A survey of laboratory 'critical (alert) limits' in the UK

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Abstract

Introduction Critical or alert limits are the values of laboratory measurements that are regarded as requiring urgent clinical action and should be communicated to a clinician urgently. Despite this, there has been little evaluation of these values in the UK.

Methods We have conducted a survey of hospital biochemistry laboratories in the UK.

Results Ninety-four laboratories responded to the questionnaire; the response rate was not recorded. Twenty-three laboratories had derived their action limits locally from a consensus with their clinicians, experience over many years, and the literature. Only two laboratories quoted literature to support their values. Seven laboratories did not submit actual critical values. There was considerable variance in the values defined as critical by the responding laboratories.

Discussion Each laboratory needs to evaluate its own list of acutely important critical values and aim for a small number of analytes that are always communicated to the doctor, so that clinical needs are met without raising the risk of information overload.

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Introduction

Critical or alert limits are the values of laboratory measurements that are regarded as requiring urgent clinical attention and should be communicated to a clinician urgently. These were first formally described in 1972 by Lundberg[1] and have been widely implemented in laboratories. The rapid communication of these abnormal biochemistry results will in some cases effect an increase in the speed of the diagnostic process, and in others result in a rapid and necessary change in patient management. There is, however, a need for laboratories to select their critical values carefully so as to create a balance between providing appropriate information and not overloading clinical staff with information that does not require urgent action.

It is accepted as good practice that laboratories have lists of critical limits for analytes and procedures for notification. The latter will include documentation of given data and recipient.[2] However, there does not appear to be a consensus on the required list of analytes, nor the range of critical values for these tests. The purpose of this study was to determine the range of tests with critical limits and the values commonly in use within clinical biochemistry laboratories in the UK.

Methods

A questionnaire requesting details of the critical limits for adult biochemistry values was distributed during October to December 2000. This questionnaire was sent to UK Clinical Biochemistry laboratories through their Association of Clinical Biochemists Clinical Audit Group coordinators. Because laboratory association with the Audit Group is variable across the country it is not possible to give a response rate, and therefore an assessment of response could be estimated either on the total number of hospital trusts (338)[3] or the number of consultant clinical biochemists (242) in England, Scotland, Wales and Northern Ireland.

Critical values were defined as values for biochemical analytes that would be telephoned to the requesting clinician or ward. Laboratories were also requested to supply the origin of their critical list values. Results for therapeutic drugs, salicylate, paracetamol and iron

