ELSTREE
Elstree Outpatients Centre
Beaufort House, The Waterfront
Elstree Road
Elstree
WD6 3BS
02039304597
Web:
www.childchestclinic.com

HATFIELD
One Hatfield Hospital
Hatfield Avenue
Hatfield Business Park
Hatfield
AL10 9UA
01707443333
Email:
drchin@childchestclinic.com

MEDICOLEGAL REPORT

Our ref:	REF REDACTED
Solicitor's ref:	REDACTED
MedCo ref:	N/A
Examination Date:	N/A
Report Date:	JANUARY 2022
Author:	Dr C Nwokoro

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Subject Details

Name:	Miss REDACTED (REDACTED)
Date of Birth:	12th BIRTH MONTH REDACTED
Address:	REDACTED
Next of Kin:	Mrs REDACTED

Expert Background

I am Dr Chinedu Nwokoro, a registered medical practitioner. I am registered with the General Medical Council (GMC) with GMC registration number 4766917. I earned my primary medical qualification at the University of Cambridge. My qualifications are MB BChir (2001), MA Hons MD (Cantab), MRCPCH (2004).

I began working in paediatrics in February 2002 and gained membership of the Royal College of Paediatrics and Child Health in July 2004. I was admitted to the GMC Specialist Register as a General Paediatrician and as a Paediatric Respiratory Subspecialist on 5th April 2011 whilst employed as a Clinical Academic at Queen Mary University of London and working towards my doctoral degree. I commenced work as a locum Consultant Respiratory and General Paediatrician at the Royal London Hospital in May 2013 and have been employed as a substantive Consultant General and Respiratory Paediatrician at The Royal London Hospital since 16th REDACTED 2013. On 20th July 2018 I was admitted to the degree of Doctor of Medicine by the University of Cambridge for my research into the genetics and biomarkers of preschool wheeze. I am currently the Network Lead for childhood asthma for the North East London Integrated Care System and also faculty and joint course director for the Lung in Childhood Seminars, the training program for Paediatric Respiratory Medicine in London and the South East of England.

Basis of Report

I have been provided with a substantial body of medical notes, numbering approximately 1100 pages. These include the following:

1. Chronology of medical records
2. Index to all records
3. DATIX dated 26 REDACTED 2017
4. Relevant medical records (relating to REDACTED only)
    a. GP records (pages 206 – 273)
    b. REDACTED University Hospitals NHS Foundation Trust records
        i. Clinical Rounds – 17.10.17-30.12.17 (pages 1002-1160)
        ii. Computerised Ward Rounds – 13.08.17-16.10.17 (pages 1416-1442)
        iii. Daily Evaluations – 12.08.17-31.12.17 (pages 1751-2139)
        iv. Care Round Reports – 13.08.17-21.08.17 (pages 2286-2309)
        v. Computerised Nursing Records – various (pages 3293-3324)
        vi. Respiratory Observations – 12.08.17-16.10.17 (pages 3376-3506)
        vii. Correspondence – 12.08.17-31.12.17 (pages 3843-3869)
    c. Updated GP records (pages 4585 – 4809)
    d. CD of Radiological Imaging – 05.05.18-01.07.19

This report is prepared from my personal review and interpretation of these records, with appropriate reference to the medical literature and relevant UK guidance as it pertains to this question. In addition, on 12th December 2021 I conducted a telephone consultation with Mrs REDACTED.

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Details of Instruction

REDACTED was born preterm, the smaller of low birth weight twins, having been treated in utero for twin-twin transfusion syndrome. She exhibited respiratory compromise and required ventilatory support. In the course of this support she required supplemental oxygen for frequent transient reductions in her blood oxygen saturation (desaturations) measured using a pulse oximeter. It is alleged that REDACTED experienced two periods of inappropriately high inspired oxygen concentration during her stay on the REDACTED Baby Unit at the REDACTED Hospital, part of REDACTED NHS Foundation Trust (then REDACTED Hospitals NHS Foundation Trust). It is further alleged that these events caused or contributed to respiratory and/or neurological injury in REDACTED.

I have been asked to consider the documents cited above and provide a detailed, independent and objective medicolegal report on the respiratory injuries sustained by REDACTED. I have been asked to comment specifically on:

- Causation of injury
    - Whether the error made on 27th BIRTH MONTH REDACTED and described below caused or contributed to REDACTED's past or current respiratory problems.
    - Whether the error made on 2nd REDACTED 2017 and described below caused or contributed to REDACTED's past or current respiratory problems.
    - If I do not consider that the error(s) caused the respiratory problems, to comment on what the likely cause may be.

- Injuries
    - What respiratory injuries, if any, has REDACTED suffered as a result of the error/s?
    - If appropriate, detail REDACTED's current respiratory difficulties (related to the error/s) with comment on the impact that these will have on her day-to-day life.
    - What is REDACTED's prognosis in relation to her respiratory difficulties, and what is the likely future impact of these?
    - Do I consider that REDACTED's respiratory condition confers a change in her life expectancy?

