demands. Most individual tests can be carried out with 0.5-1.0 mL blood depending on the patients PCV. *If multiple tests are required, please contact the laboratory for advice prior to sending* ***and*** *indicate test priority on the request form so that the most essential tests are carried out first.*

It should be remembered that adult reference ranges are often not applicable in the paediatric setting. In some cases, our laboratory reports will carry paediatric reference ranges, but please discuss the interpretation of individual results with us.

## DIAGNOSIS OF INBORN ERRORS OF METABOLISM

The investigation of unexpected inborn errors of metabolism is complex. The laboratory is always happy to discuss cases with you. Many of the more specialist investigations are provided by regional laboratories. It is advisable to discuss specimen requirements with the laboratory staff prior to obtaining samples. The following guidance has been adapted from the Association of Clinical Pathologists (Broadsheet 120, January 1989).

### a. Non-acute presentation

The initial biochemical investigations which should be considered will depend upon the clinical presentation and the family history. The principal presentations are:-

***Unexpected failure to thrive***

Investigations which should be considered will be influenced by family history and presence of any suggestive clinical or metabolic abnormalities. Plasma amino acids, plasma ammonia and urine organic acids may be helpful.

***Liver disease***

Investigations for consideration include:

Plasma: Fasting glucose, amino acids, lactate
Serum: $Alpha_1$-antitrypsin, alpha-fetoprotein, urate, cholesterol, thyroid function tests

If neonate: blood galactose-1-phosphate uridyl transferase
If more than 5 years old: copper and caeruloplasmin

***Neurological degenerative disorders***

These include the lysosomal and peroxisomal disorders. Detailed discussions with the duty biochemist may be required to ensure that the correct test and specimen is selected, but investigation might include urine and plasma amino acids, urinary glycosaminoglycans and oligosaccharides, plasma very long chain fatty acids and urinary organic acids.

### b. Acutely ill neonates or infants

Initial biochemical investigations should include the following:
Urine: Glucose, ketones, bilirubin, urobilinogen by dipstick.
Blood: pH, pCO2, bicarbonate, sodium, potassium, chloride, glucose, calcium, magnesium, bilirubin (total and conjugated), alkaline phosphatase, AST or ALT, creatinine.
Consider toxicological investigations.

Further investigations should then proceed according to the clinical problems and the biochemical abnormalities identified. These can be categorised into five groups as follows:

| Presentation | Suggested investigations for clinical presentation | Possible metabolic disorders |
|---|---|---|
| 1. Unexplained hypoglycaemia | Organic acids (U)<br>Amino acids (P)<br>Lactate (P)<br>Insulin (P) + C-peptide (P)<br>17-hydroxyprogesterone (S),<br>Cortisol (S)<br>Steroid profile (U)<br>Ammonia (P) | Organic acid disorders<br>Amino acid disorders<br>Glycogen storage disease (type 1)<br>Disorders of gluconeogenesis<br>Congenital adrenal hyperplasia |
| 2. Acid base imbalance<br>- metabolic acidosis (exclude primary cardiac and respiratory disorders) | Organic acids (U)<br>Amino acids (P),<br>Lactate (P)<br>Ammonia (P) | Organic acid disorders<br>Congenital lactic acidosis |
| - respiratory alkalosis | Amino acids (P),<br>Organic acids (U),<br>Ammonia (P) | Urea cycle disorders |
| 3. Liver dysfunction (often associated with hypoglycaemia and galactosuria) | Galactose-1-phosphate uridyl transferase (B)<br>Amino acids (P)<br>Lactate (P)<br>Succinylacetone (U)<br>AFP (S)<br>Oligosaccharides (U)<br>Organic Acids (U)<br>$\alpha_1$-antitrypsin (S) | Galactosaemia<br>Fructose 1.6 diphosphatase deficiency<br>Fructose intolerance<br>Tyrosinaemia (type 1)<br>Glycogen storage (type 1)<br>Disorders of gluconeogenesis |
| 4. Neurological dysfunction<br>- seizures<br>- depressed consciousness<br>- hypotonia | Amino acids (P)<br>Organic acids (U)<br>Orotic acid (U)<br>Ammonia (P)<br>Urate (S,U)<br>Sulphite (U)<br>Lactate (P) | Non-ketonic hyperglycinaemia<br>Glyceric acidaemia<br>Urea cycle disorder<br>Xanthine/sulphite oxidase deficiency |
| 5. Cardiomyopathy | Lactate (P),<br>Oligosaccharides (U),<br>Organic acids (U)<br>Glycosaminoglycans (U)<br>Carnitine (P)<br>Amino acids (P)<br>TFT (S) | Glycogen storage type II (Pompe's)<br>Fatty acid oxidation disorders<br>Tyrosinaemia (type I)<br>Mucopolysaccharidosis |

*Blood (B), Plasma (P), Serum (S), Urine (U)*

- **Cystic Fibrosis**
  The incidence of cystic fibrosis (CF) in the UK is 1 in 2500 live births. There is a national screening programme for CF. Identification of heterozygotes is also possible using mutation analysis. However, the gold standard test for diagnosing CF in symptomatic infants remains the sweat test with measurement of sweat chloride concentration. Sweat tests are carried out by ward staff using the Wescor Macroduct method of sweat collection followed by laboratory measurement of chloride concentration.

# TOXICOLOGY INVESTIGATIONS

(Adapted from: Guidelines for laboratory analyses for poisoned patients in the United Kingdom. Thompson JP, et al. Ann Clin Biochem. 2014 May;51:312-25)

Clinical advice on poisoning for healthcare professionals can be obtained from National Poison's information Service on 0844 892 0111 or http://www.toxbase.org.

## Carbamazepine

- The acute management of carbamazepine poisoning, including the need for multiple doses of oral activated charcoal, is determined by the clinical picture. There is no need for a carbamazepine assay in the great majority of patients who have taken an overdose
- Urgent measurement of serum carbamazepine concentrations is only required when multiple dose activated charcoal is being considered or there is doubt about the diagnosis, for example in patients with
  - Coma
  - Respiratory depression
  - Arrhythmias
- Serious complications are unusual at serum concentrations less than 25 mg/L. Most patients with life threatening toxicity have serum carbamazepine concentrations in excess of 40 mg/L
- Non-urgent measurement is helpful to determine when to restart chronic carbamazepine therapy.

## Carboxyhaemoglobin

- Carboxyhaemoglobin should be measured urgently in all patients with suspected carbon monoxide poisoning (including those with suspected smoke inhalation)
- A carboxyhaemoglobin percentage of ≥20% indicates significant exposure. However, concentrations less than this do not exclude significant poisoning and the relationship between carboxyhaemoglobin and severity of poisoning and/or clinical outcome is poor
- Management should be determined by the clinical condition of the patient rather than the carboxyhaemoglobin concentration
- High flow oxygen therapy should be administered pending the results of carboxyhaemoglobin measurement
- Reference ranges:

  Non smokers <1.5%

  Smokers 1-2 packs per day 4-5%

  Smokers greater than 2 packs per day 8-9%

  Values greater than 20% are considered toxic

  Values greater than 50% are considered lethal

## Digoxin

- Serum digoxin concentrations correlate poorly with the severity of poisoning, especially soon after acute overdose
- Severe toxicity is usually (but not invariably) associated with concentrations > 4 ug/L. Hypokalaemia enhances digoxin toxicity. In acute life-threatening poisoning, hyperkalaemia is usually present.

- Urgent measurement of serum digoxin concentration is essential if digoxin-specific antibodies are to be used. The digoxin concentration is useful in determining an appropriate dose of digoxin specific antibodies, as well as confirming the diagnosis.
- In patients with life threatening arrhythmias due to digoxin toxicity, treatment with digoxin-specific antibodies should not be delayed pending the results of plasma digoxin concentrations
- Samples should always be taken ***before*** antibody administration since plasma digoxin concentrations cannot be interpreted once these have been given
- Samples taken to investigate possible chronic digoxin intoxication should be taken at least 6 h after dosing and do not usually need to be analysed urgently, unless life-threatening features are present and use of digoxin antibodies is being contemplated
- Repeat samples, analysed routinely, may help determine when to re-institute chronic therapy after acute overdose. However, these are not of value for several days following the administration of digoxin antibodies, since the elimination half-life of the complex under normal conditions is 16-20 h
- Assays routinely used in the UK are not ideal for accurate quantification of digitoxin or plant glycosides, although they may provide qualitative supportive evidence of exposure.

**Ethanol**

- Plasma ethanol concentrations are usually not required in patients who have ingested ethanol unless severe poisoning is suspected
- Ethanol concentrations should be measured urgently

  (a) In patients with undiagnosed coma or widened osmolar gap (N.B. 1000 mg/L [21.75 mmol/L] ethanol ≡ 20 mmol/kg)

  (b) In children with unexplained metabolic acidosis

  (c) In patients with suspected severe ethanol intoxication
- Concentrations >1800 mg/L are associated with disorientation. In the absence of other toxins, ethanol concentrations >3500 mg/L are usually required to produce coma. Fatal poisoning is usually associated with concentrations > 4500 mg/L. Ethanol toxicity is enhanced in the presence of other sedative agents (and *vice versa*).
- Plasma ethanol concentrations performed urgently are essential for monitoring the use of ethanol as an antidote for poisoning with ethylene glycol or methanol, particularly if dialysis is also being used. Ethanol should be monitored every 1-2 h initially until a concentration of 1000-1500 mg/L is reached, thereafter every 2-4 h.
- For conscious patients, breath alcohol measurement may be used for monitoring ethanol therapy, if facilities are available locally, aiming for target concentrations of 440-660 ug/L (44–66 ug/100 mL) breath. (N.B. This is equivalent to 1000-1500 mg/L blood, if a blood-breath partition co-efficient value of 2300 is used).

**Iron**

- Serum iron concentrations help to determine prognosis and the need for antidotal treatment with desferrioxamine in patients with suspected iron poisoning
- They should be measured urgently in

  (a) Asymptomatic patients who have ingested > 20 mg/kg elemental iron within 6 hours.

