Home oxygen in neonatal chronic lung disease

Home oxygen therapy is used to optimise growth and development in infants with chronic lung disease of prematurity. However, the treatment also carries a significant burden to the patient and family. Current guidelines are mainly based on expert consensus due to the lack of a strong evidence base, and local practices vary. We surveyed neonatal units across England and Wales to understand current practice and areas for optimisation of care.

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Key points

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1. Thresholds guiding decisions around initiating and weaning long-term oxygen therapy for infants with CLDP vary widely across England and Wales.
2. Technical considerations affecting data output from pulse oximeters are poorly understood resulting in a wide variation in pulse oximeter settings across home oxygen services.
3. Evidence-based guidance is required alongside education to inform clinicians on best practice for infants with CLDP requiring supplemental oxygen.

Chronic lung disease of prematurity (CLDP) is the most common diagnosis for which long-term oxygen therapy (LTOT) is prescribed in children.[1] This minimises periods of hypoxia in infants with CLDP, thus optimising growth and development, but is associated with a relatively high treatment burden.[2]

Recent guidance produced by the American Thoracic Society (ATS)[3] acknowledged a striking lack of evidence regarding optimal initiation, monitoring and weaning of LTOT, and a lack of progress in the ten years since publication of the most recent British Thoracic Society (BTS) guidelines in 2009.[1,3,4] This was also highlighted in the 2020 position statement published by the Thoracic Society of Australia and New Zealand on Respiratory management of infants with chronic neonatal lung disease beyond the neonatal intensive care unit (NICU), which reflected on the "Considerable variation and little objective evidence to guide the use of long-term supplemental oxygen therapy in infants with [chronic neonatal lung disease]."[5]

Anecdotally within the UK, the lack of a strong evidence base has resulted in wide variation in practice between centres. There is also considerable variation in the interpretation of paediatric oximetry recordings by clinicians when presented with the same dataset.[6] This service evaluation aimed to understand current practice in use of LTOT for CLDP across England and Wales, to identify areas for optimisation of current care and areas requiring further research.

Methods

A ten question survey (**TABLE 1**) was distributed in November and December 2019 using an online survey platform via regional neonatal networks, and via British Paediatric Respiratory Society (BPRS), Paediatric Pan London Oxygen Group (PPLOG) and British Association of Perinatal Medicine (BAPM) newsletters. A covering letter explained the purpose of the survey. Participation in the survey implied consent to inclusion in this study. Respondents were asked to specify the centre they worked in. Where responses from the same centre were identified, only one respondent's set of answers was used. The answer set with the most complete answers was used. Responses that did not recognise appropriate units or clearly defined parameters were excluded; for example, oxygen desaturation index (ODI) threshold for weaning described in percentage terms rather than an absolute number. Where centres reported using 2009 BTS guidance, results were reviewed to determine whether reported practice was in line with BTS recommendations.

Results

In total, 49 responses were obtained. Five duplicate responses were identified and excluded, leaving 44 for analysis. Responses were obtained from neonatal teams from a range of rural and urban locations across England and Wales (level 3 units n=13, level 2 units n=16, level 1 units n=6, community neonatal teams n=3). Six respondents did not identify their place of work.

Service overview

Respondents were asked to specify which guideline or guidelines were used in their centre for LTOT in CLDP. The most common guidance used was the 2009 BTS

guidance (45% of centres); no other national or international guidelines were used. Eleven per cent of centres used a regional guideline, 32% a local guideline, and 14% of centres reported using no guideline at all.

Decisions around initiation and weaning of LTOT were made predominantly by neonatologists (66% centres) and general paediatricians (30% of units). Respondents could select more than one option; they did so in more than half of cases, reflecting a team-based approach. The 'other' category (34% of centres) denoted mainly specialist nurses (26% of centres) from neonatology or respiratory teams. In only 9% of centres, decisions were made as part of a formal sleep medicine service.

