PoCT Reference Intervals – for Laboratory Co-Located Sites

LHDs: HNE, CC, NNSW, MNC, NS(AUSLAB sites)

NSW GOVERNMENT Health Pathology

Reference and Abnormal Intervals and Critical Risk thresholds presented as "Between the Flags"

TEST	UNITS	*Critical Low (Rapid response)*	*Abnormal Low (Clinical review)*	Reference interval	*Abnormal High (Clinical review)*	*Critical High (Rapid response)*
ARTERIAL BLOOD GAS						
pH		*≤7.20*	*7.21-7.34*	**7.35 - 7.45**	*7.46-7.59*	*≥7.60*
(pH source) NSWHP Harmonised POCT RI 2016; Critical alert [1, 2].						
pCO2	mmHg	*≤20*	*21-34*	**35 - 45**	*46-64*	*≥65*
(pCO2 source) NSWHP Harmonised POCT RI 2016; Verma A. Aust Prescriber 2010; Critical alert in [2] was 70mmHg but we decided to change this to 60mmHg based on CERS protocol by NSWH 22/11/2013. (pCO2 note)There has been concern raised that COPD patients will be unnecessarily flagged if the red zone is lowered to 60 mmHg. CC Stream suggests to keep this to stay in line with CERS protocol but education of POCT staff may be required as well as a review of practice after 6 months use						
pO2	mmHg	*≤60*	*61-74*	**75 - 105**		
(pO2 source) NSWHP Harmonised POCT RI 2016; Critical alert in ref [2] was 40, but we decided to change this to 60mmHg based on CERS protocol by NSWH 22/11/2013						
CarboxyHb	%			**0.3 - 1.8**	*1.9-9.9*	*≥10.0*
(CarboxyHb source) Mayo 0.0-2.0%; Carboxy-Hb could be higher in smokers. Critical alert: 2017 NSWHP clinician survey.						
MetHb	%			**0.4 - 1.2**	*1.3-9.9*	*≥10.0*
(MetHb source) Mayo 0.0-1.5%; Critical alert: 2017 NSWHP clinician survey; See also Methaemoglobinaemia comments below.						
Bicarbonate	mmol/L	*≤10*	*11.0-21.0*	**22 - 28**	*29-39*	*≥40*
(Bicarbonate source) NSWHP ABG RI survey: 22-28 mmol/L; Critical alert [2]. (Bicarbonate note) This is a calculated parameter, which questions whether we need any yellow or red zone limits at all in this doc. Clinicians indicated that it is not specific enough to be useful, they rely more on BE; therefore CC Stream agreed to delete yellow and red zone values						
Base Excess	mmol/L	*≤-5*	*-3.1 to -4.9*	**-3 to +3**		
(BE source) NSWHP Harmonised POCT RI 2016; Critical low applies to sepsis pathway [3].						
Lactate	mmol/L			**<2.0**	*2.0-3.9*	*≥4.0*
(Lactate source) NSWHP Harmonised POCT RI 2016; Critical high applies to sepsis pathway [3] and [4].						
Sodium	mmol/L	*≤120*	*121-135*	**136 - 146**	*147-154*	*≥155*
(Sodium source) NSWHP Harmonised POCT RI 2016; Verified in NSWHP VBG RI study. ABG and VBG RI to be the same; Critical alert reflects evidence from mortality studies [5,6]. (Sodium note) Some clinicians suggested in the survey a lower threshold of 125 mmol/L if symptoms are present as a decision point for treatment. Delta change monitoring would be more relevant as an alert in acute care setting. Need to check alert frequency locally if the limit of 125 mmol/L is implemented. Alternative is to leave the red lower limit at 120 and review after 6 months - this is endorsed by CC Stream.						
Potassium	mmol/L	*≤2.5*	*2.6-3.6*	**3.7 - 4.7**	*4.8-5.9*	*≥6.0*
(Potassium source) Verified in NSWHP VBG RI study; ABG and VBG RI to be the same; Critical alert in [6,7] adjusted for whole blood. (Potassium note) Clinicians suggested 3 or 3.5 mmol/L as the lower threshold, but they may not have taken into account the sample type differences. NB, K in whole blood and plasma is approx. 0.4-0.5 mmol/L lower than in serum. CCStream endorsed 2.5 mmol/L; review in 6/12.						

