PoCT Reference Intervals – Facilities with a NSWHP Co-Located Laboratory (Cerner West)

LHDs: FW, Murrumbidgee, NBM, SNSW, WNSW & WS

Test	Age	Sex	Updated reference intervals		Critical risk threshold
			Arterial	Venous	
pH	<1 d	M+F	**7.30-7.46**	**7.30-7.42**	<7.20 or >7.60
	1d-<1mo	M+F	**7.32-7.46**	**7.30-7.42**	
	≥1mo	M+F	**7.35-7.45**	**7.30-7.40**	
pO2 mmHg	<1mo	M+F	**50-100***	-	<40 (arterial)
	***Caution**: In newborns, target PaO2 and SaO2 levels vary depending on clinical context and if preterm.*				
	≥1mo	M+F	**75-105**	-	<60 (arterial)
pCO2 mmHg	All ages	M+F	**35-45**	**40-50**	<20 (<1mo) <30 or >60 (art))>65 (ven)
O2 Saturation %	<1mo	M+F	**88-99***	-	-
	≥1mo	M+F	**95-99**	-	
Sodium mmol/L	<1 w	M+F	**132 – 147**		<125 or >155
	1 w - <18y	M+F	**133 - 144**		
	≥18	M+F	**136 - 146**		
Potassium mmol/L	<1 w	M+F	**3.5 - 6.2**		<2.5 or >6.5
	1w - <26w	M+F	**3.8 - 6.4**		
	26w - <2 y	M+F	**3.5 - 5.4**		<2.5 or >6.2
	2y - <18y	M+F	**3.3 - 4.9**		
	≥18y	M+F	**3.7 – 4.7**		
Chloride mmol/L	<1 w	M+F	**98 - 115**		-
	1w - <18y	M+F	**97 - 110**		
	≥18y	M+F	**101 - 110**		
Bicarbonate mmol/L	<1w	M+F	**15 – 28**	**15 – 29**	<10 or >40
	1w - <2y	M+F	**16 – 29**	**16 – 30**	
	2y - <10y	M+F	**17 – 30**	**17 – 31**	
	10y - <18y	M+F	**20 – 32**	**20 – 33**	
	≥18y	M+F	**22 – 28**	**22 – 32**	
Base Excess mmol/L	All ages	M+F	**-3 to +3**		< -5
Anion gap mmol/L	All ages	M+F	**8.0 – 16.0**		
Urea mmol/L	<1y	M+F	**1.5 - 5.5**		
	1y - <16y	M+F	**2.0 - 6.5**		
	≥16y	M+F	**3.0 - 8.0**		
Creatinine umol/L	<1w	M+F	**22 - 93**		> 150 Or 50% increasing delta in last 7 days
	1w - <4w	M+F	**17 - 50**		
	4w - <2y	M+F	**11 - 36**		
	2y - <6y	M+F	**20 - 44**		
	6y - <12y	M+F	**27 - 58**		
	12y - <15y	M	**35 - 83**		
	12y – 15y	F	**–35 - 74**		
	15y – 17y	M	**–50 - 100**		
	15y – 17y	F	**–38 - 82**		
	>17y	M	**–60 - 110**		> 350 Or 50% increasing delta in last 7 days.
	>17y	F	**45 - 90**		
Glucose mmol/L	All ages	M+F	**3.5-5.4**		<3.0 or >25
Lactate mmol/L	0 – 16y	M+F	**<2.0**		>2.0 excludes cord blood.
	>16y	M+F	**< 2.0**		>4.0
Calcium ionised mmol/L	<1mo	M+F	**1.10-1.35**		<0.80 or >1.60
	≥1mo	M+F	**1.15-1.30**		
Bilirubin –total umol/L	<1mo		**-**		> 250
	≥1mo	M+F	**<20**		-
Haemoglobin g/L	<2w	M+F	**125 – 225**		<100 or >235
	2w- <1mo	M+F	**101 - 175**		<70 or >180(f)/200(m)
	1mo - <14y	M+F	**95 - 158**		
	≥14y	F	**120 - 150**		
	≥14y	M	**130 - 170**		