Initiating LTOT

The vast majority of units (38 of 44, 86%) reported using an overnight continuous oxygen saturation trace to determine the need for LTOT. This was used on its own by 27 out of 44 centres (61%). In 11 out of 44 centres (25%) it was used in combination with either 'spot' oxygen saturations or daytime continuous oximetry measurements.

There was wide variation in the oximetry criteria used to determine the need to initiate LTOT in CLDP (**FIGURE 1A**). The commonest criteria used were mean SpO_2 (50% of centres) and percentage of time with SpO_2 <90% (45% of centres). Notably, centres using the same oximetry criteria to determine oxygen dependency used different cut-off thresholds: mean SpO_2 threshold values ranged from 92%-97% (mode 95%). Similarly, where percentage time with SpO_2 <90% was used, threshold ranged from 4% to 20% (mode 5%).This variability remained even where centres reported basing practice on the BTS guidance (n=20). In these centres, mean SpO_2 thresholds ranged from 92-97% (relative to a BTS guideline recommendation of ≥93%). Threshold time with SpO_2 <90% ranged from 5-10% (relative to a BTS guideline recommendation of SpO_2 <90% at ≤5%) and was not reported as a criterion used in nearly 50% of these centres (9/20).

Technical aspects of oximetry

Minimum artefact-free recording time (AFRT) deemed to constitute an acceptable quality oximetry study varied widely between centres, from 2-12 hours (**FIGURE 1C**). Averaging time set by the oximeter was widely variable (range 2-10 seconds). Notably, 55% of respondents' answers to the question on averaging time were 'Don't know' (**FIGURE 1D**).

Weaning of LTOT

As might be expected, within a given centre very similar oximetry criteria and threshold values were used to determine suitability for weaning as used for initiation of LTOT (**FIGURE 1B**). Oxygen flow rate was weaned in decrements of 0.01L/min – 0.5L/min, depending on the centre. Where a range of decrements was used (36% of centres) these ranges were also very variable, with the maximum decrement used in some centres (0.03L/min) smaller than the minimum decrement (0.1L/min) used in other centres.

	Survey questions
Service overview	1. a) Which neonatal unit are you based at? (Free text response) b) Please also rate how important you feel this topic is. (1=very important, to 5=not important at all) 2. Which guidelines are used in your service to decide which infants require LTOT? (British Thoracic Society 2009; American Thoracic Society 2018; other international; other national; regional; local; none) 3. Who is responsible for interpreting oximetry studies and making decisions about weaning LTOT? (Neonatologist; respiratory paediatrician; general paediatrician; part of a formalised programme within a sleep service; other – please specify)
Initiating LTOT	4. What type of oximetry monitoring is used to determine the need for LTOT? (Spot SpO_2; continuous monitoring study overnight/during sleep; continuous monitoring study daytime/awake; combination of above – please describe) 5. What oximetry criteria do you use for initiating LTOT? Please provide free text details of cut-off criteria. (Mean oxygen saturations; saturation nadir; 4% oxygen desaturation index (ODI); % time with saturations <92%; % time with saturations <90%; % time with saturations <88%; other)
Technical	6. For infants undergoing a continuous monitoring study, what is the minimum duration of artefact-free recording that you deem to be an acceptable quality study? (Less than 2 hours; 2 hours; 4 hours; 6 hours; unsure; other – please specify) 7. For infants undergoing continuous monitoring, what averaging time for detection of events is set by the oximeter? (2 seconds; 4 seconds; 10 seconds; don't know, other – please specify)
Weaning LTOT	8. Once infants are discharged home how frequently would you review their saturations with a view to weaning oxygen? (Free text response) 9. What oximetry criteria do you use for weaning oxygen? Please provide free text details of cut-off criteria. (Mean oxygen saturations; saturation nadir; 4% oxygen desaturation index (ODI); % time with saturations <92%; % time with saturations <90%; % time with saturations <88%; other) 10. What flow increments do you wean oxygen by? (Free text response.)

