

# pCO<sub>2</sub> variation in elective transfers of infants on non-invasive respiratory support

Repatriations to local care are an integral part of the remit of neonatal transport teams, with a significant proportion of these infants being transferred on non-invasive respiratory support. A routine blood gas on arrival at the receiving unit is part of our team's current practice for elective repatriations of infants on non-invasive respiratory support. Through retrospective review of data from a large number of patients transferred, we aimed to determine if there was a significant change in the partial pressure of carbon dioxide (pCO<sub>2</sub>) on arrival at the receiving unit, and to identify a subgroup of infants most at risk of an increase in pCO<sub>2</sub>.

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Elective repatriations of infants represent a significant proportion of transfers undertaken by neonatal transport services. While these are non-emergency transfers, they still frequently involve infants on some form of respiratory support.

The Paediatric and Neonatal Decision Support and Retrieval (PaNDR) service provides advice, critical care retrievals, transfers for specialist care and repatriation for neonatal patients across the East of England.<sup>1</sup> Our team undertakes around 600 elective repatriations per year, of which a third are on non-invasive ventilation. In our service, infants receiving invasive ventilation are classified as 'planned emergencies' rather than repatriations as they require more complex planning and care.

A routine capillary blood gas on arrival at the receiving unit is part of our practice for repatriations of stable infants on non-

invasive respiratory support – continuous positive airway pressure (CPAP), high flow nasal cannula (HFNC) or low flow nasal cannula (LFNC). The rationale being that we would document a respiratory deterioration en route. A heel prick is a painful procedure, however, and the blood gas on arrival is not necessarily actionable. It is likely the receiving team would let the infant settle and repeat a second blood gas before making changes to their ventilatory support based on that initial pCO<sub>2</sub>. Hence, we decided to study the variation of pCO<sub>2</sub> in these infants.

Our primary objective was to determine if there is a significant change in the pCO<sub>2</sub> on arrival compared to the pCO<sub>2</sub> prior to transfer, justifying our current practice. As a secondary objective, we aimed to identify subgroups most at risk of increase in pCO<sub>2</sub> as a marker of respiratory deterioration.

## Keywords

repatriations; neonatal transport; non-invasive respiratory support; partial pressure of carbon dioxide

## Key points

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1. We found no significant change in pCO<sub>2</sub> on arrival at the receiving unit in infants undergoing elective repatriations on non-invasive respiratory support.
2. A routine blood gas on arrival at the receiving unit following elective repatriations is unnecessary.