- Requirement for additional expert evidence in relation to breach of duty or causation
    - Which field of expertise.
    - Justification of this requirement

- Medical negligence

120 ○ Did the standard of care received by REDACTED fall below the standard that she could have reasonably expected?

In my letter of instruction I am reminded that my conclusions should be on the basis of my own opinion and on the civil burden of proof of the balance of probabilities.

Antenatal and Perinatal History

Family History

REDACTED is the fourth child of REDACTED (Mr REDACTED) and REDACTED (Mrs REDACTED). Mr REDACTED is a learning support worker with no medical conditions, while Mrs REDACTED is a shop assistant with a history of type 1 diabetes mellitus, depression and obsessive-compulsive disorder. REDACTED's identical twin sister REDACTED (the elder twin) was the recipient twin in their twin-twin transfusion syndrome. As a twin she was also born preterm, but does not have the medical problems experienced by REDACTED. REDACTED has a 7 year old brother, REDACTED, who has autistic spectrum disorder, and a healthy sister REDACTED, aged 9. Mr and Mrs REDACTED both smoke but report that they do so outside the house. The family have two pets (a cat and a dog) but REDACTED has not been tested for allergies. The current residence is reported to be in a non-polluted area, with adequate heating and ventilation and no damp or mould. The family live in a two-bedroomed local authority-owned property, with REDACTED, REDACTED and their older sister sharing one bedroom, and REDACTED's brother sleeping in the other room. Mr and Mrs REDACTED sleep in the lounge on a sofa bed. They are on a waiting list for a more suitable property. Despite the difficult living situation, Mrs REDACTED describes the family environment as happy and supportive.

Antenatal History

REDACTED was one of monochorionic-diamniotic twins and had a breech lie. On 30th May 2017 (21 weeks gestation) an ultrasound scan showed that the pregnancy was affected by twin-twin transfusion syndrome, in which REDACTED was the donor twin, ceding blood flow and nutrients to her sister and was estimated to weigh 21% less than REDACTED. In this scenario the donor twin is at increased risk of death, neurodevelopmental impairment, restricted growth, low birth weight and chronic lung disease(1), this last as a consequence of reduced amniotic fluid volume, poor intrauterine nutrition and low birth weight. REDACTED's parents were advised that she may not survive. On 12th June 2017 an endoscopic laser ablation of placental blood vessels was performed, with the aim of disrupting the blood flow between the twins. This procedure is recognised to increase the likelihood of survival of both donor and recipient twin, but does not reduce the risk of adverse neurodevelopmental and cardiorespiratory outcomes to that of foetuses not affected by twin-twin transfusion syndrome(2–4). On 4th July 2017 an ultrasound scan showed reduced fluid volume in REDACTED's amniotic sac. Amniotic fluid is essentially urine produced by the foetal kidney, and the reduced blood supply to the donor twin in twin-twin transfusion syndrome reduces its production; amniotic fluid is essential for the normal development of the foetal lung, and deficiency is associated with more severe neonatal lung disease, preterm birth, intrauterine growth restriction and foetal death.

Birth History

On 11th BIRTH MONTH REDACTED Mrs REDACTED experienced preterm rupture of membranes (her waters broke) and on 12th BIRTH MONTH REDACTED after 29 weeks and 6 days completed gestation was delivered of twins by emergency caesarean section. She received antenatal steroids to mature the foetal lungs. REDACTED was the second born twin, and was smaller, weighing 975g. This birth weight is classed as very low, and small for gestational age (below the 10th centile), reflecting significant intrauterine growth restriction due to the differential blood flow between the twins. REDACTED was in good condition at birth, with a good cry, pink colour (indicating good cardiac output and blood flow) but had respiratory distress syndrome and needed 30% oxygen; Apgar scores in oxygen were 9 at 1 minute, 10 at 5 minutes and 10 at 10 minutes. Oxygen requirement was weaned to 21% (the oxygen concentration in room air) and she was commenced on continuous positive airway pressure (CPAP) respiratory support in air whilst still on the delivery unit. It is notable that she did not receive intrapulmonary instillation of synthetic surfactant, a lung protective measure that might be expected to have been beneficial in this setting (where the risk of chronic lung disease of prematurity is high due to preterm birth, intrauterine growth restriction, low amniotic fluid volume and low birth weight) but is not explicitly stipulated in UK national guidance(5,6). In view of their prematurity, their risk factors for bronchopulmonary dysplasia, and REDACTED's requirement for respiratory support, both twins were transferred to the Special Care Baby Unit (SCBU) for ongoing care.