TABLE 1 The ten-question national survey on current practice around LTOT in infants with CLDP. Questions are shown subdivided by topic. Where questions were presented in a multiple choice format, answer options provided are listed in brackets; where a question required a free text response this is indicated. In the covering letter, respondents were asked to specify the thresholds they would use to decide whether an infant did/did not have an oxygen requirement (denoted as 'cut-off criteria'). For each oximetry criterion, a free text box was provided to specify the threshold value used. Key: SpO_2 = blood oxygen saturation level; ODI = oxygen desaturation index; BTS = British Thoracic Society; ATS = American Thoracic Society. 'Spot' saturations = one-off SpO_2 check, rather than a period of continuous oximetry trace.

Discussion

This service evaluation demonstrates a wide variation in practice in initiation, monitoring and weaning of LTOT for infants with CLDP across England and Wales.

While most units used an overnight oximetry trace to determine the need for LTOT, the survey results demonstrate that there is wide variation in the specifics of practice around oximetry for LTOT for CLDP. Different oximetry parameters were used in different centres, and thresholds for starting or weaning oxygen varied. The most frequently reported guideline on which practice was based was that published by the BTS in 2009.[1] However, centres reporting using this guidance often used different oximetry thresholds than the ones recommended by it.

Over 50% of respondents acknowledged a lack of awareness of oximeter averaging times, and we noted highly variable minimum AFRT durations deemed as 'acceptable'. These technological considerations have been shown to affect outcome variables such as mean SpO_2 or 4% ODI.[7] For example, where longer oximeter averaging times are used, short-lived desaturation episodes may not be detected. This is particularly important in young infants who are susceptible to short central apnoeas resulting in brief desaturations. Additionally, longer averaging times that blunt the effect of desaturations artificially lower mean saturations, which will impact on weaning infants from oxygen when targeting specific thresholds.[8-10]

Finally, the variation noted in both thresholds used to determine suitability for weaning LTOT, and in size of decrements used to wean oxygen flow rate, will result in infants being treated with LTOT for longer by some centres than others.

Overall, the wide variation in practice seen in the survey results implies that some infants are being treated with LTOT for longer or shorter than is optimal for the balance of treatment benefit and burden.

Responses were voluntary and were achieved from around 25% of neonatal units in England and Wales. While we recognise that this relatively low response rate may limit the generalisability of our findings, responding units did represent the full spread of units, from tertiary NICUs to community neonatal teams; varied settings from large city to rural; and a wide geographical spread across England and Wales.