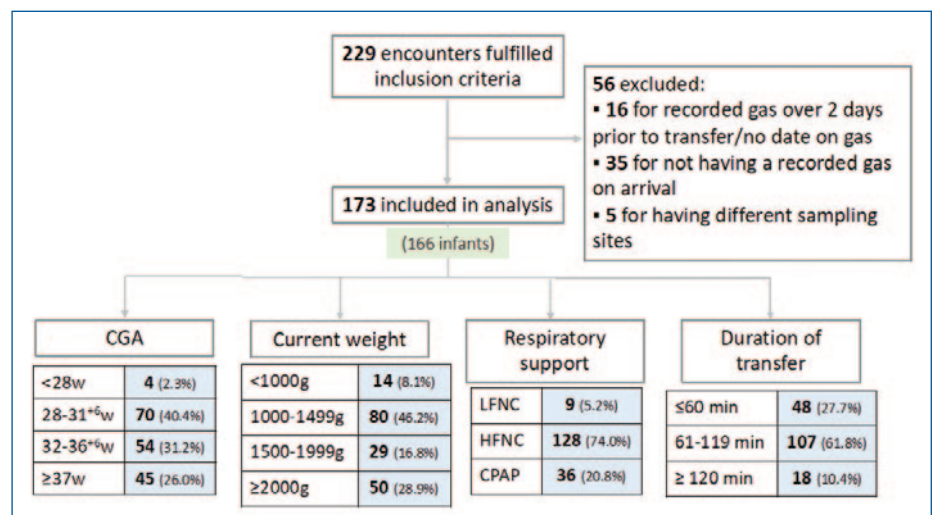
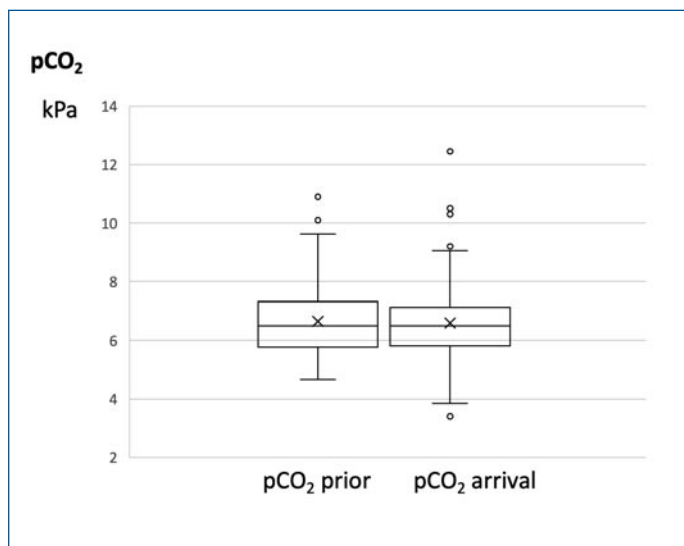
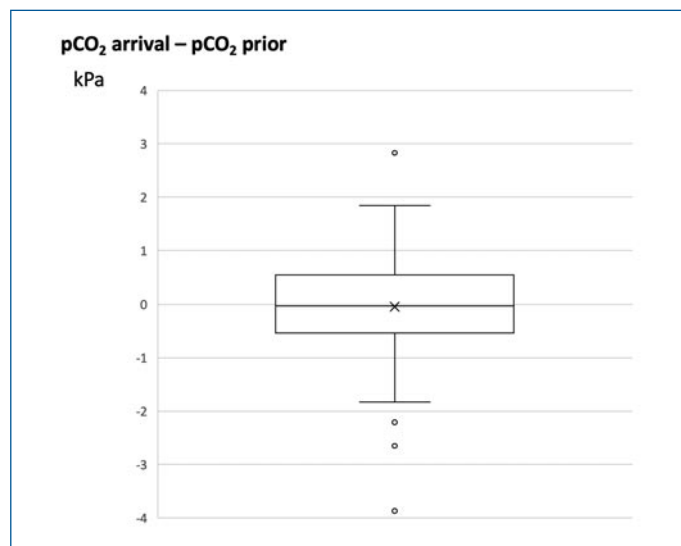


FIGURE 1 Encounters included in the analysis.



**FIGURE 2** pCO<sub>2</sub> prior to transfer and on arrival at the receiving unit.



**FIGURE 3** Absolute difference between pCO<sub>2</sub> on arrival at the receiving unit and pCO<sub>2</sub> prior to transfer.

## Methods

We performed a retrospective cohort study of infants referred to the PaNDR neonatal team for elective repatriation from January to December 2021. Data from all infants receiving non-invasive respiratory support prior to elective repatriation were reviewed. Exclusion criteria were:

- blood gas on arrival not performed or not documented
- documented blood gas on the referring unit performed more than two days prior to the transfer or date not documented
- blood gas on the referring and receiving units from different sampling sites (if the site was not documented, we assumed it was a capillary sample).

Subgroups analysed included:

- corrected gestational age (CGA) (<28 weeks, 28-31<sup>+6</sup> weeks, 32-36<sup>+6</sup> weeks and ≥37 weeks)
- current weight (<1,000g, 1,000-1,499g, 1,500-1,999g and ≥2,000g)
- mode of respiratory support (CPAP, HFNC and LFNC)
- parameters of HFNC (≤4L/min and >4L/min) and CPAP (≤5cmH<sub>2</sub>O and >5cmH<sub>2</sub>O)
- FiO<sub>2</sub> requirement prior to transfer (<0.3 and ≥0.3)
- infants who required an increase in settings during transfer (any increase ≥1L/min/1cmH<sub>2</sub>O and/or increase in FiO<sub>2</sub> ≥0.1 at arrival)
- journey duration (≤60min, 61-119 min and ≥120 min).

A paired sample t-test was used to compare pCO<sub>2</sub> prior to transfer and pCO<sub>2</sub> on arrival. A p-value <0.05 was considered

statistically significant. The absolute difference between pCO<sub>2</sub> on arrival and pCO<sub>2</sub> prior to transfer was also analysed.

