Fleming, P., Blair, P., & Pease, A. (2017). Why or how does the prone sleep position increase the risk of unexpected and unexplained infant death? *Archives of Disease in Childhood: Fetal and Neonatal Edition*.
<https://doi.org/10.1136/archdischild-2017-313331>

Peer reviewed version

Link to published version (if available):
[10.1136/archdischild-2017-313331](https://doi.org/10.1136/archdischild-2017-313331)

[Link to publication record in Explore Bristol Research](#)
PDF-document

This is the author accepted manuscript (AAM). The final published version (version of record) is available online via BMJ at <http://fn.bmj.com/content/102/6/F472>. Please refer to any applicable terms of use of the publisher

University of Bristol - Explore Bristol Research

General rights

This document is made available in accordance with publisher policies. Please cite only the published version using the reference above. Full terms of use are available:
<http://www.bristol.ac.uk/red/research-policy/pure/user-guides/ebr-terms/>

Why or how does the prone sleep position increase the risk of unexpected and unexplained infant death?

Peter Fleming, Peter Blair and Anna Pease.

For more than 25 years we have known that infants placed prone for sleep are at increased risk of dying unexpectedly, and avoiding the prone sleep position for infants leads to a much lower incidence of such deaths^{1,2}. What is less clear, despite many published investigations into the physiology and possible pathophysiology of sleep position in infants, is why this is the case.

Multiple hypotheses of varying credibility have been proposed to account for the association between infants sleeping prone and increased risk of unexpected deaths^{3,4}, but no single clear pathophysiological mechanism has yet been identified to fully explain the link between observed physiology and the pathway leading to death. Physiological studies to date suggest the possibility of multiple, probably interacting mechanisms making infants more vulnerable in the prone sleep position.

Several physiological features of the prone sleeping position in infants have been identified:

- The arousal threshold is higher and the ratio of sub-cortical to cortical arousals is lower when prone than when supine⁵
- Heat loss is reduced when prone compared to when supine⁶
- In growing preterm infants, the ventilatory response to inhaled carbon dioxide is lower when prone than when supine⁷
- Baroreflex sensitivity as assessed by the response to an imposed 15° head-up tilt is lower when prone than supine⁸
- Blood pressure is lower and heart rate higher when prone than when supine⁹
- Brain tissue oxygenation index (a measure of mean oxygen tension in brain tissue) is lower when prone than when supine between the ages of 2 weeks and 6 months¹⁰
- Whilst the prone sleeping position has been reported to be associated with higher parasympathetic and the supine with higher sympathetic activity¹¹, non-parametric frequency domain analysis (which can usually identify characteristic differences between sympathetic and parasympathetic activity) showed no differences between prone and supine position in newborn infants though such differences were present by one month of age¹².

To these may now be added the observations of Wu et al (*add reference*) showing that, in the first few days after birth, in healthy term infants when prone compared to supine, cardiac output fell, mainly because of reduced stroke volume, but there was no significant change in cerebral oxygenation at this age. This implies that cerebral blood flow has been maintained despite a fall in cardiac output in the prone position, a finding consistent with the previous observation by the same authors of a fall in skin blood flow when prone¹³. The infant's head position may also be important in this context, as turning the head 90° to one side (as is commonly observed in the prone position) leads to reduced jugular venous return and thus may contribute to reduced cardiac stroke volume¹⁴.

It is not clear whether the apparent differences in cardiovascular responses at different ages reported by different authors are real or may be explained by differences in duration of studies and / or differences in sleep state at different ages.

It is however clear that, in the prone position compared to the supine there are numerous differences in the control of cardiovascular, respiratory and thermoregulatory systems in normal infants, and a variety of potential external stressors may thus produce different physiological responses depending on the infant's position.

For example, the higher nasal airway temperature in the prone position may promote growth of vasoactive toxin-producing staphylococci, leading to a profound fall in blood pressure and thus cerebral perfusion. Several studies have shown that such bacteria are present in a higher proportion of infants who die unexpectedly than in control infants¹⁵. Physiological recordings obtained from infants at the time of unobserved and unexplained sudden deaths are compatible with the effects of the primary event being profound hypoxia possibly due to a fall in blood pressure¹⁶.

As our understanding of normal infant developmental physiology improves it may become possible to identify specific pathophysiological pathways and thus directly intervene to minimise the potential for harm, but for the present it is important to emphasise the importance of avoiding the prone sleeping position and encouraging the supine position for all infants for every sleep.

In recent years, we have become aware of devices marketed to “improve” infant sleep, or reduce the perceived risk of head asymmetry. Some of these devices involve placing the baby prone when awake and unsettled in order to facilitate settling the infant to sleep. The risk posed to infants from the use of such devices if they fall asleep in this position is likely to be significant, a message that health professionals should convey to parents.