(b) Patients with symptoms (including transient symptoms) suspected to be due to iron intoxication

For both groups, the sample should be taken immediately in patients with suspected severe poisoning. It is desirable to take a further sample 2 h after the first sample. The peak is likely to have passed 6 h after ingestion. It is important that the sample is not haemolysed

- Severe toxicity is unlikely if symptoms have not developed within 6 hours of ingestion.
- Serum iron concentrations following ingestion are interpreted as follows

| | |
|---|---|
| <55 umol/L | mild poisoning |
| 55–90 umol/L | moderate poisoning |
| >90 umol/L | severe poisoning |

- Antidotal therapy with desferrioxamine is indicated without waiting for the plasma iron concentration in patients with severe clinical features (e.g. unconscious, fitting or shocked)
- Antidotal treatment may also be indicated for patients with iron concentrations >55 umol/L if there is additional evidence of toxicity (e.g. prolonged (>4 h) gastrointestinal symptoms, leucocytosis or hyperglycaemia). Further advice on individual cases can be obtained from the NPIS.
- All colorimetric iron assays are unreliable in the presence of desferrioxamine
- Measurement of iron-binding capacity has no role in the management of iron poisoning

**Lithium**

- Blood should be sampled immediately and the serum lithium concentration measured urgently in patients who have

  (a) suspected acute on chronic or chronic toxicity

  (b) Acute lithium intoxication associated with relevant symptoms
- In acute lithium overdose where there are no relevant symptoms, the serum concentration should be measured approximately 6 hours after ingestion and the result obtained urgently.
- If severe poisoning is confirmed, or if a sustained release preparation may have been taken, the serum lithium concentration should be repeated 6-12 hourly until the concentration is falling
- The principle value of urgent lithium measurement is to determine the need for haemodialysis in severe poisoning**.** Low thresholds should be considered for haemodialysis in the presence of neurological or cardiac features, particularly if concentrations are increasing. Advice on the interpretation of lithium concentrations and on the appropriate use of haemodialysis can be obtained from the NPIS.
- There is a risk of rebound increases in lithium concentration after haemodialysis and lithium concentrations should be measured 6 h after haemodialysis is discontinued.
- Repeated measurements of lithium concentration, performed routinely (12 h post-dose), are helpful in timing the appropriate re-institution of chronic therapy following an episode of toxicity.

**Paracetamol**

- Measurement of serum paracetamol concentration is essential for determining the need for antidotal treatment and should be performed urgently in all patients with known or suspected paracetamol overdose
- Serum paracetamol concentrations should also be measured urgently in all patients when there is a clinical suspicion that paracetamol poisoning may be present. Examples would be:

(a) Drug overdose patients, when the history appears unreliable
(b) Patients with undiagnosed coma where there is a clinical suspicion of drug overdose

- Measurement of paracetamol concentrations in alert patients who deny taking paracetamol, when there is no clinical suspicion, rarely provides evidence of significant paracetamol toxicity and is therefore not routinely recommended.
- The sample must be taken 4 h after ingestion, or immediately, should the patient present after an interval of more than 4 h. The PT/INR should also be measured and this should be repeated in patients at risk of, or developing, hepatotoxicity
- Serum electrolytes, liver and renal function tests should also be undertaken
- Serum paracetamol concentration measurement is occasionally helpful in some patients with unexplained hepatotoxicity, although a negative result does not exclude paracetamol as a cause
- For the great majority of patients only a single measurement of paracetamol concentration is indicated. A second sample, after an interval of 2-3 h, may be helpful for occasional patients who have taken staggered overdoses or when the timing of ingestion is particularly uncertain. Interpretation of the results is difficult and should be discussed with the NPIS when there is uncertainty. In these cases it is often appropriate to give N-acetylcysteine pending the results of the second paracetamol concentration**.**
- NB: Samples taken after the administration of N-acetylcysteine may give falsely low paracetamol concentrations**.**

**Paraquat (urinary, qualitative assay)**

- There is no specific treatment of proven value for paraquat poisoning. Investigations are directed at confirming exposure and determining prognosis
- A qualitative urine test (dithionite spot test) should be performed urgently in all patients presenting with suspected paraquat poisoning to confirm exposure
- In patients with a positive spot test, a blood sample should be taken for routine analysis in a specialist laboratory, as this provides valuable prognostic information.
- All requests **must** be discussed with the duty biochemist.
- All samples are sent to City Assays, Birmingham for analysis.

**Phenytoin**

- Most patients with acute phenytoin overdose do not require measurement of plasma phenytoin concentration
- An urgent phenytoin concentration is helpful (but not essential) if multiple dose activated charcoal is being contemplated, particularly if the diagnosis is in doubt, e.g. in patients with coma, respiratory depression or arrhythmias. However, the clinical value of this elimination method for phenytoin intoxication is unproven
- Rarely, urgent measurement of the phenytoin concentration may help to differentiate between convulsions due to phenytoin toxicity and those resulting from inadequate anticonvulsant concentrations
- Patients with suspected chronic phenytoin toxicity as a result of therapeutic dosing should have their plasma phenytoin concentration measured, but there is no need for this to be done urgently
- Symptomatic toxicity is usually associated with concentrations >20 mg/L, while concentrations >40 mg/L suggest serious toxicity
- Routine measurements may be useful to monitor anti-epileptic therapy or to time the re-institution of chronic therapy after overdose.

### Salicylate

- **There is no need to measure salicylate concentrations in conscious overdose patients who deny taking salicylate-containing preparations and who have no features suggesting salicylate toxicity**
- Serum salicylate concentration should be measured urgently for patients who are thought to have ingested > 125 mg/kg of aspirin (acetyl salicylate), as well as those who have taken methylsalicylate (oil of wintergreen) or salicylamide
- The sample should be taken at least 2 hours (symptomatic patients) or 4 hours (asymptomatic patients) following ingestion, since it may take several hours for peak plasma concentrations to occur: longer sampling times may be required to detect peak concentrations where enteric coated preparations have been used
- A repeat sample should be taken after a further 2 hours in patients with suspected ***severe*** toxicity following recent ingestion because of the possibility of continuing absorption. Under these circumstances, measurements should be repeated every 3 h until concentrations are falling
- Salicylate concentration should also be measured in patients with unidentified poisoning or those with undiagnosed clinical features consistent with salicylate poisoning, e.g. coma, metabolic acidosis, respiratory alkalosis, tinnitus, etc
- The severity of poisoning cannot be assessed from serum salicylate concentrations alone and clinical and biochemical features should be taken into account. However, salicylate intoxication is usually associated with plasma concentrations >350 mg/L
- Patients with moderate salicylate poisoning may require urine alkalinisation, while those with severe poisoning may need treatment with haemodialysis. Advice on the interpretation of salicylate concentrations and the need for urinary alkalinisation and haemodialysis can be obtained from the NPIS.
- Serum salicylate concentrations should be repeated after dialysis

### Theophylline

- Patients with suspected theophylline poisoning should have the severity graded according to simple clinical indicators, including the serum potassium and arterial blood gases
- Serum theophylline concentration should be ascertained immediately in patients with any clinical features suggesting theophylline toxicity, including hypokalaemia or acidosis. Theophylline concentrations should not be measured earlier than 4 hours after exposure in patients who are asymptomatic
- In patients with severe poisoning or theophylline concentration >60 mg/L, the theophylline concentration should be repeated every 2-4 h, until peak concentrations have passed. This is particularly important if a slow release preparation has been taken
- Advice on the interpretation of theophylline concentrations and the need for multiple dose activated charcoal can be obtained from the NPIS.

### Unknown drug screen

- Samples for drug screens will only be sent for analysis if the results will affect clinical management. It may take several weeks for results to be returned
- Please provide information about prescribed medicines as well as suspected illicit use to aid interpretation of the results
- The preferred sample is urine obtained as soon as possible after presentation. Blood samples do not provide as much information as urine and should only be used if no urine is available
- The laboratory cannot provide adequate chain of custody evidence for samples with medico-legal implications.

## THERAPEUTIC DRUG MONITORING

The laboratory offers a therapeutic drug monitoring service for the following drugs on the following days:

| | |
|---|---|
| Daily: | digoxin, theophylline, lithium, phenytoin, valproate |
| Monday/Wednesday/Friday: | carbamazepine |
| Monday/Wednesday/Thursday/Friday: | ciclosporin, tacrolimus, sirolimus |
| Friday: | phenobarbitone |

**Samples for ciclosporin, tacrolimus and sirolimus measurement must be received in the K&CH laboratory by 1pm on the day of the analysis if a same day result is required**.

- Some drugs are only measured on a single site in the Trust: therefore, please allow time for specimen transport. Urgent analysis of these drugs may also be available in some cases following discussion with the laboratory.

- Please note that generally blood for drug analysis should be collected into plain (red-topped), **not** gel separator (gold-topped) tubes: ciclosporin, tacrolimus and sirolimus samples should be collected into EDTA (purple-topped) tubes.

- Routine monitoring of anti-epileptic drug concentrations is NOT indicated in adults or children and should only be done if clinically indicated. This includes measurement of phenytoin, lamotrigine, valproate, phenobarbitone, carbamazepine and levetiracetam. Please contact the Duty Biochemist to discuss prior to collecting samples: if measurement is indicated please ensure all clinical details accompany request.

- Ideal sampling times and therapeutic ranges for these drugs may be found in the section “Clinical Biochemistry Reference Ranges”. In the case of phenytoin and phenobarbitone, although trough samples are ideal, provided the patient is at 'steady state' the sample timing is not critical: however, sample time in relation to dose should ideally be provided with the request.

- Therapeutic ranges provide a target range of concentrations around which clinical improvement might be expected without toxicity. However, individual patients may achieve clinical response at levels below the therapeutic range and toxic effects can occur within therapeutic ranges: it is essential that dosage adjustments should be made in relation to the clinical state of the patient.

## TUMOUR MARKERS

- A range of tumour marker assays are available in the laboratory at EKHUFT.
- With the exception of CA125 (symptomatic females)) and PSA (symptomatic males), tumour marker requests should be restricted to those patients with a tissue diagnosis of the disease. The poor sensitivity and specificity of all these markers make them unsuitable for use as general population screening tests. Their main value is in monitoring the treatment of patients with proven carcinoma who have been shown to have an elevated concentration of the appropriate marker at the time of diagnosis.

## XANTHOCHROMIA TESTING FOR SUBARACHNOID HAEMORRHAGE (SAH)

- The laboratory provides a service to screen CSF for xanthochromia to rule out subarachnoid haemorrhage in CT negative patients.
- CSF samples must be collected at least 12 hours after the suspected event and within 14 days.
- Avoid using CSF taken within 3 days of a previous lumbar puncture.
- Samples MUST be protected from light and reach the laboratory within 60 minutes.
- Please provide 1 mL (20 drops) sample in addition to that for any other tests.
- Collection kits with full instructions are available in the Emergency Departments and from Clinical Biochemistry.
- The laboratory will produce same day results on samples received in the laboratory at any of the three acute sites up to 17:00 Monday to Friday and up to 10:00 on Saturday, Sunday and on public holidays. Samples received after these times will be processed the next day.
- Medical teams wishing to undertake xanthochromia testing at weekends or on public holidays (outside of the times stated above) will need to discuss this with the on-call clinical biochemist, who can be contacted via switchboard.