Neonatal History

Early neonatal unit progress

On day 2 of life REDACTED was weaned from CPAP to humidified high flow nasal cannula oxygen (HHFNC) at a flow rate of 8 litres/minute in air, a step down in respiratory therapy reflecting an apparent improvement in her lungs and on day 3 (14th BIRTH MONTH REDACTED) the HHFNC was reduced to 6 litres/minute in air. On the 15th BIRTH MONTH REDACTED, aged 4 days, REDACTED was observed to develop occasional desaturations. Over the following days these increased in frequency and became associated with bradycardia and she was investigated and briefly treated with intravenous antibiotics for possible bacterial infection. On 21st BIRTH MONTH REDACTED the antibiotics were discontinued when bacterial culture of her blood yielded no organisms and she subsequently appeared to improve; as such the HHFNC flow rate was reduced sequentially to 2 litres/minute in air by 26th BIRTH MONTH REDACTED.

1st Oxygen Delivery Incident

At 2040 on 26th BIRTH MONTH REDACTED, aged 15 days, REDACTED experienced a nasogastric feed-associated desaturation to 73% with minor associated bradycardia to 94 beats per minute. Her

oxygenation and heart rate recovered with gentle stimulation from the duty nurse. At 2120 she stopped breathing and experienced a more profound desaturation (to 54%) and bradycardia (to 65 bpm). On this occasion a different duty nurse stimulated her and appropriately increased her oxygen supply. After recovery of oxygen saturation and heart rate it would be usual in this scenario to return oxygen supply to or near to pre-event levels but nursing and medical records suggest that this did not occur:

- Oxygen saturation was recorded at 100% every hour from 2200 on 26th BIRTH MONTH REDACTED until 0800 on 27th BIRTH MONTH REDACTED (this would be unexpected in any infant not receiving supplemental oxygen, but was particularly implausible given REDACTED's documented tendency to desaturations).
- Coincident with this the HHFNC oxygen concentration was recorded as 21% (i.e. the oxygen concentration of room air, no supplemental oxygen) throughout the night, until the nurse taking over REDACTED's care at 0800 on 27th BIRTH MONTH REDACTED noted that the HHFNC oxygen concentration was actually 100% (rather than 21%).
- Furthermore, the alarm on the pulse oximeter was found to have been reconfigured with an upper warning limit of 101%, i.e. it would never alarm for high oxygen saturation.

Mrs REDACTED was made aware that REDACTED had most likely been inappropriately exposed to 10-11 hours of 100% oxygen and (dissatisfied and not reassured after serial discussions with neonatal intensive care unit staff) registered a formal complaint after reading of potential respiratory and visual damage from prolonged hyperoxia in preterm babies.

At 1422 on 27th BIRTH MONTH REDACTED REDACTED was documented to show features of gastrooesophageal reflux with retching and frequent posseting, and the treating team opted to slow her nasogastric feed rate to mitigate this.

At around 1530 on 27th BIRTH MONTH REDACTED HHFNC was stopped. While breathing unsupported in room air only REDACTED again exhibited an increase in apnoeic episodes with desaturation and at 2315 HHFNC was recommenced at 6 litres/minute in 21% oxygen. The apnoeic episodes and desaturations continued into the following day and IV antibiotics were commenced, after which it was possible to wean HHFNC gradually to 2 litres/minute by 2nd REDACTED 2017. By the evening of 2nd REDACTED 2017 REDACTED was again exhibiting increased apnoeic episodes and desaturations. It is notable that this worsening respiratory instability coincided with:

- the weaning of HHFNC from 6 litres/minute on 28th BIRTH MONTH REDACTED to 2 litres/minute on 2nd REDACTED 2017 (a reduction in respiratory support).

- the increase in gastric feed volume from 100ml/kg (with 65ml/kg intravenous feed) on 28th BIRTH MONTH REDACTED to 180ml/kg (all nasogastric feed) on 1st REDACTED 2017 (a step that may worsen gastrooesophageal reflux, with consequent increased apnoeic episodes and desaturations).

HHFNC was again increased, this time to 4 litres/minute.

2nd Oxygen Delivery Incident

At 1630 on 2nd REDACTED 2017 REDACTED desaturated to 69% and her supplemental oxygen was (briefly, as per the day nurse) increased before being reduced back to 21%. Despite the assertion by the day nurse that the oxygen supply was only transiently increased, REDACTED's oxygen saturation did not drop below 100% from 1630 until the arrival of the nurse for the night shift at 1950. On her arrival the night nurse noted that the HHFNC oxygen dial was set to deliver 60% supplemental oxygen rather than the 21% that had been documented. On investigation the day nurse asserts that the oxygen dial was returned to 21% after the 1630 desaturation, and that the dial was turned up to 60% in response to another desaturation shortly before the 2000 shift change. On this occasion the evidence for a sustained period of inappropriately high oxygen exposure is less robust (sustained documented 100% saturations and a dial set to deliver 60% oxygen at the point of shift changeover) but the possibility exists that REDACTED was again exposed to higher than intended oxygen for a period of up to 3 hours and 20 minutes. This incident was also discussed with REDACTED's parents.