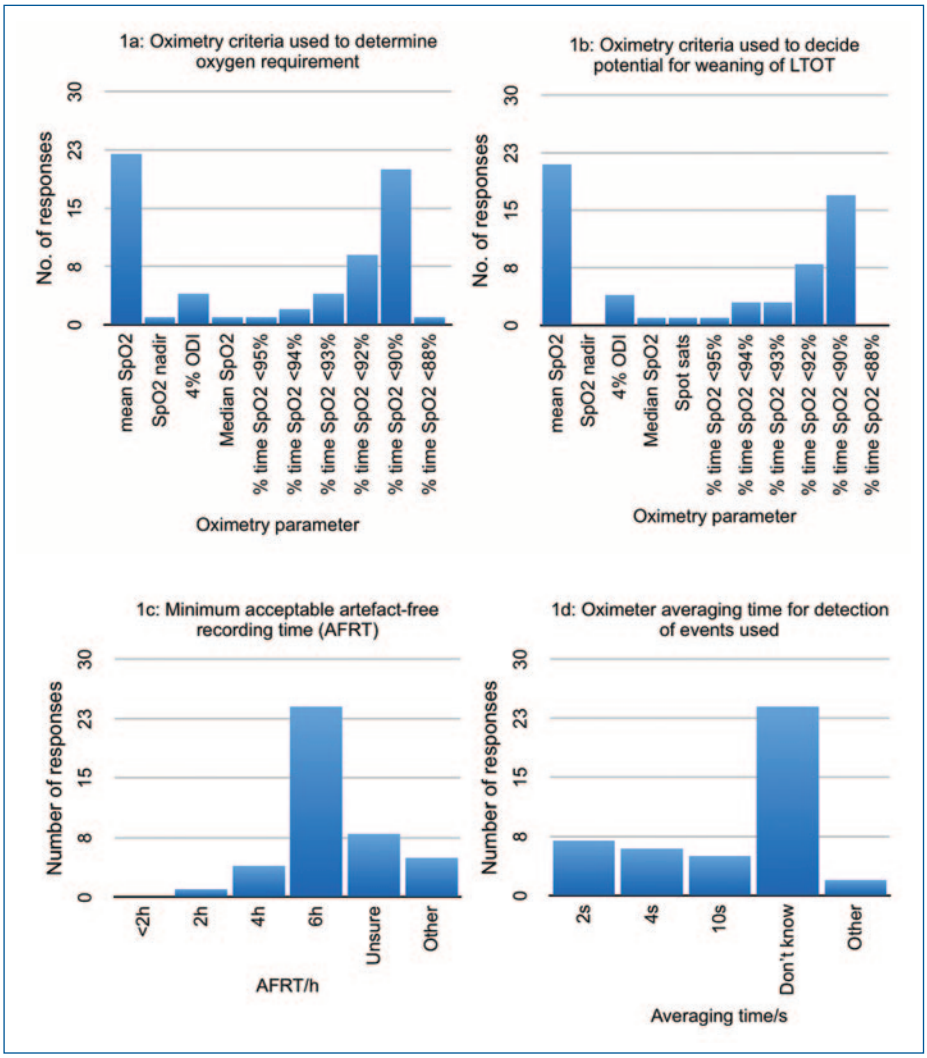

FIGURE 1 Bar charts showing criteria for oxygen initiation and weaning (1a, 1b) alongside technological considerations when interpreting oxygen saturation data (1c, 1d).

It is likely that units who believed the topic to be of value were more likely to submit information, which may skew the results. In fact, the overwhelming majority of survey respondents who rated the importance of the survey topic (n=29) rated it as 'very important' (24 out of 29). We therefore suspect the practice described most likely represents a best-case scenario for LTOT management of these infants. This underlines the variability in practice of even highly motivated teams.

Conclusions

This national survey demonstrated wide heterogeneity in the implementation, monitoring and weaning of LTOT for infants with CLDP. This most likely relates to a relative lack of an evidence base regarding SpO_2 reference ranges and the impact of intermittent hypoxia in young infants, alongside limited understanding of key factors affecting data output. This topic, and achieving consensus in management, is seen as an area of high importance by clinicians caring for these infants. More research is needed to establish evidence-based criteria and thresholds for LTOT initiation and weaning in infants with CLDP using modern oximeters, in order to optimally balance promotion of infant growth and development with minimisation of treatment cost and burden. Research outcomes should be widely disseminated alongside oximetry education programmes.

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SUPPLIER GUIDE

Temperature management: a guide to the latest equipment

Hypothermia is well recognised as influencing newborn health and a major risk factor contributing to neonatal morbidity and mortality. Maintaining a thermoneutral environment is a fundamental aspect of neonatal care. A thermoneutral environment is one in which an infant at rest maintains a core temperature of 36.8- 37.2°C so that oxygen consumption and energy expenditure are minimal, in order to optimise conditions for growth and development. Maintaining a warm chain during various interventions can prevent hypothermia-associated morbidity and mortality risk. In this issue of *Infant* we look at recent innovations in medical equipment designed to help ensure the best thermoregulated environment for a premature or sick baby.

Every cot becomes a heated cot with the ASTOPAD Baby Warmer

Stihler Electronic's ASTOPAD Baby Warmer provides premature and newborn babies with a comfortable, safe and gentle protective heat. It helps essential sleep and aids optimal development at a crucial time of life. It can be used as a heated surface under the baby and/or as a cover over the baby and takes less than three minutes to reach the desired temperature. The Baby Warmer can be used in a wide range of situations:

- in the delivery room for providing initial heat on the resting surface
- in the neonatal unit or postnatal ward for providing long-term heat for one or two babies
- before, during and after surgery to prevent perioperative hypothermia
- for maintaining the baby's body heat during skin-to-skin (kangaroo) care
- when transporting infants within the hospital using an optional integrated battery.