Table 1. *Critical values reported by participating laboratories*

		Phone ward		Phone doctor	
Test		Lower limit	Upper limit	Lower limit	Upper limit
Sodium (mmol/L)	Mean ± SD	123 ± 3·8	153 ± 3·6	121 ± 3·4	155 ± 5·1
	Range	110–130	149–160	110–127	147–170
	n	46	46	55	55
Potassium (mmol/L)	Mean ± SD	2·8 ± 0·3	6·0 ± 0·3	2·7 ± 0·4	6·2 ± 0·4
	Range	2·0–3·0	5·5–7·0	2·0–3·0	5·5–7·0
	n	45	45	55	55
Chloride (mmol/L)	Mean ± SD	85 ± 4·5	115 ± 4·8		
	Range	80–90	109–120		
	n	9	9		
Bicarbonate (mmol/L)	Mean ± SD	13 ± 2·8	39 ± 2·1	11 ± 3·9	39 ± 4·6
	Range	10–18	35–40	5–15	35–50
	n	13	9	15	9
Urea (mmol/L)	Mean ± SD		25 ± 6·7		27 ± 6·5
	Range		16–50		15–40
	n		33		36
Creatinine (μmol/L)	Mean ± SD		381 ± 119		456 ± 338
	Range		200–600		200–1800
	n		24		24
Calcium (mmol/L)	Mean ± SD	1·75 ± 0·13	3·04 ± 0·16	1·76 ± 0·16	3·06 ± 0·21
	Range	1·5–2·0	2·8–3·5	1·5–2·0	2·8–3·5
	n	29	29	25	26
Adjusted calcium (mmol/L)	Mean ± SD	1·81 ± 0·18	3·03 ± 0·15	1·76 ± 0·16	3·13 ± 0·28
	Range	1·50–2·00	2·80–3·50	1·50–2·00	2·80–4·00
	n	27	27	32	32
Phosphate (mmol/L)	Mean ± SD	0·39 ± 0·08			
	Range	0·30–0·60			
	n	22			
Albumin (g/L)	Mean ± SD	15 ± 6			
	Range	2·0–20·0			
	n	8			
Magnesium (mmol/L)	Mean ± SD	0·48 ± 0·08	1·78 ± 0·53	0·48 ± 0·08	1·89 ± 0·66
	Range	0·30–0·70	1·10–3·00	0·30–0·60	1·10–3·50
	n	30	26	28	19
Urate (mmol/L)	Mean ± SD		0·79 ± 0·26		0·70 ± 0·27
	Range		0·36–1·00		0·35–1·00
	n		6		6
Bilirubin (paediatric) (μmol/L)	Mean ± SD		285 ± 54		287 ± 29
	Range		200–360		250–340
	n		6		10
Amylase (IU/L)	Mean ± SD		318 ± 236		470 ± 332
	Range		70–1000		100–1500
	n		34		7
Glucose (mmol/L)	Mean ± SD	2·5 ± 0·4	20·7 ± 6·3	2·4 ± 0·40	22·7 ± 6·0
	Range	1·5–3·4	10–50	1·5–3·0	15–40
	n	44	45	54	52
Digoxin (nmol/L)	Mean ± SD		2·7 ± 0·5		2·9 ± 0·7
	Range		2·0–4·0		2·0–5·0
	n		38		38
Carbamazepine (μmol/L)	Mean ± SD		59 ± 12		63 ± 13
	Range		42–85		42–85
	n		23		21
Phenobarbitone (μmol/L)	Mean ± SD		197 ± 41		213 ± 37
	Range		108–260		170–300
	n		18		15
Phenytoin (μmol/L)	Mean ± SD		92 ± 15		98 ± 19
	Range		67–120		67–140
	n		30		23

Continued

Table 1. *Continued*

Test		Phone ward		Phone doctor	
		Lower limit	Upper limit	Lower limit	Upper limit
Theophylline (μmol/L)	Mean $\pm$ SD		130 $\pm$ 21		129 $\pm$ 24
	Range		110–167		110–194
	n		21		17
Lithium (mmol/L)	Mean $\pm$ SD		1·4 $\pm$ 0·3		1·4 $\pm$ 0·4
	Range		1·0–2·0		1·0–2·5
	n		35		31
Iron (μmol/L)	Mean $\pm$ SD		60 $\pm$ 27		57 $\pm$ 41
	Range		30–100		30–145
	n		9		7
Cortisol (mmol/L) (random)	Mean $\pm$ SD	96 $\pm$ 38			
	Range	20–150			
	n	7			

SD = standard deviation.

were converted to molar standard international (SI) units before statistical analysis. With respect to digoxin, when units were not provided the results were assumed to be in molar SI units (nmol/L).

The mean, standard deviation and range were determined for each analyte, where more than six laboratories responded.

Results

Ninety-four laboratories responded to the questionnaire; the response rate was not recorded. Twenty-seven laboratories listed fewer than 10 critical tests, and four listed fewer than 20 analytes. Twenty-three laboratories had derived their action limits locally from a consensus with their clinicians, experience over many years, and the literature. Only two laboratories quoted literature to support their values. Seven laboratories did not submit actual critical values. A few indicated that all emergency results were phoned, but did not include their 'routine' telephone limits. Twenty-eight laboratories had direct electronic linkage to wards; this aspect has not been further analysed, as ward links were not specifically requested and may not have been reported by some laboratories.

Actual critical values for most analytes are detailed in Table 1. Analytes included in some laboratories critical lists but not indicated in Table 1 were thyroid function tests, cyclosporin, valproate, prolactin, C-reactive protein, zinc, triglyceride, asparate transaminase, alanine transaminase, creatine kinase (CK), CK-MB and troponins.

Laboratories reported that critical results were either telephoned to wards, to clinicians, or both. In some laboratories there were differences between the action limit values telephoned to wards and those telephoned to clinicians, and as a result some laboratories returned two critical limit values for one analyte, one for the clinician and one for the ward.