Subsequent neonatal and high dependency unit progress

REDACTED continued to manifest frequent apnoeic and desaturation episodes, with associated bradycardia, and requiring stimulation, increased oxygen, or manual intermittent positive pressure ventilation. She remained in HHFNC until 21st REDACTED 2017.

On 1st REDACTED 2017 REDACTED was noted to make an inspiratory upper airway noise termed 'stridor', which can reflect irritation, inflammation or narrowing of the upper airways due to infection, gastrooesophageal reflux, trauma or as a congenital anatomical abnormality.

REDACTED underwent investigations to identify the cause (or sequelae) of her respiratory events:

- Ophthalmology review — No retinopathy of prematurity (13REDACTED17, 27REDACTED17)
- Fine nasal endoscopy — Normal upper airway anatomy (23REDACTED17)
- Barium swallow — Showed mild gastrooesophageal reflux with no malrotation (25REDACTED17)
- pH-Impedance study — Acid reflux possibly contributing to desaturations (27REDACTED17, 11REDACTED17)

- Echocardiogram — Structurally normal heart with small interatrial communication (28REDACTED17)
- MRI brain — Normally formed brain (5REDACTED17)
- Neurology review — Bulbar dysfunction with absent swallow and rooting reflex, reduced gag reflex, incoordinate suck, tight hamstrings.
- Tubeoesophagram — Showed mild gastrooesophageal reflux with no H-type fistula (10REDACTED17)
- Electroencephalogram — No seizure activity (11REDACTED17)
- Ambulatory EEG — Normal, no seizure activ17)
- Speech and language therapy (SLT) assessment — No swallow, no gag, and no reflex cough on oropharyngeal suction.
- Genetics — Normal karyotype, Trisomy X identified in the placenta.

REDACTED also had trials of the following therapeutic options:

- Antireflux medication — No clear impact on respiratory events but maintained
- Nasojejunal feeding — No clear impact on respiratory events so returned to nasogastric feeds
- Antisialogogues — Maintained and effective at reducing respiratory secretions
- Caffeine — A stimulant medication which reduced the respiratory episodes.

On 21st REDACTED 2017 at 35 weeks and 3 days gestational age REDACTED was successfully weaned off all respiratory support. On 17th REDACTED 2017 she was transferred to the High Dependency Unit (HDU) at the REDACTED Children's Hospital for ongoing care and on 2nd January 2018, aged 4 ½ months, REDACTED was discharged home breathing on her own and in air.

Progress after discharge home

On 3rd January 2018 REDACTED was readmitted with bronchiolitis, remaining in hospital for oxygen and other supportive (non-HDU) treatment until 10th January 2018.

On 20th January 2018, aged 5 months, she experienced a further brief admission for observation of mild bronchiolitis but did not need oxygen or other significant intervention and was discharged the following day.

On 25th January 2018 she attended the emergency department to request tape to secure the feeding tube.

On 26th January 2018 she attended the emergency department for resiting of her nasogastric feeding tube.

On 27th January 2018 REDACTED was admitted to hospital with respiratory difficulty, vomiting, and a displaced nasogastric tube and was again thought to have bronchiolitis. She received IV antibiotics, oxygen, chest physiotherapy and other supportive therapy. She remained in hospital until 19th March 2018. During this time multiple assessments were made to explain her respiratory vulnerability:

- Repeat pH-Impedance study suggested non-acid gastrooesophageal reflux with no definitive evidence of aspiration but good evidence that reflux was triggering respiratory symptoms.
- Nuclear medicine pulmonary aspiration study showed no aspiration on nasojejunal feeds.
- Speech and language therapy assessment indicated that she was still not able to feed orally.
- Audiology review showed bilateral conductive hearing loss.
- Chest x-ray showed infectious changes.
- PHOX2B genetic screen for congenital central hypoventilation syndrome was negative.
- BVVS genetic screen for Brown-Vialetto-Van Laere syndrome was negative.

Longterm treatment changes included:

- Nasojejunal feeding tube insertion.
- BAHA band inserted to support hearing.
- Commenced glycopyrronium (an antisialogogue).
- Commenced daily chest physiotherapy.
- Commenced night time oxygen 0.1L/minute.

On 20th March 2018 (just after discharge) REDACTED had a home sleep study on 0.1L/minute nasal cannula oxygen and this was satisfactory with normal oxygen saturations throughout.

On 25th March 2018 REDACTED was again admitted with respiratory compromise. She was transferred to HDU for HHFNC support and was discharged on 30th March 2018 to complete one week of antibiotics.

On 9th April 2018 REDACTED attended for replacement of her nasojejunal tube.

On 12th April 2018 REDACTED attended with vomiting despite normal position of the nasojejunal tube.