## IMMUNOLOGY (INCLUDING ALLERGY AND PROTEINS)

Clinical Biochemistry is responsible for the provision of the autoimmune serology service within the Trust and also provides a laboratory immunology service for the rest of Kent and Medway. Interpretive advice and help is available from senior staff within the laboratory and also through a service level agreement with the Protein Reference Unit at St George's Hospital, London.

The following table lists the major tests available and the main indications for their use. Request the tests in **bold type** as appropriate and we will automatically do the appropriate follow-up investigations.

The antibody tests are all IgG antibodies unless stated otherwise. This table lists the relevant antigens.

### AUTOIMMUNE RHEUMATIC DISEASE – SLE, RHEUMATOID ARTHRITIS

| TEST/REQUEST | POSSIBLE CLINICAL OUTCOME | COMMENTS |
|---|---|---|
| Rheumatoid factor | Rheumatoid arthritis | • Low concentrations may be seen in the elderly and in patients with chronic infections.<br>• Lacks sensitivity for monitoring RA – use CRP instead of rheumatoid factor. |
| **Anti cyclic citrullinated peptide antibody (CCP)** | Rheumatoid arthritis | • Useful when rheumatoid factor results and the clinical picture are inconsistent.<br>• Positive anti CCP antibodies and rheumatoid factor are suggestive of worse disease in RA.<br>Consultant Rheumatologist ONLY requests. **Guidelines available on http://www.ekhuft.nhs.uk/clinicalbiochemistry**. |
| **Anti-nuclear antibodies (ANA)** | Connective tissue disorders | • Low titre ANA may be seen in the elderly and associated with viral infections.<br>• Weak positive ANA with no clear clinical pattern – suggest recheck in 3-6 month if symptoms persist or worsen.<br>• Positive ANA may also be found in autoimmune liver disease.<br>• **Further tests: specimens showing a significantly positive ANA will be automatically further tested for antibodies to double stranded DNA and extractable nuclear antigens (SSA, SSB, RNP, Sm, Scl-70 and Jo-1). Other antigen specificities will be tested depending upon the clinical details.** |
| **Double stranded DNA antibody (dsDNA)** | Diagnosis and monitoring of SLE | • Used for monitoring SLE – typically every 3-6 months, but may be more frequent in active disease and disease exacerbations. |
| **SSA (Ro) antibody** | Sjogrens syndrome SLE | • Associated with neonatal heart block.<br>• Not useful for monitoring disease. |
| **SSB (La) antibody** | Sjogrens syndrome SLE | • Not useful for monitoring disease. |
| **Ribo-nuclear protein antibody (RNP)** | Mixed connective tissue disease | • Not useful for monitoring disease. |
| **Sm antibody** | SLE | • Not useful for monitoring disease. |

| | | |
|---|---|---|
| **Scl-70 antibody** | Systemic sclerosis | • Not useful for monitoring disease. |
| **Jo-1 antibody** | Dermatomyositis | • Not useful for monitoring disease. |
| **Centromere antibody** | CREST syndrome | • Not useful for monitoring disease. |
| **Myositis specific autoantibody panel** | Myositis syndromes | • Not useful for monitoring disease. |
| **Complement C3 and C4** | Immune complex diseases | • Falling C4 concentration may predict lupus nephritis.<br>• Cryoglobulin analysis may be indicated with an unexpected low C4 concentration – Call the lab for collection protocol. |

## AUTOIMMUNE THYROID DISEASE AND DIABETES

| TEST/REQUEST | POSSIBLE CLINICAL OUTCOME | COMMENTS |
|---|---|---|
| **Thyroid peroxidase antibody (TPO)** | Autoimmune thyroiditis | • Anti thyroid peroxidase antibodies should only be requested in particular situations – the most common is when the TSH is between 5 and 10 mU/L with a normal free T4.<br>• No indication for monitoring disease - use thyroid function tests. |
| **TSH receptor antibody** | Thyrotoxicosis, Grave's disease | • Pathogenic antibodies that may be associated with neonatal hyperthyroidism.<br>• Can be used to monitor but TFTs usually used instead. |
| **Diabetes autoantibodies (GAD, IA-2 & ZnT8)** | Type 1 diabetes mellitus | • **Guidelines available on http://www.ekhuft.nhs.uk/clinicalbiochemistry**<br>• Diabetes autoantibodies should not be measured routinely to confirm type 1 diabetes<br>• May be useful if clinical presentation is atypical |

## LIVER DISEASE

| TEST/REQUEST | POSSIBLE CLINICAL OUTCOME | COMMENTS |
|---|---|---|
| **Mitochondrial antibody** | Primary biliary cirrhosis | • M2 subtype may be indicated if results are inconsistent with clinical findings.<br>• Raised IgM concentrations often seen with PBC.<br>• Not typically used to monitor treatment.<br>• If you do want to recheck, request no more than every 6 -12 months. |
| **Smooth muscle antibody** | Autoimmune hepatitis | • Not typically used to monitor treatment.<br>• ANA may also be found. |
| **LKM antibody (Liver kidney microsomal)** | Autoimmune hepatitis | • Not typically used to monitor treatment. |
| **α1 anti trypsin (concentration ± phenotype)** | Liver disease<br>Lung disease | • Important investigation in prolonged neonatal jaundice.<br>• Deficiency phenotype can exacerbate liver disease. |

## GUT DISEASES

| TEST/REQUEST | POSSIBLE CLINICAL OUTCOME | COMMENTS |
|---|---|---|
| **Gastric parietal cell antibody (GPC)** | Atrophic gastritis Pernicious anaemia | • Can be a non-specific finding.<br>• Not used to monitor treatment. |
| **Intrinsic factor antibody** | Pernicious anaemia | • Not used to monitor treatment. |
| **Anti TTG antibodies (IgG and IgA)** | Coeliac disease | • Initial screen for coeliac disease.<br>• Positive results are confirmed with IgG and IgA anti endomysial antibodies.<br>• Occasionally used to monitor compliance to gluten free diet when anti TTG antibodies should disappear |
| **Endomysial antibodies (IgG & IgA)** | Coeliac disease | • Follow-up investigation for positive anti TTG antibodies. |
| **IgE and specific IgE (please specify allergens)** | Allergic reactions can cause a variety of symptoms including diarrhoea, vomiting, abdominal pain and anaphylactic reactions. | There are a wide range of allergens available. **Please use the Kent and Medway allergy guide and request form available on http://www.ekhuft.nhs.uk/clinicalbiochemistry**.<br><br>In children occasionally the reduction in specific IgE concentration is used to predict "residual" reactivity to an allergen before challenge testing is done – must be interpreted by clinical allergists. |

## SKIN DISEASES

| TEST/REQUEST | POSSIBLE CLINICAL OUTCOME | COMMENTS |
|---|---|---|
| **Skin antibodies to intercellular cement** | Bullous pemphigus | • Not typically used to monitor treatment. |
| **Skin antibodies to basement membrane** | Bullous pemphigoid | • Not typically used to monitor treatment. |
| **IgE and specific IgE (please specify allergens)** | Allergic reactions can cause a variety of symptoms including eczema, dermatitis. | There are a wide range of allergens available. **Please use the Kent and Medway allergy guide and request form available on http://www.ekhuft.nhs.uk/clinicalbiochemistry**.<br><br>In children occasionally the reduction in specific IgE concentration is used to predict "residual" reactivity to an allergen before challenge testing is done – must be interpreted by clinical allergists. |

## RENAL DISEASE AND VASCULITIS

| TEST/REQUEST | POSSIBLE CLINICAL OUTCOME | COMMENTS |
|---|---|---|
| **Glomerular basement membrane antibody (GBM)** | Goodpasture's syndrome | • Useful in monitoring disease.<br>• Suggest samples are taken daily while on plasmaphoresis.<br>• For longer term monitoring suggest every 1-3 months depending on the clinical picture. |
| **Anti neutrophil cytoplasmic antibody** | | • **Please see ANCA testing guidelines, in the pathology area within TrustNet http://www.ekhuft.nhs.uk/clinicalbiochemistry**<br>• Specimens showing a positive ANCA pattern will be tested for antibodies to specific antigens (see below): |
| c-ANCA (IgG abs to proteinase 3) | Granulomatosis with polyangiitis (formerly known as Wegener's granulomatosis) | • Can be useful in monitoring disease.<br>• Suggest samples are taken weekly after start of treatment.<br>• For longer term monitoring suggest every 1-3 months depending on clinical picture. |
| p-ANCA (IgG abs to myeloperoxidase) | Microscopic polyangiitis, Churg-Strauss syndrome, Polyarteritis nodosa | • Can be useful in monitoring disease.<br>• Suggest samples are taken weekly after start of treatment.<br>• Longer term monitoring suggest every 1-3 months depending on clinical picture. |
| **Paraprotein studies** (serum and urine) | Presence of paraproteins (particularly Bence Jones protein) may be associated with renal disease. | • Follow-up frequency depends on clinical picture |
| **Cryoprotein investigations** | Cryoglobulin analysis may be indicated in patients with deteriorating renal function, an unexpected low C4 concentration, history of hepatitis C infection etc. | • Call the lab for sample collection protocol. |

## IMMUNODEFICIENCY AND INFECTION

| TEST/REQUEST | POSSIBLE CLINICAL OUTCOME | COMMENTS |
|---|---|---|
| **Immunoglobulins** (IgG, IgA & IgM) | Essential in the investigation of:<br><br>Suspected immunoglobulin deficiency<br><br>Suspected B cell malignancy | • Used to monitor immunoglobulin replacement therapy.<br>• Also check urine for Bence Jones protein.<br>• Patients with normal immunoglobulin concentrations, no immune deficiency or B cell malignancy do not need repeat immunoglobulins unless the clinical picture changes. |
| **IgG subclasses (IgG1, 2, 3 &4)** | May be indicated in patients (particularly children) with recurrent infections.<br><br>IgG4 related disease (IgG4-RD) | • Not indicated in patients with low IgG concentrations or on immunoglobulin replacement therapy.<br>• IgG4-RD is an immune-mediated fibroinflammatory condition characterized histopathologically by three hallmark features in involved tissue: obliterative phlebitis, storiform fibrosis, and a dense lymphoplasmacytic infiltrate. IgG4-RD can affect any organ with common presentations including Riedel's thyroiditis, autoimmune pancreatitis, sclerosing cholangitis, sialadenitis, dacryoadenitis, periaortitis, an eosinophilic rash, and pseudotumor of the lung, lymph nodes, or orbits. However, serum IgG4 quantification lacks sensitivity for IgG4-RD and is most useful as a predictor of relapse in patients who have been treated for IgG4-RD. |
| **Complement CH50** | Used to exclude deficiencies of the classical complement cascade. | • Sample must be separated within 30 mins of collection and frozen immediately. |
| **C1 inhibitor (C1 INH) deficiency** | Hereditary angioedema | • Also check C3 and C4 – low C1 INH and low C4 concentrations are consistent with hereditary angioedema.<br>• There is a rare form of functional C1 inhibitor deficiency with normal or raised C1 INH concentration – please call the lab to discuss.<br>• Patients with C1 inhibitor deficiency on treatment can be monitored every 2-3 months with C3, C4 and C1 INH measurements. |