Chloride	mmol/L			**101 - 110**		
(Chloride source) Laboratories may decide to remove test from Radiometer blood gas analyser test profile, depending on clinical need. Verified in NSWHP VBG RI study; ABG and VBG RI to be the same. Note SPIA HRI cannot be used due to ABL method bias.						
Anion Gap	mmol/L			**8.0-16.0**		
(Anion Gap source) RCPA test manual; Verified in NSWHP VBG RI study. Calculation includes K						
Ionized Calcium	mmol/L	*≤0.80*	*0.81-1.14*	**1.15 - 1.30**	*1.31-1.59*	*≥1.60*
(iCalcium source) Verified in NSWHP VBG RI study. ABG and VBG RI to be the same; Critical alert [7].						
Urea	mmol/L			**3.0 - 8.0**	*8.1-29.9*	*≥30*
(Urea source) SPIA HRI; Critical alert [7,8].						
Creatinine (Male)	umol/L			**60 - 110**	*111-399*	*≥400*
Creatinine (Female)	umol/L			**45 - 90**	*91-399*	*≥400*
(Creatinine source) SPIA HRI; Critical alert [7,9]; Critical high does not apply to end stage renal disease patients on dialysis and under the care of renal physicians.						
Glucose (Fasting)	mmol/L	*≤3.0*	*3.1-3.4*	**3.5 - 5.4**	*5.5-24.9*	*≥25*
(Glucose source) Fasting RI in venous plasma: Diabetes Australia/NHMRC 2009 guidelines; Critical alert [9] and [13]. (Glucose note) Note, lower red alert of 3 mmol/L is very close to the RI adopted from the NHMRC guideline, but newer ADA guidelines recommended 3 mmol/L as critical.						
Haemoglobin (Male)	g/L	*≤70*	*71-129*	**130 - 170**	*171-199*	*≥200*
Haemoglobin (Female)	g/L	*≤70*	*71-119*	**120 - 150**	*151-199*	*≥200*
(Hb source) RI [12]; Critical alert [2,10,11].						
Haematocrit (Male)	L/L	*<0.20*	*0.21-0.39*	**0.40 - 0.50**	*0.51-0.59*	*≥0.6*
Haematocrit (Female)	L/L	*<0.20*	*0.21-0.35*	**0.36 - 0.46**	*0.47-0.59*	*≥0.6*
(Hb source) RI [12]; Critical alert [2,10,11].						
OTHER POCT (ARTERIAL)						
cTroponin-I (i-STAT)	ug/L			**≤0.04**	*>0.04*	
(cTnI note) Changed from 0.08 ug/L to 0.04 ug/L November 2018 based on successful evidence based changes made by Queensland Health and in response to concerns from clinicians in NSW that current cutoffs were not suitably sensitive.						
cTroponin-I (AQT-90)	ng/L			**≤23**	*≥24*	
BNP (i-STAT)	ng/L			**≤50**	*≥51*	
INR	INR			**2.0 - 3.5**	*3.6-3.9*	*≥4.0*
(INR note) INR therapeutic range applies to patients treated with vitamin K antagonists such as warfarin. They are not applicable to other anticoagulants. Results ≥4.0 should be checked using a laboratory method.						