On 24th April 2018 REDACTED was admitted with a displaced nasojejunal tube. It was replaced on 25th April 2018 and she was sent home the following day.

REDACTED was followed up by gastroenterology, respiratory, speech and language therapy (SLT), neurology, and audiology in the outpatient department.

Medical Status Summary and Causation Review

REDACTED's current medical status is instructive as regards her respiratory status and the impact of any hyperoxic exposure. Her current state is summarised below, categorised by bodily system:

Neurological

REDACTED did not have seizures on EEG and had a structurally normal brain on MRI scan. Nonetheless she has global developmental delay, manifest by the following:

- Markedly impaired cough, gag, swallow, suck, and rooting reflex
- Sensorineural hearing impairment
- Tight hamstrings

The impaired cough, gag and swallow make it difficult for her to manage her upper airways secretions (through swallowing and coughing), which instead may pool in her mouth before spilling out as drool or being aspirated into the lungs, with consequent noisy breathing, respiratory distress, and infection. This initially prevented her from feeding safely by mouth, and necessitated antisialogogue medication coupled with frequent suction of the mouth and throat. In preterm babies the pooling of secretions in the back of the throat (or their aspiration into the lungs) may also stimulate bradycardia and apnoeic episodes with associated desaturation. REDACTED has made remarkable progress in this regard, such that she is now able to feed entirely by mouth, with any liquids thickened with carobel (a feed thickener) to reduce the risk of aspiration. She still requires glycopyrronium to reduce the volume of saliva to a manageable level.

Visual

REDACTED did not develop retinopathy of prematurity and was discharged from ophthalmology care while an inpatient.

Gastroenterological

REDACTED was unable to swallow any significant feed volume safely, due to the aspiration risk posed by her gastrooesophageal reflux and bulbar dysfunction. The former necessitated antireflux medications and (naso)jejunal tube feeding, while the latter was mitigated by the prohibition of oral feeding, with any exposure to oral nutrition (for example with pureed tastes and thickened fluids) being managed under the speech and language therapy team. These measures formed a key part of

her respiratory protective measures and facilitated the improvement in her apnoeic episodes and respiratory infection risk.

Respiratory

REDACTED has not required longterm[1] non-invasive respiratory support since HHFNC was discontinued on 21st REDACTED 2017, when she was 35 weeks and 3 days gestational age. As she remained largely independent of supplemental oxygen she did not meet criteria for bronchopulmonary dysplasia, which requires a sustained need for supplemental oxygen at 36 weeks gestation or 28 days after birth.

REDACTED's lung disease is not typical of bronchopulmonary dysplasia. From shortly after birth she had no consistent need for supplemental oxygen, rather she had intermittent desaturations which appear related to gastrooesophageal reflux and bulbar dysfunction with resultant aspiration and airway irritation from refluxed stomach contents and mismanaged oral secretions. I have reviewed chest radiology from 5th May 2018 to 1st July 2019, and in my view this is not typical of bronchopulmonary dysplasia; I am not a paediatric radiologist but it is within the remit of my professional role as a paediatric respiratory physician to interpret such images and I am competent and confident to do so. Furthermore, it is my view that radiologist interpretation of the images would not materially alter my report as the opinion offered does not hinge on the interpretation of these images.

REDACTED experienced frequent chest infections in early life with an associated tendency to wheezing, and these may result from the triggers previously stated, on a background of low birth weight, low amniotic fluid volume, and intrauterine growth restriction, all of which hinder lung development, resulting in relatively low calibre airways.

REDACTED is currently under follow-up by Professor REDACTED, an experienced and competent respiratory paediatrician. She no longer performs chest physiotherapy but remains on antisialogogue and antireflux medications. She receives a combination inhaled steroid-bronchodilator to protect against the aforementioned wheezing tendency, a prophylactic antibiotic to protect against infection in the winter months and receives the seasonal flu vaccine[2]. She uses her salbutamol inhaler during

[1] It is not uncommon for children with respiratory vulnerabilities to require *short-term* respiratory support during acute illness (as REDACTED did on: 3-10th January, 27th January-19th March, 25-30th March 2018), this does not influence the diagnosis of bronchopulmonary dysplasia.

[2] REDACTEDand REDACTED refused this this year.

colds, but has had no additional antibiotics, oral steroids, or emergency department visits in the preceding 12 months[3].

Opinion on Causation

It is not clear that REDACTED received high levels of oxygen during the episode dated 2nd REDACTED 2017. It is accepted by both parties that REDACTED inappropriately received 10-11 hours of 100% inspired oxygen on the night of 26th BIRTH MONTH REDACTED.

On the balance of probabilities I do not believe that either incident led to meaningful respiratory injury.