## NEUROLOGY

| TEST/REQUEST | POSSIBLE CLINICAL OUTCOME | COMMENTS |
|---|---|---|
| **Acetylcholine receptor abs.** | Associated with myasthenia gravis | • Pathogenic antibodies that may be associated with neonatal myasthenia.<br>• Can be used to monitor (e.g. every 3-6 months). |
| **Paraneoplastic antibodies and neurological antibodies** | There is an increasing number of antibodies associated with neurological conditions. | Please specify the antibody required. |
| **Fluid Tau protein** | Beta-2 transferrin can be used to determine whether a fluid leaking for example from the nose or ear is a CSF leak. | |

## ALLERGY AND HYPERSENSITIVITY

| Symptoms | Suggested specific IgE panel |
|---|---|
| Asthma, all year | HDM, cat, dog, moulds |
| Asthma, all year worse at night | HDM, cat, dog, mixed feathers |
| Seasonal rhinitis | HDM, cat, dog, mixed grass (trees and weeds available on request) |
| Eczema | HDM, mixed foods |
| Food allergy screen | Mixed foods (includes egg, milk, wheat, peanut, soya, cod fish) |
| Peanut allergy | Mixed nuts, peanut |
| Insect venom anaphylaxis | Bee venom, wasp venom |
| Penicillin allergy | Penicillin G and V |
| Wheat intolerance | Wheat and suggest check anti TTG antibodies |

**Further hypersensitivity testing**
We have a large number of other allergens please telephone to check availability.

Other antibiotic allergy testing and allergen component testing is available upon request, please contact us to discuss.

We also test for specific IgG to Aspergillus Fumigatus, pigeon antigens & budgerigar antigens.

**Tryptase**
Anaphylaxis should be investigated by measuring serum tryptase concentrations. The NICE guideline (NG134): Anaphylaxis: assessment and referral (2011) states the following:

- Record the time of onset of the reaction.
- Record the circumstances immediately before the onset of symptoms to help to identify the possible trigger.

- After a suspected anaphylactic reaction in adults or young people aged 16 years or older, take timed blood samples for mast cell tryptase testing as follows:
  - a sample as soon as possible after emergency treatment has started
  - a second sample ideally within 1–2 hours (but no later than 4 hours) from the onset of symptoms.
- After a suspected anaphylactic reaction in children younger than 16 years, consider taking blood samples for mast cell tryptase testing as follows if the cause is thought to be venom-related, drug-related or idiopathic:
  - a sample as soon as possible after emergency treatment has started
  - a second sample ideally within 1–2 hours (but no later than 4 hours) from the onset of symptoms.

**Paraprotein studies and protein electrophoresis**

- Paraprotein bands in serum are associated with B cell malignancies (e.g. myeloma, Waldenstrom's macroglobulinaemia, lymphoma).
- The detection, characterisation and quantitation of paraprotein bands are used for diagnosis and monitoring disease.
- Paraproteins can occur incidentally without associated B cell tumours (monoclonal gammopathy of undetermined significance), especially in the elderly.
- The absence of a serum paraprotein band does not exclude myeloma: Bence Jones protein in the urine may be the only biochemical indication of malignancy in approximately 20% of cases of myeloma.
- If myeloma is suspected **please always send serum and random plain urine samples** for analysis. If a monoclonal band is detected, we will automatically carry out immunofixation/immunotyping to determine the type of paraprotein. All requests for serum protein electrophoresis will automatically receive total protein and albumin measurement.

**Cryoproteins (cryoglobulins and cryofibrinogen)**

- Blood (30 mL) for cryoproteins must be collected into warm tubes and kept at 37°C during transit to the laboratory. Please contact the immunology laboratory for information.

# 22. TEST REPERTOIRE

This section details the repertoire of tests provided by clinical biochemistry and immunology, including reference ranges, turnaround times, special requirements/comments and sample requirements. Please contact the laboratory for advice if the test you require is not listed. Unless stated otherwise, reference ranges shown are adult ranges. A variety of factors can affect the interpretation of clinical laboratory results: reference ranges should only be used as a guide.

Turnaround times have been agreed in consultation with the clinical commissioning groups as described in the 'Service Specification for Pathology/Laboratory Medicine'. Turnaround times of some selected representative tests are audited on a monthly basis as key performance indicators and reviewed by the Pathology Quality Forum. Turnaround times are based upon the normal working days of the laboratory being Monday to Friday, excluding public holidays. Whilst every effort is made to adhere to these targets operational difficulties (e.g. analyser failures) may, on occasion, compromise our service delivery. Conversely, in many case, results will be available more quickly than the indicated turnaround time. Where an asterisk (*) appears next to a turnaround time, results may be available significantly more quickly for urgent and in-patient requests.

| ANALTYE | SAMPLE TYPE | REFERENCE RANGE | NOTES (AGE/GENDER/COLLECTION CONDITIONS) | TURNAROUND TIME | REFERRAL LABORATORY (IF NOT PROVIDED WITHIN EKHUFT) |
|---|---|---|---|---|---|
| Acyl carnitine | blood spot | Contact lab. | | 6 weeks | Viapath |
| Adalimumab | serum | > 6 ug/mL | | 6 weeks | Viapath |
| Adalimumab antibodies | serum | < 10 ng/mL | | 6 weeks | Viapath |
| Adrenocorticotrophic hormone (ACTH) | plasma (EDTA) | < 50 ng/L<br>< 10 ng/L<br>< 46 ng/L | 9:00 AM<br>Midnight<br>Other times | 6 weeks | Viapath |
| Adrenal antibody | serum | negative | | 6 weeks | St Georges University of London |
| Alanine transaminase (ALT) | serum | 5 - 45 U/L | male/female 0-3 y | 1 day* | |
| | | 10 - 25 U/L | male/female 4-6 y | | |
| | | 10 - 35 U/L | male/female 7-9 y | | |
| | | 10 - 35 U/L | male 10-11 y | | |
| | | 10 - 55 U/L | male 12-13 y | | |
| | | 10 - 45 U/L | male 14-16 y | | |
| | | 10 - 30 U/L | female 10-13 y | | |
| | | 5 - 30 U/L | female 14-16 y | | |
| | | 0 - 70 U/L | male >16 y | | |
| | | 0 - 50 U/L | female >16 y | | |

| | | | | | |
|---|---|---|---|---|---|
| Albumin | serum | 30 - 45 g/L | <1 y | 1 day* | |
| | | 30 - 50 g/L | 1 y-16 y | | |
| | | 35 - 50 g/L | >16 y | | |
| Albumin | urine | <3.0 mg/mmol | albumin/creatinine ratio | 7 days | |
| Albumin ascites gradient (SAAG) | serum/ascitic fluid | Contact lab. | Contact lab. | 2 days | |
| Alcohol (see ethanol) | | | | | |
| Aldosterone | plasma (EDTA) | 90 - 700 pmol/L | Contact lab. | 6 weeks | Imperial (Charing Cross) |
| Aldosterone/renin ratio | plasma (EDTA) | <680<br>>850<br>>1700 | Conn's unlikely<br>Conn's possible<br>Conn's very likely | 6 weeks | Imperial (Charing Cross) |
| Alkaline phosphatase (ALP) | serum | 90 - 273 U/L | male & female < 15 d | 1 day* | |
| | | 134 – 518 U/L | male & female 15 d – < 1y | | |
| | | 156 – 369 U/L | male & female 1 y - <10 y | | |
| | | 141 – 460 U/L | male & female 10 y - <13 y | | |
| | | 127 – 517 U/L | male 13 y - <15 y | | |
| | | 62 – 280 U/L | female 13 y - <15 y | | |
| | | 89 – 365 U/L | male 15 y - < 17 y | | |
| | | 54 – 128 U/L | female 15 y - <17 y | | |
| | | 59 – 164 U/L | male 17 y - <19 y | | |
| | | 48 – 95 U/L | female 17 y - <19 y | | |
| | | 30 - 130 U/L | > 19 y | | |

| | | | | | |
|---|---|---|---|---|---|
| Alkaline phosphatase isoenzymes | serum | not applicable | | 2 weeks | |
| Allergy testing ('RAST') | serum | Contact lab. | | 2 weeks | |
| Alpha-1-antitrypsin | serum | 0.90 - 2.20 g/L | <6 m | 7 days | |
| | | 0.80 - 1.80 g/L | 6-12 m | | |
| | | 1.10 - 2.00 g/L | 1-5 y | | |
| | | 1.10 - 2.20 g/L | 6-10 y | | |
| | | 1.40 - 2.30 g/L | 11-15 y | | |
| | | 1.10 - 2.10 g/L | >15 y | | |
| Alpha-1-antitrypsin phenotyping | serum | not applicable | | 6 weeks | St. George's Hospital |
| Alpha-fetoprotein (tumour marker) | serum | 0 - 1653 kU/L | < 1 m | 7 days | |
| | | 8 - 1123 kU/L | 1 – < 6 m | | |
| | | 0.3 - 85 kU/L | 6 m < 1 y | | |
| | | 0.7 – 11.6 kU/L | 1 - <19 y | | |
| | | < 8 kU/L | 19 - 50 y | | |
| | | < 15 kU/L | 50 - 70 y | | |
| | | < 20 kU/L | 70 – 90 y | | |
| Alpha-fetoprotein (maternal) | serum | Contact lab. | | 6 weeks | King George Hospital |
| Alpha-1-microglobulin | urine | <1.5 mg/mmol | Contact lab. | 2 days | |
| Aluminium | plasma (Na hep) | <0.37 umol/L | hazardous >2.2 umol/L | 6 weeks | Unv. Hospital Wales |
| Amikacin | serum | < 5 mg/L | Single daily dose, pre-dose | 1 day* | |
| | | < 10 mg/L | BD regime, pre-dose | | |