## Results

We identified 229 encounters that fulfilled inclusion criteria, of which 56 were excluded, leaving a total of 173 encounters for analysis (**FIGURE 1**), corresponding to 166 infants. Around half the infants included were under 31<sup>+6</sup> weeks CGA and under 1,500g. About three quarters were on HFNC with only nine infants on LFNC. The journey lasted between one and two hours for the majority of infants.

The mean pCO<sub>2</sub> prior to transfer was 6.65 ± 1.17kPa and on arrival at the receiving unit was 6.59 ± 1.20kPa (p=0.35; **FIGURE 2**).

Of the subgroup analysis (**TABLE 1**), only infants between 28 weeks and 31<sup>+6</sup> weeks CGA showed a trend towards a statistically, but not clinically, significant increase in pCO<sub>2</sub> on arrival (M ± SD 6.44 ± 0.98 and 6.59 ± 0.93; p=0.06). Infants on different types of non-invasive respiratory support (CPAP, HFNC, LFNC) and with different oxygen requirements (FiO<sub>2</sub> <0.3 and ≥0.3) did not have an increase in pCO<sub>2</sub> on arrival at the receiving unit.

The absolute difference between pCO<sub>2</sub> on arrival and pCO<sub>2</sub> prior to transfer followed a normal distribution around a mean of -0.04kPa ± 0.84 (**FIGURE 3**). The maximum increase in pCO<sub>2</sub> was 1.84kPa, with one outlier showing an increase of 2.83kPa and three outliers displaying a decrease in pCO<sub>2</sub> between 2.21 and 3.87kPa. All the outliers corresponded to infants on FiO<sub>2</sub> ≥0.3 prior to transfer.

## Discussion

Out of the 229 encounters that fulfilled the inclusion criteria, 56 (24.4%) had to be excluded, mainly for not having a blood gas on arrival. The clinical team's decision not to perform a blood gas on some infants could potentially reflect the clinical stability of the patient and better patient demographics and baseline ventilation status (such as higher CGA and weight, lower respiratory support settings), skewing the final sample towards babies that were thought to be more at risk of increase in pCO<sub>2</sub>. When compared with the total cohort, the excluded encounters were demographically similar in terms of CGA and weight, but were more likely to be from babies on LFNC who were perhaps considered more clinically robust than those on CPAP or HFNC.

In the overall sample there was no change in mean pCO<sub>2</sub> on arrival compared to mean pCO<sub>2</sub> prior to the transfer and the absolute difference followed a normal distribution around a mean of zero with a maximum and minimum of around 1.8kPa. All the outliers were infants on FiO<sub>2</sub> ≥0.3 suggesting that these infants may have a wider variation in pCO<sub>2</sub>. A change of pCO<sub>2</sub> of up to 1.8kPa in an infant that has just been transferred does not necessarily warrant action, particularly if the infant is otherwise well. It is important to note that our sample included some patients who had a clinical deterioration en route, such as apnoeas requiring stimulation or frequent desaturations and bradycardia. It was reassuring that even when including these infants, the

maximum increase in pCO<sub>2</sub> was not at a level where the receiving team would have needed to act on it.

In the subgroup analysis, we used CGA and current weight rather than gestational age and weight at birth because we transfer preterm infants across a range of corrected gestations and weight. An extremely preterm infant term-corrected has a different maturity level than a younger

infant. This means that in our sample term-corrected infants who were born extremely preterm, were classified in the same gestational age group as their term counterparts, even though the pathology behind the need for non-invasive respiratory support is likely different.

Infants between 28 weeks and 31<sup>+6</sup> weeks CGA showed a non-statistically or clinically significant trend towards a higher

pCO<sub>2</sub> on arrival. We only completed four repatriations of infants under 28 weeks CGA. In this group, the mean pCO<sub>2</sub> on arrival decreased, suggesting that there was no deterioration en route, but considering the vulnerability of these infants, we would need a larger sample size to be able to safely suggest the discontinuation of a routine blood gas on arrival. The current weight and journey duration were also not determinant of a significant change in pCO<sub>2</sub> on arrival.