Evidence supporting a causative role for the hyperoxic episode

Bronchopulmonary dysplasia occurs when the immature lungs of preterm babies are exposed to prolonged, high level invasive ventilation coupled with high concentrations of oxygen and is mediated at least in part by highly reactive oxygen free radicals. There is no consensus or reliable evidence on the minimum duration of exposure that leads to sustained harm in preterm babies, but data suggests that resuscitation with 100% oxygen rather than room air (a relatively short duration exposure) is associated with lung damage and even reduced survival(7); adult diving medicine employs a theoretical Unit of Pulmonary Toxicity Dosage (UPTD) to predict the extent of pulmonary damage with complicated and prolonged therapy whereby one minute of 100% oxygen at 1 atmosphere is taken to produce 1 UPTD, and a UPTD of 1425 will produce a 10% reduction in the vital capacity(8).

REDACTED had a number of risk factors for development of bronchopulmonary dysplasia:

- As a twin-twin transfusion syndrome donor REDACTED experienced intrauterine growth restriction which predisposes to bronchopulmonary dysplasia(9).
- REDACTED's oligohydramnios would have hindered pulmonary development, increasing her vulnerability to bronchopulmonary dysplasia.
- REDACTED did not receive artificial surfactant (which can reduce the requirement for ventilator support) at delivery, and this omission may have increased her risk of bronchopulmonary dysplasia.

[3] As of 12th December 2021, as per Mrs REDACTED.

Evidence supporting alternative causation

If the hyperoxic incident caused injury to REDACTED it would be expected to be manifest as retinopathy of prematurity or bronchopulmonary dysplasia (amongst other manifestations of oxygen toxicity in the preterm newborn)(10). The former was demonstrably not present, suggesting that the inappropriate oxygen exposure was insufficient to cause at least one recognised consequence. The latter would usually manifest in an early need for invasive ventilation or non-invasive positive pressure airway support such as CPAP, as well as a baseline flow rate of supplemental oxygen. REDACTED did not require invasive ventilation and was placed on CPAP in air almost immediately after birth, before being weaned to (the lesser support of) HHFNC also in room air. This suggests that her lungs were sufficiently healthy to support adequate gas exchange, which is not typically the case in bronchopulmonary dysplasia. REDACTED developed a sustained oxygen requirement at 5 ½ months of age, at a stage post-partum when her lungs should have been improving from any bronchopulmonary dysplasia caused by ventilator injury or oxygen toxicity. It is notable that this followed an episode of pulmonary infection, an event that seems a more likely trigger for oxygen requirement than does bronchopulmonary dysplasia in this context.

It is my opinion that the primary drivers for REDACTED's respiratory vulnerability (manifest initially as oxygen desaturation and apnoeic and bradycardic episodes, and subsequently as frequent respiratory infections and oxygen requirement) are a combination of adverse neurological status allied to (and exacerbated by) prematurity with intrauterine growth restriction.

That is not to say that oxygen toxicity did not play a part, rather that it is impossible to quantify the extent to which the exposures in question contributed, and that on the balance of probabilities other factors were more important. Reviewing her history REDACTED has demonstrable neurological compromise, most likely due to her intrauterine growth restriction, and manifest as:

- Bulbar dysfunction - which means she does not manage her upper airway secretions and is prone to aspirate them into her lungs causing infection.
- Immature respiratory drive – which means she is prone to apnoeic episodes with associated desaturation.

REDACTED was treated for symptomatic gastrooesophageal reflux. This is not technically a sign of neurological compromise but is more common in neurologically compromised and also in preterm infants. Reflux events can stimulate bradycardic and apnoeic episodes, and can further lead to wheeze and chest infection through pulmonary aspiration of lung contents. In my view the chest x-rays made available show changes consistent with aspiration and infection.

Unrelated to bronchopulmonary dysplasia but relevant to her later respiratory illness, REDACTED had low birth weight, and this can predispose to wheezing and lower respiratory tract infection due to lower airway calibre.

Medical Negligence

This question is separate to the issue of causation of any pulmonary illness. It is recognised that sustained exposure to extreme oxygen concentrations is particularly harmful to preterm newborns. The neonatal team would reasonably be expected to take steps to minimise such exposure, and therefore to permit at least one but likely two episodes of prolonged unnecessary hyperoxia in a vulnerable preterm infant represents a standard of care that falls below that which would reasonably be expected. This assertion does not alter the stated view on the causation of any respiratory harms sustained by REDACTED.

Declaration and Statement of Truth

Protocol declaration

I understand that my duty is to help the court on matters within my expertise and that this duty overrides any obligation to the person from whom I have received instructions or by whom I am paid. I have stated the substance of all material instructions, whether written or oral, on the basis of which the report is written. My evidence is my independent product, uninfluenced by the pressures of litigation. The opinions I have expressed are objective, unbiased and based on matters within my own expertise and I have not adopted the role of an advocate for the party instructing me. I have made clear if a question or issue falls outside my area of expertise. I have considered whether there is any conflict of interest and declared any potential conflict identified. I have given details of any literature or other material relied on in making the report. I have set out the substance of all facts which are material to the opinion expressed in this report or upon which my opinions are based. I have made clear which of the facts stated in the report are within my own knowledge. I have said when there is a range of opinion on a relevant issue and summarised the range of opinions and I have formed my own independent view as to the appropriate point in that range applicable to this case and given reasons for that view.