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|---|---|---|---|---|---|
| | | 20 - 30 mg/L | BD regime, post-dose | | |
| Amino acids | Plasma (li. hep.) | Contact lab. | Contact lab. | 6 weeks | Viapath |
| Amino acids | urine (random) | Contact lab. | Contact lab. | 6 weeks | Viapath |
| Ammonia | plasma (EDTA - paeds; li.hep- adults) | <150 umol/L | sick/premature infant | 1 day* | |
| | | <100 umol/L | <1 m | | |
| | | <50 umol/L | >1 m | | |
| Amylase | serum | <125 U/L | | 1 day* | |
| Amyloid A | serum | 0 – 10.0 mg/L | | 6 weeks | Sheffield PRU |
| | | | | | |
| Androstenedione | serum | No range | male | 6 weeks | UHSM |
| | | 0.8 – 4.7 umol/L | female | | |
| Angiotensin converting enzyme (ACE) | serum | 29 – 112 U/L | 6 m – 18 y | 7 days | |
| | | 20-70 U/L | adult | | |
| Anti-acetylcholine receptor Ab | serum | <0.25 nmol/L | | 6 weeks | St. George's Hospital |
| Anti-centromere Ab | serum | not applicable | | 6 weeks | |
| Anti-endomysial Ab | serum | negative | | 7 days | |
| Anti-GBM Ab | serum | negative | | 2 days* | |
| Anti-Mullerian hormone | serum | < 2.2 pmol/L | Very low fertility | 6 weeks; upto three months if sample from children | NKPS (Adult) GOSH (Children) |
| | | 2.2 – 15.7 pmol/L | Low fertility | | |
| | | 15.8 – 28.6 pmol/L | Satisfactory fertility | | |

| | | | | | |
|---|---|---|---|---|---|
| | | 28.7 – 48.6 pmol/L | Optimal fertility | | |
| | | > 48.6 pmol/L | High (may be associated with PCOS) | | |
| Anti-neutrophil cytoplasmic Ab (ANCA) | serum | negative | | 2 days* | |
| Anti-thyroid peroxidase (TPO) Ab | serum | <5.5 IU/mL | | 1 day* | |
| Aspartate transaminase (AST) | serum | 32 - 162 U/L | male/female 0 – 14d | 1 day* | |
| | | 20 – 67 U/L | male/female 15 d – 1 y | | |
| | | 21 – 44 U/L | male/female 1 – 7 y | | |
| | | 18 – 36 U/L | male/female 7 – 12 y | | |
| | | 14 – 35 U/L | male 12 – 19 y | | |
| | | 13 – 26 U/L | female 12 – 19 y | | |
| | | 0 - 50 U/L | male/female ≥ 19 y | | |
| Aspergillus IgG antibodies | serum | 0 – 39 mgA/L | negative | 2 weeks | |
| | | > 40 mgA/L | positive | | |
| Avian IgG antibodies | serum | Pigeon: 0-37.9 mgA/L<br>Budgerigar: 0-7.9 mgA/L | | 2 weeks | |
| Autoantibody screen | serum | not applicable | | 7 days | |
| Bence Jones protein | urine | not detected | | 2 weeks | |
| Beta-2-microglobulin | serum | 1.2 - 2.4 mg/L | | 6 weeks | St. George's Hospital |
| Bicarbonate | serum | 22 - 29 mmol/L | | 1 day* | |

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|---|---|---|---|---|---|
| Bile acids | serum | <40 µmol/L | RCOG cut-off | 7 days | |
| Bilirubin (total) | serum | 0 - 29 µmol/L | male | 1 day* | |
| | | 0-22 µmol/L | female | 1 day* | |
| Bilirubin (conjugated/direct) | serum | <15% of total | | 1 day* | |
| C1 esterase inhibitor | serum | 0.15 - 0.35 g/L | | 6 weeks | St. George's Hospital |
| C1 esterase inhibitor function | serum | 0.7 – 1.3 units/mL | | 6 weeks | St. George's Hospital |
| CA 12-5 | serum | <35 kU/L | | 2 weeks | |
| CA 15-3 | serum | <31 kU/L | | 2 weeks | |
| CA 19-9 | serum | <37 kU/L | | 2 weeks | |
| Caeruloplasmin | serum | 0.07 – 0.24 g/L | 0 m - 2 m | 2 weeks | |
| | | 0.14 - 0.33 g/L | 2 m-6 m | | |
| | | 0.14 – 0.39 g/L | 6 m - 12 m | | |
| | | 0.22 – 0.43 g/L | 1 y - 8 y | | |
| | | 0.21 – 0.40 g/L | 8 y - 14 y | | |
| | | 0.17 – 0.35 g/L | male 14 y - 19 y | | |
| | | 0.21 – 0.43 g/L | female 14 y - 19 y | | |
| | | 0.25 – 0.60 g/L | adult range | | |
| Calcitonin | plasma (EDTA) | <2 mIU/L | old IRMA method | 6 weeks | Sheffield PRU |
| | | < 10.6 ng/L | new ECL method | | |
| Calcium | serum | 2.0 - 2.7 mmol/L | <1 m | 1 day* | |
| | | 2.2 - 2.7 mmol/L | 1 m-16 y | | |
| | | 2.2 - 2.6 mmol/L | >16 y | | |
| Calcium | urine (24 h) | 2.5 - 7.5 mmol/24 h | | 7 days | |

| | | | | | |
|---|---|---|---|---|---|
| Calcium creatinine clearance ratio | serum & urine | > 0.01 | excludes familial benign hypocalciuric hypercalcaemia | 7 days | |
| Calculi | calculus | not applicable | | 6 weeks | City Assays |
| Calprotectin | faeces | Contact lab. | funded CCGs only | 6 weeks | MTW |
| Carbamazepine | serum (no gel) | 4 - 12 mg/L | preferably pre-dose | 7 days | |
| Carbon dioxide (pCO2) | blood (heparin) | 4.5 - 6.0 kPa | | 1 day* | |
| Carboxyhaemoglobin | blood (heparin or EDTA) | <1.5% | non-smokers | 1 day* | |
| | | >20% | toxic | | |
| Carcinoembryonic antigen (CEA) | serum | <5 ug/L | non-smokers | 2 weeks | |
| Carnitine (free) | blood spot | 10-45 umol/L | | 6 weeks | Viapath |
| Carotene (beta) | serum | 0.19 – 0.89 umol/L | | 6 weeks | Birmingham City Hospital |
| CART | plasma (EDTA) | < 130 pmol/L | | 6 weeks | Imperial College Healthcare NHS Trust |
| Chloride | serum | 95 - 108 mmol/L | | 1 day* | |
| Chloride | urine | contact lab | | | |
| Cholesterol (total) | serum | interpret using QRISK2 | | 1 day* | |
| Cholesterol (high density lipoprotein) | serum | interpret using QRISK2 | | 1 day* | |
| Cholesterol (low density lipoprotein) | serum | not applicable | calculated | 1 day* | |
| Cholesterol (non-HDL) | serum | not applicable | calculated | 1 day* | |
| Cholinesterase (pseudo-) | serum | Contact lab. | suxamethonium | 6 weeks | Cardiff |
| Cholinesterase | serum | not applicable | suxamethonium | 6 weeks | Cardiff |

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|---|---|---|---|---|---|
| (phenotype) | | | | | |
| Cholinesterase (RBC) | blood (EDTA) | Contact lab. | organophosphates | 6 weeks | H&S Laboratory |
| Chromogranin A | plasma (EDTA) | <60 pmol/L | Complete overnight fast; patient must be at rest. H2 blockers should be stopped for 72h, and Omeprazole for two weeks, before blood is taken. 3 X EDTA blood tubes. Samples must be delivered to the laboratory within 15 minutes of collection. They must then be spun and plasma frozen. | 6 weeks | Charing Cross Hospital |
| Chromogranin B | plasma (EDTA) | <150 pmol/L | Complete overnight fast; patient must be at rest. H2 blockers should be stopped for 72h, and Omeprazole for two weeks, before blood is taken. 3 X EDTA blood tubes. Samples must be delivered to the laboratory within 15 minutes of collection. They must then be spun and plasma frozen. | 6 weeks | Charing Cross Hospital |
| Chromium | blood (EDTA) | < 7 ppb | | 6 weeks | University of Surrey |
| Ciclosporin | blood (EDTA) | 80 – 200 µg/L | trough (pre-dose) 3-6 m after renal transplant | 2 days | |
| Citrate | urine (24 h) | 0.60 - 4.80 mmol/24 h | male | 7 days | |
| | | 1.30 - 6.00 mmol/24 h | female | | |
| Cobalt | blood (EDTA) | < 7 ppb . | | 6 weeks | University of Surrey |

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|---|---|---|---|---|---|
| Complement protein C3 | serum | 0.75 - 1.65 g/L | | 7 days | |
| Complement protein C4 | serum | 0.14 - 0.54 g/L | | 7 days | |
| Copper | serum | 12 - 25 umol/L | >1 y | 2 weeks | |
| Copper | urine (24 h) | 0.0 - 0.9 umol/24 h | | 7 days | Viapath (Kings) |
| Cortisol | serum | interpretation provided on reports | | 7 days | |
| | | <40 nmol/L | midnight | | |
| Cortisol | urine (24 h) | <200 nmol/24 h | | 7 days | |
| C-peptide | serum | 298 – 2350 pmol/L | Sample must arrive in the laboratory within 30 minutes of collection. Serum sample should be taken when patient is hypoglycaemic (plasma glucose less than 3 mmol/L) or during an insulin induced hypoglycaemia test. A simultaneous sample (fluoride oxalate) should be taken for glucose measurement. A non-fasting sample may be required in certain situations, e.g. for differentiating between type-1 and type-2 diabetes mellitus | 6 weeks | Viapath (Kings) |
| C-reactive protein | serum | <10 mg/L | adult range | 1 day* | |
| Creatine kinase (CK) | serum | 40 - 320 U/L | male | 1 day* | |
| | | 25 - 200 U/L | female | | |
| Creatinine | serum | 27 - 81 umol/L | male & female <30 d | 1 day* | |
| | | 14 - 34 umol/L | male & female 1-12 m | | |
| | | 15 - 31 umol/L | male & female 1-2 y | | |