Other features include a soft, flexible and disinfectable blanket and no consumables. The ASTOPAD Baby Warmer is available from Eden Medical.

The TempWatch: 24/7 monitoring for detecting neonatal hypothermia

In hospital settings, especially in the neonatal intensive care unit, a thermoneutral environment is maintained by keeping newborn babies in warmers and incubators. However, once in the step-down nursery or postnatal ward, infants are at a higher risk of becoming hypothermic and a lack of continuous monitoring may lead to hypothermia going undetected. Hence there is need for an accurate, simple and easy to understand device that aids the mother in continuous monitoring of temperature during her baby's hospital stay and also in the home setting following discharge.

The TempWatch bracelet is a silicone band with a thermistor metal cup that provides 24/7 monitoring to detect neonatal hypothermia. The bracelet continuously monitors for one month following activation, displaying a blue light for a normal temperature. It blinks with an orange light and sounds an alarm if the infant's core temperature falls below 36.5°C, indicating hypothermia. It has sensitivity and specificity of 98.6% and 95%, respectively, making it a reliable tool to help assess the prevalence of hypothermia. TempWatch is available from Delta Medical International.

Baby warming systems using Kanmed and Thermocare

The Kanmed BabyBed can be used with the Kanmed BabyWarmer to create the Kanmed Baby Warming System, which enables babies to to be cared for out of the traditional incubator environment. It is available from Central Medical Supplies (CMS).

The warmer is designed to enable a gentle warmth transfer from the mattress to the baby. Kanmed BabyWarmers are available with a choice of interchangeable mattresses, which include water and gel. The integrated heat pad of the new gel mattress is heated to the selected temperature, which replicates the mother's warm skin. The BabyWarmer also comes complete with a soft baby nest, which can be adjusted to create a snug sleeping place with clear boundaries. A twin version of the BabyBed is available for co-bedding twins.

CMS also offers the Thermocare range of baby warming beds by Weyer GmbH. The Thermocare standalone baby warming system is ideal for babies requiring surveillance in an intermediate care unit. The modular design of Thermocare beds enables users to configure the different units available to their exact requirements. The base unit, Thermocare K, consists of the mobile bed with an under-pad heating device that provides a thermally stable environment for babies. This model is an ideal replacement for existing under pad warming beds where there is no requirement for additional overhead radiant warmers. Thermocare C consists of the mobile bed with an overhead radiant warming system and Thermocare KCE includes both the under pad and overhead warming devices.

Weyer's Ceramotherm radiant warmer can warm the actual patient's temperature using its skin temperature sensors. It offers a flexible approach and can be operated in three different modes, such as pre-warming of patient pads, warming beds or manual mode – ideal for baby changing, examination and intensive care situations.

Taking temperature: accuracy matters to Exergen's temporal artery thermometer

The starting point for assessing an infant or child's health is taking their temperature and for this the accuracy of the thermometer is essential. Understanding the difference between a temporal artery thermometer (TAT) and a 'no-touch thermometer' (infrared gun) is important. A recent study compared the accuracy of the two and found that no-touch thermometers missed five out of every six fevers. The Exergen TAT has more than 87 published studies supporting its accuracy, from premature babies to infants and geriatrics. According to its manufacturers, the Exergen TAT-5000S delivers superior functionality in a demanding hospital environment. It stands up to the heavy duty demands of a high-performance hospital workplace, including the neonatal intensive care unit, emergency department and all inpatient settings. After two years of research and testing, Exergen has succeeded in its objective of eliminating case cracking caused by harsh chemical disinfectants commonly used in hospitals. The proprietary 'super plastic' cases are now used in all Exergen Temporal Scanner TAT-5000 series professional models. The TAT5000 is so robust that it comes with a lifetime warranty.