Statement of truth

I confirm that I have made clear which facts and matters referred to in this report are within my own knowledge and which are not. Those that are within my own knowledge I confirm to be true. The opinions I have expressed represent my true and complete professional opinions on the matters to which they refer. I understand that proceedings for contempt of court may be brought against anyone who makes, or causes to be made, a false statement in a document verified by a statement of truth without an honest belief in its truth.

Signed: Chinedu Nwokoro Digitally signed by Chinedu Nwokoro Date: 2022.04.13 00:09:00 +01'00' Dr Chinedu Nwokoro January 2022

Glossary

470	**Ambulatory EEG**	A study whereby electrical brain activity is recorded throughout the day and night over a period of one or more days.
	Antireflux medication	Medicine to treat gastrooesophageal reflux by reducing acid production, neutralising acid or increasing gastric motility.
	Antisialogogue	A compound that acts to reduce production of saliva.
	Apgar score	A composite measure of physical condition at birth scoring infants 0, 1 or 2 at 1, 5, and 10 minutes in 5 domains (colour, heart rate, irritability, respiratory effort, tone).
	Apnoeic episode	An apnoea is defined as a pause in breathing for 20 seconds or longer or a shorter pause accompanied by bradycardia, cyanosis, or pallor.
480	**Aspiration**	The phenomenon whereby liquid or solid material such as food, vomit or saliva is introduced into the lower respiratory tract, usually causing respiratory symptoms, often caused by gastrooesophageal reflux, bulbar dysfunction, or abnormal anatomical connection between the intestinal and respiratory tracts.
	BAHA band	A bone anchored hearing aid (BAHA) is like other hearing aids, but instead of being inserted into the ear canal or held behind the ear, it is attached to a soft band worn on the head or fixed to a metal implant inserted into the skull.
	Barium swallow	Radiological imaging investigation outlining the upper gastrointestinal tract with radio-opaque contrast.
490	**Bradycardia**	A fall in heart rate below normal levels for age. In newborn infants this is usually less than 100 beats per minute, and typically follows desaturation, but may also reflect infection, pain, vagus nerve activity, cardiac rhythm anomaly, thyroid disease and drug effects.
	Breech lie	The state in which the orientation of a foetus in the womb is with the lower limbs nearest to the cervix, while the head is adjacent to the uterine fundus; may be associated with hip problems.
	Bronchiolitis	A viral infection of the small airways of the lungs common in infant children. Symptoms can range from asymptomatic to intensive care admission.

Bronchopulmonary dysplasia

Also known as chronic lung disease of prematurity, a condition whereby preterm babies require supplemental oxygen beyond 36 weeks completed gestation, due to a combination of lung immaturity and injury to the developing lung from positive pressure ventilation and longterm exposure to high oxygen concentrations.

Bulbar dysfunction Impaired function of the muscles innervated by the 9-12th cranial nerves (those that emerge from the bulblike medulla oblongata of the brainstem) leading to defective swallow, gag, speech and tongue movement.

Chronic lung disease of prematurity

See bronchopulmonary dysplasia.

Combination inhaled steroid-bronchodilator

Preventer treatment prescribed to treat symptoms of asthma and wheezing.

Continuous Positive Airway Pressure (CPAP)

A form of positive airway pressure (PAP) ventilation in which a constant level of pressure greater than atmospheric pressure is continuously applied to the upper respiratory tract of a person.

Desaturation A drop in the level of blood oxygen saturation below normal physiological levels.

Electroencephalogram (EEG) a study of the electrical activity of the brain.

Fine Nasal Endoscopy Fibreoptic visual inspection of the nasal and upper airway.

Gastrooesophageal reflux

The retrograde passage of stomach contents into the oesophagus and beyond via a lax or otherwise dysfunctional lower oesophageal sphincter.

Humidified high flow nasal cannula (HHFNC)

A mode of respiratory support providing a variable concentration of oxygen at a higher flow rate than is tolerable with conventional oxygen therapy by means of warming and humidification.

Hyperoxia Occurs when cells, tissues and organs are exposed to an excess supply of oxygen (O_2) and can cause tissue damage from exposure to reactive oxygen species/free radicals.

Intermittent positive pressure ventilation

A method of assisting pulmonary ventilation, using a device that inflates the lungs under positive pressure. Exhalation is usually passive. Lung inflation is achieved using a hand-operated device, or a mechanical ventilator for longer term support.