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|---|---|---|---|---|---|
| | | 23 - 37 umol/L | male & female 3-4 y | | |
| | | 25 - 42 umol/L | male & female 5-6 y | | |
| | | 30 - 48 umol/L | male & female 7-8 y | | |
| | | 28 - 57 umol/L | male & female 9-10 y | | |
| | | 37 - 63 umol/L | male & female 11-12 y | | |
| | | 40 - 72 umol/L | male & female 13-14 y | | |
| | | 64 - 104 umol/L | male >15 y | | |
| | | 49 - 90 umol/L | female >15 y | | |
| Creatinine | urine (24 h) | 13 - 18 mmol/24 h | male | 7 days | |
| | | 7 - 13 mmol/24 h | female | | |
| Cryoglobulin | serum | not detected | Contact lab. | 2 weeks | |
| Cyclic citrullinated peptide (CCP) Ab | serum | 0 - 7 U/mL | | 1 week | |
| Cystatin C | serum | 0.57 - 1.05 mg/L | Contact lab. | 1 week | |
| Cystic fibrosis mutations | blood (EDTA) | not applicable | | 8 weeks | Viapath |
| Cystine | urine (24 h) | <100 mg/24 h | | 6 weeks | South Manchester Pathology Services |
| Dehydroepiandrosterone (DHEAS) | serum | no range | male | 6 weeks | UHSM |
| | | 0.9 - 10 umol/L | female < 29 y | | |
| | | 0.9 – 9.6 umol/L | female 30 - 39 y | | |
| | | 1.3 – 6.7 umol/L | female 40 – 49 y | | |
| | | 0.1 – 4.0 umol/L | female > 50 y | | |
| ds DNA antibody | serum | < 10 IU/mL | negative | 1 week | |
| | | 10 – 15 IU/mL | equivocal | | |

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|---|---|---|---|---|---|
| | | > 15 IU/mL | positive | | |
| Diabetes autoantibodies | serum | Contact lab. | | 2 weeks | Devon & Exeter Hospital |
| Digoxin | serum | 0.5 - 1.0 ug/L | > 6 h post-dose | 1 day* | |
| Down's screening | serum | Contact lab. | | 1 week | King George's Hospital |
| Drug screen | urine | nothing detected | | 6 weeks | City Assays |
| Elastase | faeces | > 200 ug/g | normal | 6 weeks | City Assays |
| | | 100 - 200 ug/g | Mild pancreatic insufficiency | | |
| | | < 100 ug/g | Severe pancreatic insufficiency | | |
| Erythropoietin | serum | 5.0-25.0 IU/L | with Hb within reference range | 6 weeks | Viapath (Kings) |
| Ethanol | plasma | not detected | (fl.ox.) | 1 day* | |
| Extractable nuclear antigen Ab's (ENA) | serum | negative | | 7 days | |
| Faecal immunological test (FIT, primary care) | faeces | < 10 ug Hb/g | low risk for colorectal cancer; monitor and safety net as appropriate | 6 weeks | |
| | | ≥ 10 ug Hb/g | refer under 2ww fast track pathway for suspected colorectal cancer | | |
| Ferritin | serum | 22 - 275 ug/L | male | 7 days | |
| | | 5.0 - 204 ug/L | female | 7 days | |
| Folate | serum | 4.8 - 19.0 ug/L | | 7 days | |
| Follicle stimulating hormone (FSH) | serum | <1.6 IU/L | male pre-pubertal | 7 days | |
| | | 0.4 – 5.5 IU/L | female pre-pubertal | 7 days | |
| | | 1.0 - 12.0 IU/L | Male post-pubertal | 7 days | |
| | | 3.1 - 8.1 IU/L | follicular | 7 days | |

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|---|---|---|---|---|---|
| | | 2.6 - 16.7 IU/L | mid-cycle peak | 7 days | |
| | | 1.0 - 5.5 IU/L | luteal | | |
| | | > 27 IU/L | post-menopausal | | |
| Fructosamine | serum | 205 - 286 umol/L | | 6 weeks | Viapath |
| Galactose-1-phosphate uridyl transferase | blood (heparin) | | Contact lab. | 6 weeks | Birmingham Childrens |
| Gamma glutamyl transferase | serum | 12 - 64 U/L | male | 1 day* | |
| | | 9 - 36 U/L | female | | |
| Gastrin | plasma (EDTA) | <40 pmol/L | Contact lab. | 6 weeks | Charing Cross Hospital |
| Gentamicin | serum | < 1 mg/L | Single daily dose, 18 h post | 1 day* | |
| | | < 2 mg/L | BD & TDS regimes, pre dose | | |
| | | 5 – 10 mg/L | BD & TDS regimes, 1hr post dose | | |
| Globulin | serum | 20 - 35 g/L | | 1 day* | |
| Glomerular basement membrane antibodies | serum | < 7 U/mL | negative | 2 days | |
| | | 7 – 10 U/mL | equivocal | | |
| | | > 10 U/mL | positive | | |
| Glucose (fasting) | plasma (fl.ox.) | 3.3 – 5.4 mmol/L | normal fasting glucose | 1 day* | |
| | | ≥5.5 – 6.9 mmol/L | Non-diabetic hyperglycaemia (NDH). There is high risk of progression to type 2 diabetes. Consider referral to National Diabetes Prevention Programme | | |

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|---|---|---|---|---|---|
| | | ≥7.0 mmol/L | Indicative of diabetes. If patient symptomatic, diagnosis is confirmed. If asymptomatic, repeat testing within 4 weeks is required for confirmation. | | |
| Glucose | CSF | 60 - 80% of plasma glu. | fluoride oxalate | 1 day* | |
| Glucagon | plasma (EDTA) | <50 pmol/L | Contact lab. | 6 weeks | Charing Cross Hospital |
| Glycated haemoglobin (HbA1c) (diagnosis/screening) | blood (EDTA) | < 42 mmol/mol | normal | 7 days | |
| | | 42 - 47 mmol/mol | Non-diabetic hyperglycaemia (NDH). There is a high risk of progression to type 2 diabetes. Consider referral to National Diabetes Prevention Programme | | |
| | | > 48 mmol/mol | Indicative of diabetes. If patient is symptomatic, diagnosis is confirmed. If asymptomatic, repeat testing within 4 weeks is required for confirmation. | | |
| Glycated haemoglobin (HbA1c) (monitoring) | blood (EDTA) | Individualised targets recommended. Please refer to NICE Guidance [NG28]: Type 2 Diabetes in adults: management / NICE Guidance [NG17]: Type 1 Diabetes in adults- diagnosis and management | | 7 days | |
| Glycine | CSF | 2 – 15 umol/L | | 6 weeks | Viapath |

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| 6-GTN | blood (EDTA) | 235 - 450 pmol/8x$10^8$ cells | Maximum drug efficacy in inflammatory bowel disease | 6 weeks | Birmingham City Hospital |
| Growth hormone | serum | Contact lab. | | 2 weeks | |
| Gut hormone screen | plasma (EDTA) | Contact lab. | Contact lab. | 6 weeks | Charing Cross Hospital |
| Haemochromatosis mutations | blood (EDTA) | not applicable | C282T & H63D tested | 6 weeks | Viapath |
| Haptoglobin | serum | 0.5 - 2.0 g/L | male | 7 days | |
| | | 0.4 - 1.6 g/L | female | | |
| HbA1c - see 'Glycated haemoglobin' | | | | | |
| Homovanillic acid (HVA) | urine | Contact lab. | | 6 weeks | Great Ormond Street |
| Human chorionic gonadotrophin (HCG) | serum | <5 IU/L | female, non-pregnant range | 7 days* | |
| | | 5 - 25 IU/L | equivocal, may indicate early pregnancy, suggest repeat | | |
| | | <2 IU/L | male | | |
| Human chorionic gonadotrophin (HCG, molar) | serum | Contact lab. | Tumour marker for molar preg. | 6 weeks | Charing Cross Hospital |
| Human chorionic gonadotrophin (HCG) | urine | qualitative | pregnancy test | 1 day | |
| Hydrogen ion | arterial | 36 - 44 nmol/L | | 1 day | |
| 5' hydroxyindoleacetic acid (5 HIAA) | urine (24 h) | <42 umol/24 h | | 3 weeks | |
| 17-hydroxyprogesterone | serum | Contact lab. | Contact lab. | 6 weeks | UHSM |
| 25-hydroxyvitamin D (see vitamin D, below) | | | | | |

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|---|---|---|---|---|---|
| Immunoglobulin A (IgA) | serum | | | 7 days | |
| | | 0.01 - 0.08 g/L | < 2 w | | |
| | | 0.02 - 0.15 g/L | 2 - 6 w | | |
| | | 0.05 - 0.4 g/L | 7 w - 12 w | | |
| | | 0.10 - 0.5 g/L | 13 w - 6 m | | |
| | | 0.15 - 0.7 g/L | 7 - 9 m | | |
| | | 0.2 - 0.7 g/L | 10 - 12 m | | |
| | | 0.3 - 1.2 g/L | 12 - 24 m | | |
| | | 0.3 - 1.3 g/L | 2 - 3 y | | |
| | | 0.4 - 2.0 g/L | 4 - 6 y | | |
| | | 0.5 - 2.4 g/L | 7 - 9 y | | |
| | | 0.7 - 2.5 g/L | 10 - 12 y | | |
| | | 0.8 - 2.8 g/L | 13 - 15 y | | |
| | | 0.8 - 2.8 g/L | 16 - 45 y | | |
| | | 0.8 - 4.0 g/L | > 45 y | | |
| Immunoglobulin E (IgE) | serum | < 11 kU/L | < 3 m | 7 days | |
| | | < 29 kU/L | 3 m-12 m | | |
| | | < 52 kU/L | 1 - 5 y | | |
| | | < 63 kU/L | 6 - 10 y | | |
| | | < 75 kU/L | 11 - 15 y | | |
| | | < 81 kU/L | > 15 y | | |
| Immunoglobulin G (IgG) | serum | | | 7 days | |
| | | 5.0 - 17.0 g/L | < 2 w | | |
| | | 3.9 - 13.0 g/L | 2 - 6 w | | |
| | | 2.1 - 7.7 g/L | 7 - 12 w | | |