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LHDs: FW, Murrumbidgee, NBM, SNSW, WNSW & WS

Test	Age	Sex	Updated reference intervals		Critical risk threshold
			Arterial	Venous	
Haematocrit	<2w	M+F	**0.38-0.68**		<0.30 or >0.70
	2w-<1mo	M+F	**0.32-0.54**		
	1mo - <14y	M+F	**0.27-0.46**		<0.20 or >0.60
	≥14y	F	**0.36 – 0.46**		
	≥14y	M	**0.40 - 0.50**		
O2Hb %	<1mo	M+F	**85-98**	-	-
	≥1mo	M+F	**90-98**	-	
COHb %	All ages	M+F	**0.3 - 1.8**		> 10
MetHb %	<1mo	M+F	**0.4 – 1.2**		>2.5
	≥1mo	M+F			>10
cTroponin-I (i-STAT)	µg/L	M+F	≤0.04		>0.04
INR (Therapeutic Interval)		M+F	2.5 – 3.5 (prosthetic heart valve) 2.0 – 3.0 (most other therapies)		>4.0 = retest in laboratory

Reference Intervals for PoCT – Source Table.

Analyte	Age	Sex	References
pH (ABL, iSTAT, GEM)	<1 d	M+F	RCH 1993; UTD VBG
	1d-<1mo	M+F	RCH 1993; UTD VBG; Cousineau 2005
	1mo -150y	M+F	NSWHP harm BG RI 2017; Tietz 5th Ed; Higgins 2008
pO2 mmHg (ABL, iSTAT, GEM)	<1mo	M+F	
	1 mo-150y	M+F	NSWHP harm BG RI 2017; Tietz 5th Ed Critical alert in ref [2] was 40, but we decided to change this to 60mmHg based on CERS protocol by NSWH 22/11/2013
pCO2 mmHg (ABL, iSTAT, GEM)	<1y	M+F	Tietz 5th Ed; Cousineau 2005; UTD VBG
	1y -150y	M+F	NSWHP harm BG RI 2017; Higgins 2008, 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
O2 Saturation % (ABL, iSTAT, GEM)	<1mo	M+F	Soldin; UTD Newborn noninvasive O2 delivery
	1mo-150y	M+F	Radiometer 2014; Soldin
Sodium mmol/L (ABL, iSTAT, GEM)	<1 w	M+F	SPIA V3
	1 w - 18y	M+F	SPIA V3
	18-150 y	M+F	NSWHP harm BG RI 2017. 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 (ABL, iSTAT, GEM)	<1 w	M+F	SPIA V3
	1w - <26w	M+F	SPIA V3
	26w - <2 y	M+F	SPIA V3
	2y - <18y	M+F	SPIA V3
	18y - 150 y	M+F	NSWHP harm BG RI 2017. 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 (ABL, iSTAT, GEM)	<1 w	M+F	SPIA V3
	1w - <18y	M+F	SPIA V3
	18y - 120 y	M+F	NSWHP harm BG RI 2017
Bicarbonate mmol/L -Actual (ABL, iSTAT, GEM)	<1w	M+F	SPIA V3, UTD VBG
	1w - <2y	M+F	SPIA V3, UTD VBG
	2y - <10y	M+F	SPIA V3, UTD VBG
	10y - <18y	M+F	SPIA V3, UTD VBG
	18y-150y	M+F	NSWHP harm BG RI 2017, SPIA V3, UTD VBG. (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