We have become aware from recent discussions with numerous families, including some recently bereaved families whose infants have died suddenly and unexpectedly that there is a widespread belief that, if they use a “breathing” monitor (more accurately a baby movement sensor) their baby will be protected from the risk of unexpected death, and thus placing their baby to sleep in the prone position is acceptable.

Despite multiple studies investigating the potential benefits from baby breathing monitors there is no evidence that the use of apnoea monitors (or other types of monitor) has any effect in reducing the risk of unexpected infant death¹⁷.

Certainly, the use of a monitor does not reduce the risk of placing infants in side or front sleeping positions. The provision or sale of such monitors for “*parental reassurance*” is thus potentially misleading.

The observations reported of babies who have died unexpectedly whilst on physiological monitors have shown that in most such events cessation of breathing was not the primary event but occurred at the end of period of cardiovascular compromise¹⁶. Thus a breathing monitor would almost certainly be of no value in such an episode.

Understanding why ‘back is best’ provides parents with the knowledge and the confidence they need to make decisions about their baby’s sleeping position. As healthcare professionals, it is thus important that we seek to ensure that parents receive accurate, up to date information on the

background to safe infant care practices, and to continue to emphasise the importance of the supine sleep position for every sleep for every baby.

References.

1. Fleming PJ, Gilbert RE, Azaz Y, Berry PJ, Rudd PT, Stewart A, Hall E. The interaction between bedding and sleeping position in sudden infant death syndrome: A population-based case-control study. *B.M.J.* 1990;301:85-89
2. Wigfield RE, Fleming PJ, Berry PJ, Rudd PT, Golding J. Can the fall in Avon's sudden infant death rate be explained by the observed sleeping position changes? *B.M.J.* 1992;304:282-283
3. Fleming PJ, Blair PS, Pease A. Sudden Unexpected Death in Infancy: Aetiology, Pathophysiology, Epidemiology and prevention in 2015. *Arch Dis. Childhood.* 2015;100:984-988.
4. Galland BC, Taylor BJ, Bolton DPG. Prone versus supine sleep position: A review of the physiological studies in SIDS research. *J. Paed. Child Health* 2002;38:332-338
5. Richardson HL, Walker AM, Horne RSC. Sleep position alters arousal processes maximally at the high-risk age for sudden infant death syndrome. *J. Sleep Research* 2008; 17: 450-457
6. Stothers JK, Warner RM. Thermal balance and sleep state in the newborn. *Early Human Development* 1984;9:313-322
7. Smith APR, Saiki T, Hannam S, Rafferty GF, Greenough A. The effects of sleeping position on ventilatory responses to carbon dioxide in premature infants. *Thorax* 2010; 65: 824-828.
8. Yiallourou SR, Sands SA, Walker AM, Horne RSC. Baroreflex Sensitivity During Sleep in Infants: Impact of Sleeping Position and Sleep State. *Sleep* 2011;34 : 725-732
9. Yiallourou SR, Walker AM, Horne RSC. Effects of sleeping position on development of infant cardiovascular control *Arch Dis Child* 2008;93:868-872
10. Wong FW, Witcombe NB, Yiallourou SR, Yorkston S, Dymowski AR, Krishnan L, walker AM, Horne RSC. Cerebral oxygenation is depressed during sleep in healthy term infants when they sleep prone. *Pediatrics* 2011; 127: e558 – e565.
11. Bergman NJ. Proposal for mechanisms of protection of supine sleep against sudden infant death syndrome: an integrated mechanism review. *Pediatric Research* 2015; 77: 10-19
12. Lucchini M, Fifer WP, Perez A, Signorini MG. Influence of sleep state and position on cardio-respiratory regulation in newborn babies. *Conf Proc IEEE Eng Med Biol Soc.* 2015;2015:302-5

13. Ma M, Noori S, Marek JM et al. Prone positioning decreases cardiac output and increases systemic vascular resistance in neonates. *J. Perinatol.* 2015;35: 424-427.
14. Cowan F, Thoresen M. Changes in superior sagittal sinus blood velocities due to postural alterations and pressure on the head of the newborn infant. *Pediatrics* 1985; 75: 1038 – 1047.
15. Blackwell C, Moscovis S, Hall S, Burns C, Scott RJ. Exploring the risk factors for sudden infant deaths and their role in inflammatory responses to infection. *Front Immunol.* 2015 Mar 5;6:44. doi: 10.3389/fimmu.2015.00044. eCollection 2015.
16. Poets CF, Meny RG, Chobanian MR, Bonofiglio RE. Gasping and Other Cardiorespiratory Patterns during Sudden Infant Deaths *Pediatric Research* (1999) 45, 350–354
17. AAP Policy Statement. Apnea, Sudden Infant Death Syndrome, and Home Monitoring. *Pediatrics.* 2003; 111: 914-917