As expected, infants on CPAP and/or FiO<sub>2</sub> ≥0.3 had a higher pCO<sub>2</sub> compared to infants on HFNC and/or FiO<sub>2</sub> <0.3. Babies on CPAP and with higher oxygen requirements likely represent preterm infants with evolving bronchopulmonary dysplasia, thus explaining the higher baseline pCO<sub>2</sub>. They did not, however, have a significant change in pCO<sub>2</sub> on arrival to the referring unit. Similarly, infants on higher settings of HFNC or CPAP did not display a significant change in their pCO<sub>2</sub> compared to infants on lower settings. Infants with a deterioration en route where the team deemed it necessary to increase the settings on the HFNC/CPAP (flow ≥1L/min or pressure ≥1cmH<sub>2</sub>O) and/or FiO<sub>2</sub> ≥0.1 at the time of arrival had a non-statistically or clinically significant decrease in pCO<sub>2</sub>.

Limitations of this work include its retrospective design relying on accurate documentation and data collection, the heterogeneity of our sample and the significant proportion of encounters excluded from the analysis.

## Conclusions

There was no significant change in pCO<sub>2</sub> for infants on non-invasive respiratory support undergoing elective repatriation, hence we can safely consider discontinuing our current practice of a routine blood gas on arrival for these infants. It is reasonable to maintain this practice in infants with a CGA below 28 weeks, particularly considering the very small number of infants studied in this age group and their potential for greater fragility. Despite not displaying a change in pCO<sub>2</sub> in our study, we recommend as good practice performing a blood gas on arrival for infants with a clinical deterioration en route.

## Reference

1. Paediatric and Neonatal Decision Support and Retrieval Service (PaNDR). Online at: <https://pandrestofengland.co.uk/home>

	pCO <sub>2</sub> prior to transfer, M±SD (kPa)	pCO <sub>2</sub> on arrival, M±SD (kPa)	p-value
<b>Overall sample (n=173)</b>	6.65 ± 1.17	6.59 ± 1.20	0.35
<b>Corrected gestational age</b>			
<28 weeks (n=4)	6.23 ± 0.78	5.43 ± 1.46	--
28-31 <sup>+6</sup> weeks (n=70)	6.44 ± 0.98	6.59 ± 0.93	0.06
32-36 <sup>+6</sup> weeks (n=54)	6.59 ± 1.2	6.41 ± 1.05	0.10
≥37 weeks (n=45)	7.09 ± 1.3	6.93 ± 1.6	0.32
<b>Current weight</b>			
<1,000g (n=14)	6.49 ± 0.82	6.45 ± 1.13	0.83
1,000-1,499g (n=80)	6.53 ± 1.07	6.58 ± 1.03	0.50
1,500-1,999g (n=29)	6.55 ± 1.19	6.48 ± 0.99	0.64
≥2,000g (n=50)	6.95 ± 1.37	6.71 ± 1.56	0.11
<b>Type of respiratory support</b>			
CPAP (n=36)	7.44 ± 1.5	7.33 ± 1.62	0.56
HFNC (n=128)	6.46 ± 0.99	6.41 ± 0.99	0.49
LFNC (n=9)	6.26 ± 0.67	6.22 ± 1.02	0.88
<b>FiO<sub>2</sub> prior to transfer</b>			
<0.3 (n=108)	6.31 ± 0.94	6.23 ± 0.92	0.25
≥0.3 (n=56)	7.39 ± 1.31	7.36 ± 1.36	0.87
<b>HFNC</b>			
≤4L/min (n=50)	6.29 ± 0.79	6.27 ± 0.73	0.81
>4L/min (n=78)	6.57 ± 1.09	6.51 ± 1.12	0.50
<b>CPAP</b>			
≤5cmH <sub>2</sub> O (n=6)	5.90 ± 0.70	5.74 ± 0.81	0.60
>5cmH <sub>2</sub> O (n=30)	7.75 ± 1.43	7.65 ± 1.56	0.64
<b>Increase in flow ≥1L/min or pressure ≥1cmH<sub>2</sub>O and/or FiO<sub>2</sub> ≥0.1 at arrival</b>			
No (n=139)	6.56 ± 1.05	6.53 ± 1.13	0.66
Yes (n=25)	7.30 ± 1.66	7.07 ± 1.55	0.29
<b>Journey duration</b>			
≤60min (n=48)	6.67 ± 1.03	6.56 ± 1.00	0.31
61-119min (n=107)	6.63 ± 1.22	6.56 ± 1.26	0.43
≥120min (n=18)	6.76 ± 1.26	6.89 ± 1.37	0.54

**TABLE 1** pCO<sub>2</sub> prior to transfer and on arrival: subgroup analysis.