TEST	UNITS	*Critical Low (Rapid response)*	*Abnormal Low (Clinical review)*	Reference interval	*Abnormal High (Clinical review)*	*Critical High (Rapid response)*
VENOUS BLOOD GAS						
pH		*≤7.20*	*7.21 - 7.29*	**7.30 - 7.40**	*7.41-7.59*	*≥7.60*
(pH source) NSWHP VBG RI study. Critical alert [1, 2].						
pCO2	mmHg	*≤20*	*21 – 39*	**40 - 50**	*51-64*	*≥65*
(pCO2 source) NSWHP VBG RI study 2014/2017 combined: 38-61 mmHg which results in a flag rate of 6% in hospital patient population.NSWHP 2017 RI study with smokers excluded: 19-59mmHg. Clinical review and consultation recommends a lower upper limit of 50 mmHg; this also reflects manufacturer's RI which is expected to flag about 15-20% of ED cases; Critical alert in [2] was 70mmHg but we decided to change this to 65mmHg based on CERS protocol by NSWH 22/11/2013. (pCO2 note) Note differences in RIs obtained in the 2014 and 2017 studies with an upper ref limit (URL) around 60 mmHg, and the finally recommended URL of 50 mmHg, based on clinicians' opinion. The high abnormal flag rate may lead to unnecessary alarm. CC Stream suggests follow-up clinical feedback after 3 months of use of these RIs.						
pO2	mmHg			**No range**		
(pO2 note) pO2 and O2sat% is unreliable in VBG and can only be measured and interpreted in ABG samples.						
CarboxyHb	%			**0.3 - 1.8**	*1.9-9.9*	*≥10.0*
(CarboxyHb source) Mayo 0.0-2.0%; Carboxy-Hb could be higher in smokers. Critical alert: 2017 NSWHP clinician survey.						
MetHb	%			**0.4 - 1.2**	*1.3-9.9*	*≥10.0*
(MetHb source) Mayo 0.0-1.5%; Critical alert: 2017 NSWHP clinician survey; See also Methaemoglobinaemia comments below.						
Bicarbonate	mmol/L	*≤10*	*11.0-21.0*	**22 - 32**	*33-39*	*≥40*
(Bicarbonate source) NSWHP VBG RI study 2014/2017 combined: 23-31 mmol/L; NSWHP 2017 RI study: 23-30 mmol/L, close to SPIA HRI in venous plasma. Chem Path Stream advises to keep SPIA HRI; Critical alert [2]. (Bicarbonate note) This is a calculated parameter, which questions whether we need any yellow or red zone limits at all in this doc. Clinicians indicated that it is not specific enough to be useful, they rely more on BE; therefore CC Stream agreed to delete yellow and red zone values.						
Base Excess	mmol/L	*≤-5*	*-3.1 to -4.9*	**-3 to +3**		
(BE source) NSWHP Harmonised POCT RI 2016; Critical low applies to sepsis pathway [3].						
Lactate	mmol/L			**<2.0**	*2.0-3.9*	*≥4.0*
(Lactate source) NSWHP Harmonised POCT RI 2016; Verified in NSWHP 2017 RI study (non-smokers): 0.5-2.0 mmol/L. Critical high applies to sepsis pathway [3] and [4].						
Sodium	mmol/L	*≤120*	*121-135*	**136 - 146**	*147-154*	*≥155*
(Sodium source) NSWHP VBG RI study. ABG and VBG RI to be the same. Critical alert [5,6]. (Sodium note) Some clinicians suggested in the survey a lower threshold of 125 mmol/L if symptoms are present as a decision point for treatment. Delta change monitoring would be more relevant as an alert in acute care setting. Need to check alert frequency locally if the limit of 125 mmol/L is implemented. Alternative is to leave the red lower limit at 120 and review after 6 months - this is endorsed by CC Stream.						
Potassium	mmol/L	*≤2.5*	*2.6-3.6*	**3.7 - 4.7**	*4.8-5.9*	*≥6.0*
(Potassium source) NSWHP VBG RI study; ABG and VBG RI to be the same; Critical alert in [6,7] adjusted for whole blood.						

(Potassium note) Clinicians sugested 3 or 3.5 mmol/L as the lower threshold, but they may not have taken into account the sample type differences. NB, K in whole blood and plasma is approx. 0.4-0.5 mmol/L lower than in serum. CCStream endorsed 2.5 mmol/L; review in 6/12.						
Chloride	mmol/L			**101 - 110**		
(Chloride source) Laboratories may decide to remove test from Radiometer blood gas analyser test profile, depending on clinical need. Verified in NSWHP VBG RI study: 2014/2017 study combined - 101-110 mmol/L, 2017 study 101-109 mmol/L; ABG and VBG RI to be the same. Note SPIA HRI cannot be used due to ABL method bias.						
Anion Gap	mmol/L			**8 - 16**		
(Anion Gap source) RCPA test manual; Verified in NSWHP VBG RI study. Calculation includes K						
Ionized Calcium	mmol/L	*≤0.80*	*0.81-1.14*	**1.15 - 1.30**	*1.31-1.59*	*≥1.60*
(iCalcium source) Verified in NSWHP VBG RI study: 2014/2017 combined RI study: 1.16-1.32 mmol/L, 2017 RI study: 1.16-1.28 mmol/L. ABG and VBG RI to be the same; Critical alert [7].						
Urea	mmol/L			**3.0 - 8.0**	*8.1-29.9*	*≥30*
(Urea source) SPIA HRI; Critical alert [7,8].						
Creatinine (Male)	umol/L			**60 - 110**	*111-399*	*≥400*
Creatinine (Female)	umol/L			**45 - 90**	*91-399*	*≥400*
(Creatinine source) SPIA HRI; Critical alert [7,9]; Critical high does not apply to end stage renal disease patients on dialysis and under the care of renal physicians.						
Glucose (Fasting)	mmol/L	*≤3.0*	*3.1-3.4*	**3.5 - 5.4**	*5.5-24.9*	*≥25*
(Glucose source) Fasting RI in venous plasma: Diabetes Australia/NHMRC 2009 guidelines; Critical alert [9] and [13].						
(Glucose note) Note, lower red alert of 3 mmol/L is very close to the RI adopted from the NHMRC guideline, but newer ADA guidelines recommended 3 mmol/L as critical.						
Haemoglobin (Male)	g/L	*≤70*	*71-129*	**130 - 170**	*171-199*	*≥200*
Haemoglobin (Female)	g/L	*≤70*	*71-119*	**120 - 150**	*151-199*	*≥200*
(Hb source) RI [12]; Critical alert [2,10,11].						
Haematocrit (Male)	L/L	*<0.20*	*0.21-0.39*	**0.40 - 0.50**	*0.51-0.59*	*≥0.6*
Haematocrit (Female)	L/L	*<0.20*	*0.21-0.35*	**0.36 - 0.46**	*0.47-0.59*	*≥0.6*
(Hct source) RI [12]; Critical alert [2,10,11].						
OTHER POCT (VENOUS)						
cTroponin-I (i-STAT)	ug/L			**≤0.04**	*>0.04*	
(cTnI note) Changed from 0.08 ug/L to 0.04 ug/L November 2018 based on successful evidence based changes made by Queensland Health and in response to concerns from clinicians in NSW that current cutoffs were not suitably sensitive.						
cTroponin-I (AQT-90)	ng/L			**≤23**	*≥24*	
BNP (i-STAT)	ng/L			**≤50**	*≥51*	
INR	INR			**2.0 - 3.5**	*3.6-3.9*	*≥4.0*
(INR note) INR therapeutic range applies to patients treated with vitamin K antagonists such as warfarin. They are not applicable to other anticoagulants. Results ≥4.0 should be checked using a laboratory method.						