The majority of laboratories did not provide critical limits for arterial blood gases, carboxyhaemoglobin (COHb), salicylate, paracetamol, alcohol, paraquat, ammonia, lactate and cerebrospinal fluid analysis, as these were often requested as emergencies and results would be phoned or electronically transmitted. Given the large standard deviation for amylase critical values (*see* Table 1) no reliable critical limit for amylase could be derived. This is probably a result of the diversity of analytical methods in use, with a consequent variety of reference ranges. Request for multiples of the upper reference intervals would have provided an improved definition of the critical limit.

Discussion

This survey shows that there is no consensus policy with regard to critical limits practised by clinical biochemistry laboratories in the UK. All laboratories had critical values for common tests that might reflect life-threatening emergencies, i.e. sodium, potassium and glucose, and only one laboratory did not report a critical limit for calcium. Despite the universality of the use of critical values for these analytes, there were very wide ranges for the values, for example, the upper limits for sodium and potassium were 147–170 and 5·5–7·0 mmol/L, respectively. The range of tests on the critical list in this report is similar to that of trauma and medical centres in the USA.[4]

The mean critical values in this report are similar to those quoted by Lum,[5] Kost[4] and Emancipator[6] (*see* Table 2). Although each laboratory will need to customize its critical values list to suit its organizational needs and resources, the similarity of results

Table 2. *Comparison of critical values with other studies*

Analyte	Survey mean range of results phoned to clinician	CAP Q Probes study[6]	VA medical centres[8]	USA trauma centres (mean values)[4]
Sodium (mmol/L)	<121 or >155	<120 or >160	<121 or >159	<120 or >158
Potassium (mmol/L)	<2·7 or >6·2	<2·8 or >6·2	<2·8 or >6·1	<2·8 or >6·2
Calcium (mmol/L)	<1·76 or >3·06	<1·5 or >3·25	<1·65 or >3·10	<1·65 or >3·2
Glucose (mmol/L)	<2·4 or >22·7	<2·2 or >24·8	<2·7 or >24·0	<2·6 or >26·9
Urea (mmol/L)	>26·8	>28·6		>37·1
Creatinine (μmol/L)	>456	>442		>654
Magnesium (mmol/L)	<0·48 or >1·89	<0·41 or >1·91		<0·41 or >2·02
Phosphate (mmol/L)	<0·39	<0·32		<0·39 or >2·87

indicates that for the majority of tests quoted in Table 2, universally acceptable standards could be agreed.

The essential aspect of a critical list of laboratory analytes is whether clinicians respond to these abnormal test results. Bunton and Gaede[7] found that initial abnormalities of serum potassium, creatinine and urea were the results most frequently followed by changes in treatment. Despite this, in our survey only 25% of respondents offered a critical value for creatinine. Although not frequently requested, abnormalities in magnesium were followed by a change in treatment in two-thirds of patients. Paradoxically, the most frequently abnormal analyte, serum albumin, never led to a change in diagnosis, treatment, further tests or consultation. Despite this, eight laboratories in this report quote a low critical value for albumin (10–20 g/L). Lum[8] has determined that clinicians respond to calcium >3·0 mmol/L immediately, whereas raised values <3·0 mmol/L are acted upon the next day.

Several laboratories quoted therapeutic drug critical values. These values do not appear to be related to clinical toxicology. For example, critical digoxin values cited were 2·0–5·0 nmol/L, whereas clinical toxicity occurs almost invariable at concentrations exceeding 3·8 nmol/L.[9] Theophylline values were cited at 110–194 μmol/L, whereas serious side effects have been reported to occur with increasing frequency at plasma concentrations above 110 μmol/L.[9] There are clinical benefits to be gained from alerting clinical staff to abnormal results and advising and discussing investigations and action. However, as this survey has shown, in biochemistry laboratories there is a lack of consensus on the definition of which analytes and values are critical. We did not ask if there were different approaches depending on whether an abnormal result was new, nor whether there was a critical change value (which might be within a reference range).

The wide disparity between laboratories could be inferred to mean either that the case and clinical skill mix in different hospitals varies, or that there is a need for a set of national standards. Unfortunately, few clinical audits of critical values have been performed to answer these questions. Until they are, it is clearly necessary for each laboratory to formulate its own list of acutely important critical values.

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