Analyte	Age	Sex	References
Bicarbonate total mmol/L (ie Total CO2) L (iSTAT) NB RIs same as for Bicarbonate (plus 1mmol/L)	<1w	M+F	SPIA V3, UTD VBG
	1w - <2y	M+F	SPIA V3, UTD VBG
	2y - <10y	M+F	SPIA V3, UTD VBG
	10y - <18y	M+F	SPIA V3, UTD VBG
	18y-150y	M+F	NSWHP harm BG RI 2017, SPIA V3, UTD VBG
Base Excess mmol/L -Standard or actual (ABL, iSTAT, GEM)	<1mo	M+F	Soldin 2007
	1mo - <1y	M+F	Soldin 2007
	1y-150y	M+F	NSWHP harm BG RI 2017, Soldin 2007. ; Critical low applies to sepsis pathway [3].
Anion gap mmol/L (ABL, iSTAT, GEM)	All ages	M+F	NSWHP harm BG RI 2017 Verified in NSWHP VBG RI study. Calculation includes K
Urea mmol/L (iSTAT)	<1y	M+F	PW/Consensus of Sonic data
	1y - <12y	M+F	PW/Consensus of Sonic data
	16y - 150y	M+F	NSWHP harm BG RI 2017. Critical alert [7,8].
Creatinine umol/L (ABL, iSTAT)	<1w	M+F	SPIA V3
	1w - <4w	M+F	SPIA V3
	4w - <2y	M+F	SPIA V3
	2y - <6y	M+F	SPIA V3
	6y - <12y	M+F	SPIA V3
	12y - <15y	M	SPIA V3
	15y - <18y	M	SPIA V3
	18y - 150y	M	NSWHP harm BG RI 2017, SPIA V3. Critical alert [7,9]; Critical high does not apply to end stage renal disease patients on dialysis and under the care of renal physicians.
	12y - <15y	F	SPIA V3
	15y - <18y	F	SPIA V3
	18y - 150y	F	NSWHP harm BG RI 2017, SPIA V3. 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 mmol/L (ABL, iSTAT, GEM)	All ages	M+F	NSWHP harm BG RI 2017.) 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.
Lactate mmol/L (ABL, iSTAT, GEM)	All ages	M+F	NSWHP harm BG RI 2017. Critical high applies to sepsis pathway [3] and [4].
Calcium ionised mmol/L (ABL, iSTAT, GEM)	All ages	M+F	NSWHP harm BG RI 2017. Verified in NSWHP VBG RI study. ABG and VBG RI to be the same; Critical alert [7].
Bilirubin –total umol/L (ABL, GEM)			
Haemoglobin g/L (ABL, iSTAT, GEM)	<3 d	M+F	Haem RIs Nathan & Oski 2003
	3 d - <1mo	M+F	Haem RIs Nathan & Oski 2003
	1mo - <6y	M+F	Haem RIs Nathan & Oski 2003
	6y - <14y	M+F	Haem RIs Nathan & Oski 2003
	14y - 150y	F	NSWHP harm BG RI 2017. RI [12]; Critical alert [2,10,11].
	14y- 150y	M	NSWHP harm BG RI 2017. RI [12]; Critical alert [2,10,11].
Haematocrit (iSTAT, GEM)	<3 d	M+F	Haem RIs Nathan & Oski 2003
	3 d - <1mo	M+F	Haem RIs Nathan & Oski 2003
	1mo - <6y	M+F	Haem RIs Nathan & Oski 2003
	6y - <14y	M+F	Haem RIs Nathan & Oski 2003
	14y – 150y	F	NSWHP harm BG RI 2017. RI [12]; Critical alert [2,10,11].
	14y – 150y	M	NSWHP harm BG RI 2017. RI [12]; Critical alert [2,10,11].
O2Hb % (ABL)	<1mo		
	>1mo	M+F	Radiometer Handbook 2014

Analyte	Age	Sex	References
COHb % (ABL)	All ages	M+F	NSWHP harm BG RI 2017.) Mayo 0.0-2.0%; Carboxy-Hb could be higher in smokers. Critical alert: 2017 NSWHP clinician survey.
MetHb % (ABL)	All ages	M+F	NSWHP harm BG RI 2017.) Mayo 0.0-1.5%; Critical alert: 2017 NSWHP clinician survey; See also Methaemoglobinaemia comments following.
P50 (ABL)	< 1 m	M+F	Radiometer handbook 2014
	> 1 m	M+F	Radiometer handbook 2014
TnI ug/L (iSTAT)	All ages	M+F	NSWHP harm BG RI 2017. (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.
INR	All ages	M+F	(INR note) INR therapeutic interval 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 and Notes

- Reference interval 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 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 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.