Comments/Notes

- Reference interval (**white background**) indicates the expected range of test values for 95% of a healthy population.
    - The arterial blood gas reference intervals (RI) are based on a survey of NSWHP laboratories and on manufacturers' recommendations and represent the consensus of NSWHP Chemical Pathology Stream.
    - The venous blood gas reference intervals have been determined by a study on n=216 healthy adult volunteers using Radiometer ABL 800 series Blood Gas Analysers - Refer to POW summary document dated 23 August 2017. Transferability of these intervals will need to be established when applying to other devices.
    - The reference intervals listed above apply to adults. They have not been validated for children or neonates.

- Abnormal intervals/clinical review (**yellow background**) signify pathological changes with a concentration dependent graded risk of significant adverse outcomes. These results require clinical review within a clinically appropriate time frame to ensure appropriate clinical action and to prevent patient harm.

- Critical risk thresholds/rapid response (**red background**) signify results that represent immediate risk of major adverse outcomes to patients. These results must be immediately notified to the treating clinician in order to ensure urgent clinical evaluation and medical intervention.

- Critical risk thresholds are based on a systematic survey of the literature and a 2017 survey of NSWH clinicians.

- Association of clinical symptoms with Methaemoglobinaemia:

3-15%	slate grey skin discoloration
20%	cyanosis or asphyxia
25-50%	headache, lightheaded, weak, chest pain, confusion
50- 70%	dysrhythmia, delirium, seizure, lactic acidosis, coma
>70%	arrhythmia and death

- References:

1. Hanna D, Griswold P, Leape LL, Bates DW. Communicating critical test results: safe practice recommendations.Jt Comm J Qual Patient Saf 2005;31:68 – 80.
2. Howanitz PJ, Steindel SJ, Heard NV. Laboratory critical values policies and procedures: a college of American Pathologists Q-Probes Study in 623 institutions. Arch Pathol Lab Med 2002;126:663–9
3. NSW Health Sepsis Pathway, 2016

4. Sheldon SH, Saenger AK, Jaffe AS. Incidence and significance of elevated lactate in the identification of critically ill patients. Clin Chem Lab Med 2012;50:1819 –23.
5. Howanitz JH, Howanitz PJ. Evaluation of serum and whole blood sodium critical values. Am J Clin Pathol 2007;127:56 –9.
6. Doering TA, Plapp F, Crawford JM. Establishing an evidence base for critical laboratory value thresholds. AmJ Clin Pathol 2014;142:617–28.
7. Aakre KM, Hov GG, Skadberg O, Piehler A, Distante S, Hager HB. Notification of highly abnormal laboratory results to doctors outside hospitals. Tidsskr Nor Laegeforen 2013;133:E1– 6.
8. Campbell C, Horvath A. Towards harmonisation of critical laboratory result management - review of the literature and survey of Australasian practices. Clin BiochemRev 2012;33:149 – 60.
9. RCP (UK). The communication of critical and unexpected pathology results. London, UK: RCPath; 2016.
10. Lum G. Should the transfusion trigger and haemoglobin low critical limit be identical? Ann Clin Lab Sci 1997;27:130–4.
11. Kost GJ. Critical limits for urgent clinician notification at US medical centers. JAMA 1990;263:704 –7.
12. Bain B, Bates I, Laffan M & Lewis S. Dacie & Lewis Practical Haematology 11th ed. 2011
13. Agiostratidou G, Anhalt H, Ball D, Blonde L, Gourgari E, Harriman KN, et al. Standardizing Clinically Meaningful Outcome Measures Beyond HbA1c for Type 1 Diabetes. Diabetes Care 2017;40:1622–1630.