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|---|---|---|---|---|---|
| | | 2.4 - 8.8 g/L | 13 w - 6 m | | |
| | | 3.0 - 9.0 g/L | 7 - 9 m | | |
| | | 3.0 - 10.9 g/L | 10 - 12 m | | |
| | | 3.1 - 13.8 g/L | 12 - 24 m | | |
| | | 3.7 - 15.8 g/L | 2 - 3 y | | |
| | | 4.9 - 16.1 g/L | 4 - 6 y | | |
| | | 5.4 - 16.1 g/L | 7 - 15 y | | |
| | | 6.0 - 16.0 g/L | > 15 y | | |
| Immunoglobulin G subclasses (IgG1-4) | serum | Contact lab. | | 6 weeks | St. George's |
| Immunoglobulin M (IgM) | serum | | | 7 days | |
| | | 0.05 - 0.2 g/L | < 2 w | | |
| | | 0.08 - 0.4 g/L | 2 - 6 w | | |
| | | 0.15 - 0.7 g/L | 7 - 12 w | | |
| | | 0.2 - 1.0 g/L | 13 w - 6 m | | |
| | | 0.4 - 1.6 g/L | 6 - 9 m | | |
| | | 0.6 - 2.1 g/L | 10 - 12 m | | |
| | | 0.5 - 2.2 g/L | 1 - 3 y | | |
| | | 0.5 - 2.0 g/L | 4 - 6 y | | |
| | | 0.5 - 1.8 g/L | 7 - 12 y | | |
| | | 0.5 - 1.9 g/L | 13 - 15 y | | |
| | | 0.5 - 1.9 g/L | 15 - 45 y | | |
| | | 0.5 - 2.0 g/L | > 45 y | | |
| Infliximab | serum | < 1.2 µg/mL | sub therapeutic | 6 weeks | Viapath (Kings) |
| | | 1.2 – 2.4 µg/mL | intermediate | | |

| | | | | | |
|---|---|---|---|---|---|
| | | > 2.4 µg/mL | therapeutic | | |
| Infliximab antibodies | serum | < 10 ng/mL | | 6 weeks | Viapath (Kings) |
| Insulin | serum | 4.4 – 26.0 mIU/L | Fasting<br>Send concurrent glucose | 6 weeks | Viapath (Kings) |
| Insulin-like growth factor (IGF)-1 | serum | Contact lab. | | 2 weeks | |
| Intrinsic factor Ab | serum | negative | | 7 days | |
| Iron | serum | 11 - 28 umol/L | males | 7 days* | |
| | | 7 - 26 umol/L | females | | |
| Kappa free light chains | serum | 3.3 - 19.4 mg/L | | 6 weeks | Royal Free Hospital |
| Kappa: Lambda ratio | serum | 0.26 - 1.65 | | 6 weeks | Royal Free Hospital |
| Lactate | plasma (fl.ox.) | 0.50 - 2.20 mmol/L | | 1 day* | |
| Lactate | CSF (fl.ox.) | 1.1 – 2.4 mmol/L | Contact lab. | 1 day* | |
| Lactate dehydrogenase (LDH) | serum | 125 - 220 U/L | | 1 day* | |
| Lambda free light chains | serum | 5.7 - 16.3 mg/L | | 6 weeks | Royal Free Hospital |
| Lamotrigine | serum (no gel) | 3 - 15 mg/L | preferably pre-dose | 6 weeks | Epilepsy Society |
| Lead | blood (EDTA) | < 0.24 umol/L | ≤ 5 y | 6 weeks | Univ Hospital Wales |
| | | < 0.5 umol/L | > 6 y | | |
| Lipase | serum | 5 – 65 IU/L | | 7 days | |
| Lithium | serum | 0.4 - 1.0 mmol/L | 12 h post-dose | 1 day* | |
| Luteinising hormone (LH) | serum | < 0.3 IU/L | male & female pre-pubertal | 7 days | |
| | | 1.1 - 8.8 IU/L | male | | |
| | | 2.4 - 6.6 IU/L | follicular | | |
| | | 9.1 - 74 IU/L | mid-cycle peak | | |

| | | | | | |
|---|---|---|---|---|---|
| | | 0.9 - 9.3 IU/L | luteal | | |
| Magnesium | serum | 0.60 - 1.00 mmol/L | <1 m | 1 day* | |
| | | 0.70 - 1.00 mmol/L | >1 m | | |
| Magnesium | urine (24 h) | 2.4 - 6.5 mmol/24 h | | 7 days | |
| Metanephrine | plasma (EDTA) | <510 pmol/L | Seated | 7 days | |
| | plasma (EDTA) | <450 pmol/L | Supine | | |
| Methotrexate | plasma (EDTA) | < 0.1 umol/L | high-dose Rx only | 6 weeks | Great Ormond St. |
| 3-methoxytyramine | plasma (EDTA) | < 180 pmol/L | seated | 7 days | |
| | | < 180 pmol/L | supine | | |
| Mucopolysaccharides | urine | Contact lab. | | 8 weeks | Viapath |
| Myeloperoxidase antibody | serum | 0-2 U/mL | | 2 days | |
| 6-MMPN | blood (EDTA) | > 5700 pmol/8x$10^8$ cells | Associated with increased risk of hepatotoxicity | 6 weeks | Birmingham City Hospital |
| N-acetyl-β-D-glucosaminidase (NAG) | urine | ≤26 U/mmol creatinine | Contact lab. | 6 weeks | |
| Neurone-specific enolase | serum | ≤ 16.3 µg/L | | 1 day | Viapath |
| Normetanephrine | plasma (EDTA) | < 1180 pmol/L | seated | 7 days | |
| | | < 730 pmol/L | supine | | |
| NT pro-BNP | plasma (EDTA) | < 400 ng/L | Heart failure unlikely | 1 day* | |
| | | 400 - 2000 ng/L | Recommend 6 week referral | | |
| | | > 2000 ng/L | Recommend 2 week referral | | |
| Oestradiol | serum | <160 pmol/L | male | 7 days | |
| | | 100 - 920 pmol/L | follicular | | |
| | | 110 - 2400 pmol/L | mid-cycle peak | | |

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|---|---|---|---|---|---|
| | | 100 - 1150 pmol/L | luteal | | |
| Oligoclonal bands | CSF & serum | not detected | | 6 weeks | St. George's Hospital |
| Organic acids | urine | Contact lab. | | 6 weeks | Viapath |
| Osmolality | serum | 275-295 mmol/kg | | 1 day* | |
| Osmolality | urine | Contact lab. | | 1 day* | |
| Oxalate | urine (24 h) | 0.08 - 0.49 mmol/24 h | males | 7 days | |
| | | 0.04 - 0.32 mmol/24 h | females | | |
| Oxygen (pO2) | blood (heparin) | 11.0 - 14.4 kPa | lower in elderly | 1 day* | |
| Oxygen (% saturation) | blood (heparin) | 94 - 98% | | 1 day* | |
| Pancreatic polypeptide | plasma (EDTA) | < 300 pmol/L | | 6 weeks | Imperial College |
| Paracetamol | serum | not detected | | 1 day* | |
| Paraquat | urine | not detected | Contact lab. | 1 day | Birmingham City Hospital |
| Parathyroid hormone (PTH) | plasma (EDTA) | 1.6 - 7.2 pmol/L | | 1 week | |
| Pemphigus/oid Ab | serum | not applicable | | 2 weeks | |
| pH | blood | 7.36 - 7.44 | | 1 day* | |
| pH | urine | 4.5 - 6.0 | | 1 day* | |
| Phenobarbitone | serum (no gel) | 10 - 40 mg/L | preferably pre-dose | 7 days | |
| Phenytoin | serum (no gel) | 5 - 20 mg/L | preferably pre-dose | 7 days* | |
| Phosphate | serum | 1.30 - 2.60 mmol/L | < 1 m | 1 day* | |
| | | 1.30 - 2.40 mmol/L | 1 m - 1 y | | |
| | | 0.90 - 1.80 mmol/L | 1 y - 16 y | | |
| | | 0.80 - 1.50 mmol/L | > 16 y | | |
| Phosphate | urine (24 h) | 15 - 50 mmol/24 h | | 7 days | |

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| Phospholipase A2 receptor antibody | serum | negative | | 6 weeks | Viapath |
| Porphobilinogen | urine | <1.5 umol/mmol creatinine | keep in dark | 1 day | |
| Porphyria screen | blood/urine/faeces | Contact lab. | | 6 weeks | Viapath |
| Potassium | serum | 3.5 - 5.3 mmol/L | | 1 day* | |
| Potassium | urine (24 h) | 25 - 125 mmol/24 h | | 7 days | |
| Procalcitonin | serum | Contact lab. | Contact lab. | 1 day | |
| Procollagen III | serum | 10 - 50 ug/L | < 2 y | 6 weeks | PRU Sheffield |
| | | 5 – 15 ug/L | 2 - 4 y | | |
| | | 5 – 10 ug/L | male, 5 – 14 y | | |
| | | 5 – 10 ug/L | female, 5 – 10 y | | |
| | | 8 – 15 ug/L | female, 11 – 14 y | | |
| | | 8 – 20 ug/L | male, 15 – 19 y | | |
| | | 2 – 8 ug/L | female 15 – 19 y | | |
| | | 1.7 – 4.2 ug/L | > 20 y | | |
| Progesterone | serum | >30 nmol/L | suggests ovulation | 7 days | |
| Prolactin | serum | <700 mU/L | male | 7 days | |
| | | <1000 mU/L | female | | |
| Prostate specific antigen (PSA) | serum | < 2.5 ug/L | 40 – 49 y | 7 days | |
| | | < 3.0 ug/L | 50 - 69 y | | |
| | | < 5.0 ug/L | ≥ 70 y | | |
| | | < 10.0 ug/L | ≥ 80 y | | |
| Proteinase-3 antibody (PR3) | serum | 0 - 6 U/mL | | 2 days | |

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| Protein electrophoresis | serum | no significant abnormality detected | | 1 week | |
| Protein electrophoresis | urine | no significant abnormality detected | | 1 week | |
| Protein (total) | serum | 44 - 76 g/L | <1 y | 1 day* | |
| | | 56 - 75 g/L | 1 - 2 y | | |
| | | 60 - 80 g/L | 3 - 18 y | | |
| | | 60 - 80 g/L | >18 y | | |
| Protein (total) | urine (24 h) | 0.03 - 0.14 g/24 h | | 7 days | |
| Protein (total) | urine (random) | <15 mg/mmol creatinine | | 1 day* | |
| Protein (total) | CSF | 0.65 – 1.50 g/L | < 28 d | 1 day* | |
| | | 0.50 – 0.90 g/L | 29 – 56 d | | |
| | | 0.05 – 0.35 g/L | 2 m – 18 y | | |
| | | 0.15 - 0.45 g/L | 18 -60 y | | |
| | | 0.15 – 0.60 g/L | > 60 y | | |
| Renin | plasma(EDTA) | 0.5-3.5 nmol/L/h | Contact lab. | 6 weeks | Charing Cross Hospital |
| Rheumatoid factor | serum | <30 IU/mL | | 1 day* | |
| Salicylate | serum | not detected | | 1 day* | |
| Sex hormone binding globulin (SHBG) | serum | 16.5 - 55.9 nmol/L | male 20 - 50 y | 6 weeks | MTW |
| | | 19.3 - 76.4 nmol/L | male > 50 y | | |
| | | 24.6 - 122.0 nmol/L | female 20 - 50 y | | |
| | | 17.3 - 125.0 nmol/L | female > 50 y | | |
| Sirolimus | blood (EDTA) | 3 - 8 ug/L | trough (pre-dose) | 2 days | |
| sFlt-1/PlGF ratio | serum | Contact lab. | Only for 20 to 34+6 weeks | 1 day* | |