Intrauterine growth restriction (IUGR)

Describes poor growth of a foetus while in the womb during pregnancy. IUGR is defined by clinical features of malnutrition and evidence of reduced growth regardless of an infant's birth weight percentile.

Karyotype The number, complement and arrangement of chromosomes.

Monochorionic-diamniotic twins

(Usually) identical twins that share a placenta (compare dichorionic twins each with their own placental blood supply) but inhabit discrete amniotic sacs in utero.

pH-Impedance study An investigation measuring acid and electrical impedance in the oesophagus as a marker of gastrooesophageal reflux.

Oligohydramnios The state of pregnancy in which there are low levels of amniotic fluid surrounding the foetus, with consequent underdevelopment of the foetal lung.

Oxygen saturation The percentage of the circulating blood haemoglobin that is saturated with oxygen.

Nasogastric feeding Feeding via tube passed through the nostril into the stomach to reduce the effort of breathing and reduce the risk of aspiration of intestinal contents into the lungs.

Nasojejunal feeding Feeding via a tube passed through the nostril, via the stomach to the small intestine, usually as a treatment for gastrooesophageal reflux.

Posseting The regurgitation of small quantities of undigested milk following a feed.

Post-partum Describing a period or event occurring after delivery of a baby (parturition).

Preterm Birth occurring before 37 weeks completed gestation.

Pulse oximeter A monitor that reads signals from a probe affixed to the skin and converts these to oxygen saturation readings.

Respiratory distress syndrome

A syndrome whereby preterm infants with insufficient surfactant manifest increased respiratory effort and low oxygen saturations and require respiratory support.

Retinopathy of prematurity

A condition in which preterm newborn babies sustain damage to the posterior wall of the eye. Risk factors include low birth weight, hyperoxia and extreme prematurity.

Salbutamol inhaler Most commonly used medication for symptomatic relief of asthma or wheeze.

Surfactant A surface-active complex of phospholipids and proteins formed by type II alveolar cells that serves to reduce surface tension in the lungs and reduce the effort required for breathing. It is produced late in foetal development and its deficiency in early preterm birth contributes to respiratory distress syndrome and chronic lung disease in preterm infants. Synthetic and animal-derived surfactants administered to the lungs at or shortly after birth have dramatically improved pulmonary outcomes and survival in preterm babies since their development.

Trisomy X The presence in a bodily tissue of 3 copies of the X chromosome in the cell nucleus.

Tubeoesophagram A radiological technique for obtaining a detailed double-contrast examination of the oesophagus.

Twin-twin transfusion syndrome

Condition in which twin foetuses share a placental blood supply and one foetus receives the majority of the blood flow at the expense of the other, conferring a risk of death or disability to one or both twins.

References

1. Chiswick M. Assessing outcomes in twin-twin transfusion syndrome. Arch Dis Child - Fetal Neonatal Ed. 2000 Nov 1;83(3):F165–7.

2. Hessami K, Nassr AA, Sananès N, Castillo J, Castillo HA, Sanz Cortes M, et al. Perinatal risk factors of neurodevelopmental impairment after fetoscopic laser photocoagulation for twin–twin transfusion syndrome: systematic review and meta-analysis. Ultrasound Obstet Gynecol. 2021 Nov 1;58(5):658–68.

3. Sananès N, Gabriele V, Weingertner AS, Ruano R, Sanz-Cortes M, Gaudineau A, et al. Evaluation of long-term neurodevelopment in twin–twin transfusion syndrome after laser therapy. Prenat Diagn. 2016 Dec 1;36(12):1139–45.

4. Graeve P, Banek C, Stegmann-Woessner G, Maschke C, Hecher K, Bartmann P. Neurodevelopmental outcome at 6 years of age after intrauterine laser therapy for twin-twin transfusion syndrome. Vol. 101, Acta Paediatrica, International Journal of Paediatrics. 2012. p. 1200–5.

5. NICE. Specialist neonatal respiratory care for babies born preterm - Evidence reviews for respiratory support. Nurs Child Young People. 2019;31(3):11–11.

6. NICE. Specialist neonatal respiratory care for babies born preterm. Nurs Child Young People. 2019;31(3):11–11.

7. Gitto E, Pellegrino S, D'Arrigo S, Barberi I, Reiter RJ. Oxidative stress in resuscitation and in ventilation of newborns. Vol. 34, European Respiratory Journal. European Respiratory Society; 2009. p. 1461–9.

8. Chawla A, Lavania AK. Oxygen toxicity. Med J Armed Forces India. 2001;57(2):131–3.

9. Frank L, Lewis PL, Garcia-Pons T. Intrauterine growth-retarded rat pups show increased susceptibility to pulmonary O2 toxicity. Pediatr Res. 1985;19(3):281–6.

10. Saugstad OD. Oxygen radical disease in neonatology. Semin Neonatol. 1998 Aug 1;3(3):229–38.