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| | | | gestation with a singleton pregnancy | | |
| Sodium | serum | 133 - 146 mmol/L | | 1 day* | |
| Sodium | urine (24 h) | 40 - 220 mmol/24 h | random may be useful | 1 day* | |
| Sodium valproate | see valproate | | | | |
| Somatostatin | plasma (EDTA) | < 150 pmol/L | | 6 weeks | Imperial College |
| Steroid profile | urine | Contact lab. | | 6 weeks | Viapath |
| Stone analysis (renal) | calculus | not applicable | | 6 weeks | City Assays |
| Tacrolimus (FK506) | blood (EDTA) | 3 - 14 ug/L | trough (pre-dose) | 2 days | |
| Testosterone | serum | > 12 nmol/L | males | 7 days | |
| | | 0.0 - 2.0 nmol/L | females | | |
| | | < 0.5 nmol/L | pre-pubertal | | |
| Theophylline | serum | 10 - 20 mg/L | 4-6 h post-dose | 2 days* | |
| Thiopurine methyltransferase (TPMT) | blood (EDTA) | < 10 mU/L | Deficient | 6 weeks | City Assays |
| | | 20 - 67 mU/L | Low | | |
| | | 68 - 150 mU/L | Normal | | |
| | | > 150 mU/L | High | | |
| Thyroglobulin antibody (Tg Ab) | serum (no gel) | < 3 kU/L | | 7 days | |
| Thyroglobulin (Tg) | serum (no gel) | < 0.14 ug/L | | 7 days | UHB |
| Thyroid stimulating hormone (TSH) | serum | 0.40 - 5.0 mU/L | adult ref range. | 7 days | |
| Thyroxine (T4, free) | serum | 9 - 19 pmol/L | adult ref range | 7 days | |
| Tissue transglutaminase Ab (IgA/IgG) | serum | <10 U/mL | | 7 days | |

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| Tobramycin | serum | < 2 mg/L | Single daily dose,18 h post | 1 day* | |
| | | < 2 mg/L | BD &TDS regimes, pre dose | | |
| Toxicology screen | urine | not applicable | | 6 weeks | City Assays |
| Transferrin | serum | 2.00 - 3.60 g/L | | 1 day* | |
| Transferrin saturation | serum | 20 - 50% | | 1 day* | |
| Triglyceride | serum | see www.nice.org.uk/cg181 for interpretation | | 1 day* | |
| Triiodothyronine (T3, free) | serum | 2.4 – 6.0 pmol/L | adult ref range | 7 days | |
| Troponin I | serum | <34 ng/L | male | 1 day* | |
| | | <16 ng/L | female | | |
| Tryptase | serum | 2.0 – 14.0 ug/L | Contact lab. | 6 weeks | St. George's Hospital |
| Urea | serum | 0.8 - 5.5 mmol/L | < 1 m | 1 day* | |
| | | 1.0 - 5.5 mmol/L | 1 m - 1 y | | |
| | | 2.5 - 6.5 mmol/L | 1 y - 16 y | | |
| | | 2.5 - 7.8 mmol/L | > 16 y | | |
| Urea | urine (24 h) | 330 - 580 mmol/24 h | | 7 days | |
| Uric acid | serum | 120 - 320 umol/L | male <16 y | 1 day* | |
| | | 200 - 430 umol/L | male >16 y | | |
| | | 120 - 320 umol/L | female <16 y | | |
| | | 140 - 360 umol/L | female >16 y | | |
| Uric acid | urine (24 h) | 1.5 - 4.5 mmol/24 h | | 7 days | |
| Valproate | serum (no gel) | no range | not for routine monitoring | 7 days* | |
| Vancomycin | serum | 15 - 20 mg/L | pre dose | 1 day* | |

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| Very long chain fatty acids (VLCFA) | plasma (EDTA) | Contact lab. | | 6 weeks | Viapath |
| VIP | plasma (EDTA) | < 30 pmol/L | Contact lab. | 6 weeks | Imperial College Healthcare NHS Trust |
| Vitamin A | serum | 0.70 - 1.50 umol/L | up to 7 y | 6 weeks | City Assays |
| | | 0.90 - 1.70 umol/L | from 7 y up to 13 y | | |
| | | 0.90 - 2.50 umol/L | from 13 y up to 20 y | | |
| | | 0.99 - 3.35 umol/L | adult female (≥ 20 y) | | |
| | | 0.77 - 3.95 umol/L | adult male (≥ 20 y) | | |
| Vitamin B12 | serum | 189 - 883 ng/L | | 7 days | |
| Vitamin B6 (pyridoxine) | blood (EDTA) | 250 – 680 pmol/g Hb | | 6 weeks | Glasgow Royal Infirmary |
| Vitamin B1 (thiamine) | blood (li.hep) | 275 - 675 ng/g Hb | | 6 weeks | Glasgow Royal Infirmary |
| | | 15 0 - 275 ng/g Hb | subclinical deficiency | | |
| | | < 150 ng/g Hb | clinically deficient | | |
| Vitamin D (25-hydroxy) | serum | <25 nmol/L | deficient | 7 days | |
| | | 25 - 50 nmol/L | insufficient | | |
| | | >50 nmol/L | sufficient | | |
| Vitamin E | serum | 11.5 - 24.4 umol/L | up to 1 y | 6 weeks | City Assays |
| | | 7.0 - 21.0 umol/L | from 1 y up to 7 y | | |
| | | 10.0 - 21.0 umol/L | from 7 y up to 13 y | | |
| | | 13.0 - 24.0 umol/L | from 13 y up to 20 y | | |
| | | 9.5 - 41.5 umol/L | adults (≥ 20 y) | | |
| White cell enzymes | blood (li.hep) | Contact lab. | | 8 weeks | Viapath |

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| Xanthochromia | CSF | Contact lab. | see TrustNet policy | 1 day* | |
| Zinc | serum | 11-24 umol/L | | 6 weeks | City Assays |
| **TESTS HIGHLIGHED ARE NOT CURRENTLY UKAS ACCREDITED** | | | | | |

# 23. REFERRAL LABORATORIES

| **REFERRAL LABORATORY** | | |
|---|---|---|
| Black Country Pathology Services (City assays)<br>Birmingham City Hospital,<br>Dudley Road,<br>Birmingham B18 7QH | Cardiff toxicology Laboratory<br>The Academic Centre<br>Llandough Hospital<br>Penarth<br>CF64 2XX | Charing Cross Hospital,<br>(Imperial College Healthcare),<br>The SAS Laboratory,<br>Fulham Palace Road,<br>London W6 8RF |
| Glasgow Royal Infirmary,<br>Department of Clinical Biochemistry,<br>Macewan Building,<br>Glasgow G4 0SF | Great Ormond Street Hospital for Children,<br>Chemical Pathology, Camilia Botnar Laboratories,<br>Great Ormond Street,<br>London WC1N 3JH | Viapath<br>Guy's and St. Thomas' Hospital NHS Trust,<br>Central Pathology Reception,<br>5th Floor, North Wing, London SE1 7EH |
| Viapath<br>Kings College Hospital,<br>Denmark Hill,<br>London SE5 9RS | King George's Hospital,<br>Prenatal Screening Laboratory,<br>Barley Lane, Goodmayes,<br>Essex IG3 8YB | Maidstone & Tunbridge Wells (MTW) NHS Trust,<br>Hermitage Lane,<br>Maidstone,<br>Kent |
| Medway Maritime Hospital,<br>Windmill Road,<br>Gillingham ME7 5NY | Immunology Department,<br>Churchill Hospital<br>Headington, Oxford<br>OX3 7LE | Regional Endocrine Laboratory<br>Clinical Laboratory Services<br>Level Minus 1<br>Queen Elizabeth Hospital<br>Birmingham<br>Mindelsohn Way<br>Edgbaston<br>Birmingham<br>B15 2WB |
| Protein Reference Unit, St Georges Hospital<br>Cranmer Terrace,<br>London SW17 0RE | University College Hospital,<br>3rd Floor,<br>60 Whitfield Street,<br>London W1T 4EU | University of Surrey,<br>Trace Elements Centre,<br>Guildford GU2 7HX |

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|---|---|---|
| Royal Surrey County Hospital,<br>Egerton Road Guildford,<br>GU7 7XX | Department of Biochemistry<br>University Hospital of Wales<br>Cardiff<br>CF14 4XW | Well child Laboratory<br>Arctic (1St Floor)<br>Evelina Children's Hospital<br>St Thomas' Hospital<br>Lambeth Palace Road<br>London<br>SE1 7EH |
| Neurometabolic Unit (Box 105)<br>National Hospital for Neurology and Neurosurgery<br>Queen Square<br>London<br>WC1N 3BG | Lysosomal Storage Disease Unit,<br>Molecular Laboratory<br>Haematology department,<br>Royal Free Hospital,<br>Pond Street,<br>LONDON NW3 2PX | Newborn Screening and Biochemical Genetics,<br>Birmingham Children's Hospital NHSFT,<br>Steelhouse Lane,<br>Birmingham B4 6NH |
| Sheffield PRU,<br>Department of Immunology,<br>PO Box 894,<br>Sheffield S5 7YT | SAS Genetic Enzyme Laboratory<br>Genetics Centre<br>5th Floor Guy's Tower<br>Guy's Hospital<br>London<br>SE1 9RT | Clinical Biochemistry Area A2<br>Royal Devon & Exeter NHS Foundation<br>Trust<br>Barrack Road<br>Exeter<br>EX2 5DW |
| Manchester, Clinical Science Building,<br>University Hospital of South Manchester, Southmoor Road<br>Manchester, M23 9LT | Health and Safety Laboratory,<br>Harpur Hill,<br>Buxton SK17 9JN | Epilepsy Society,<br>Therapeutic Drug Monitoring Unit ,<br>Chesham Lane, Chalfont St Peter<br>Buckinghamshire SL9 ORJ |
| Genetics Centre<br>5th floor, Tower Wing<br>Guy's Hospital<br>Great Maze Pond<br>London SE1 9RT | | |