Neuroscience speaks to quality of neonatal outcomes

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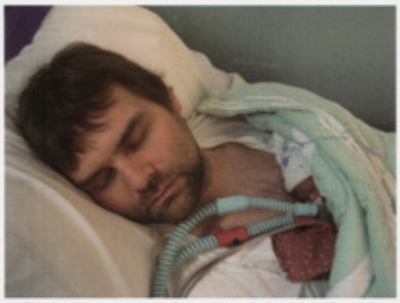
The last twenty years has seen an explosion of knowledge in neuroscience.[1] The bottom line is that the fetal and neonatal brain does not only have cardio-respiratory and metabolic needs, but is an active agent in its own neurodevelopment.[2] This is contrary to old assumptions on preterm care, which was based on a belief that the human brain was too immature at that age, and as long as the heart, lungs and stomach were working, then the brain would be fine.

The incubator was invented 100 years ago and "active management" of low birth weight infants started about 50 years ago.[3] This care assumed the incubator was the only possible PLACE such care could be given. The care was focused on improving survival, and we now have amazing survival rates, even at 24 weeks gestation.[4,5] However, these survivors have physical and psychological problems, the more so the lower the gestation.[6] In fact, we now know that even late preterm infants perform poorly when they start school,[7] and economically cost more to support[8] (there are more of them!). For the last twenty years these outcomes have not improved.[9,10] Without a proper understanding of the latest neuroscience, our care will continue its success with respect to **quantity of survival,** but without achieving any **quality of survival.**

The fetal brain development with respect to its anatomy is complete at 20 weeks, at 23 weeks the fetus is conscious and aware, and all its basic connections are complete at 28 weeks.[2] Development requires collecting sensory information about the world, this fires and wires pathways[11] that mould the brain to be suited or adjusted to that world (called adaptation).[12,13] The sensations in the uterus are pressure contact, movement, mother's sounds and smell, and all these provide a sense of safety and wellbeing. Good sensations provide a strong platform for higher level development.[14,15] Bad sensations and experiences fire and reinforce more lower level defensive pathways, (read "stress") and can delay or even abolish, the firing of higher level circuits.[15] The circuits affected most by stress are the ones that are "plastic", the ones that are in development at the specific time of the stress.[16] A second consequence of stress is that coping mechanisms are overused in achieving homeostasis, and this results in "wear and tear" on basic neural pathways and endocrine systems.[13] The result is "vulnerability", so that future stresses and "knocks in life" trigger pathway and system failures that show themselves in a variety of physiological and behavioural problems in later life.[17,18]



Skin-to-skin contact with father, Uppsala Academic Hospital, Sweden. Infant is 25 weeks gestation, 520 grams, on TP and CPAP

One of the most basic abilities, and that appears early in development, is to determine whether a sensation (or even constellation of such) is **safe** or **dangerous** or **life-threatening**.[19] This is seen in early fetal life and is fully competent from 28 weeks. The normal uterine sensations tell the fetus it is SAFE. Vaginal birth is highly stressful, and this birthing stress is necessary to activate the systems that make for breathing air and coping with "life outside".[20,21] But once outside, the need for being SAFE is primary, and essentially it is only mother's presence, providing sensations that are familiar, that achieve this. The chest of the mother is to the newborn its SAFE PLACE of care.[22] SAFE care means providing the three basic biological needs and mother skin-to-skin contact as PLACE of care ensures **warmth**, her breasts provide **nutrition**, and her arms cover baby for **protection**.[12] The baby is wired by highly conserved neuroendocrine responses[23] inherited in our evolutionary biology to respond to this PLACE in many different ways. At birth, the first and most urgent response we call self-attachment and breastfeeding.[24,25] After feeding, undisturbed sleep cycling is essential to establish the pathways that were fired.[1,26] Smell (and probably also mother's movements) support the newborn brain in maintaining quality sleep.[27] This sense of being safe activates the amygdala, the emotional processing unit of the brain, which connects to the frontal lobe, which controls **approach** and **avoid choices**.[2,28,29] When the brain develops in an environment that it perceives as safe, social approach is fired, and a secure attachment is formed.[2,30]

When mother is absent, the newborn brain feels unsafe, its basic needs are not provided. Mother's absence is perceived not just as unsafe but as life-threatening.[31] The amygdala tells the frontal lobe to avoid, to evade, to hide. The baby might make a short burst of crying, but the brain is likely to activate a powerful parasympathetic defence reaction, similar to that of frogs and reptiles.[31,32] This is an immobilisation defence that reduces all activity, lowering heart rate and temperature, with active suppression of movements. This looks like sleep, but is not! Careful observation over 10 minutes will reveal eye and facial twitches and whole body movements. This state is maintained by high levels of cortisol, which is a key ingredient in the "wear and tear" described above.[13] High cortisol disrupts brain architecture and healthy sleep, so neural behaviour pathways are not fired.[15] If this is reinforced in other ways, an insecure attachment is the likely result.

The brain is coded with a desperate need to feel safe, the more confusing the "safe versus unsafe" messages are to the child, the more disordered the attachment.[33,34] Birth is a highly sensitive period, how babies experience birth matters!

The human sympathetic system only matures at 2 months of age. It is however present before birth, and human infants actually need to experience some stress to develop properly.

STRESS	DEGREE	CONTEXT	RESULT
Positive stress	moderate and short-lived	stable and supportive relationships	necessary aspect of healthy development
Tolerable stress	severe but time limited	buffered by supportive relationships	brain can recover; facilitates adaptive coping
Toxic stress	severe or prolonged	in ABSENCE of buffering protection of adult support	disrupts brain architecture; stress systems respond at lower thresholds

The above table is derived from work by Shonkoff and others[35] and "absence of buffering protection of adult support" is in my own mind, a key phrase to understanding neurodevelopment. The currently accepted standard of optimal childhood development is measured by "secure attachment", this

as described by Bowlby and measured by Ainsworth.[30] A secure attachment in infancy is widely accepted as an essential aspect of future psychological health. The gold standard for measuring this is however only valid at about one year of age. Understanding the underlying neurobiology can make a difference to how the attachment is shaped before that. Infants that do not have their needs met – as expected by the genes of their evolutionary biology – may develop disordered attachments described as avoidant or ambivalent or disorganised.[30] This is succinctly described by Salk:

"There's no harm in a child crying: the harm is done only if his cries aren't answered. If you ignore a baby's signal for help, you don't teach him independence, what you teach him is that no other human being will take care of his needs."

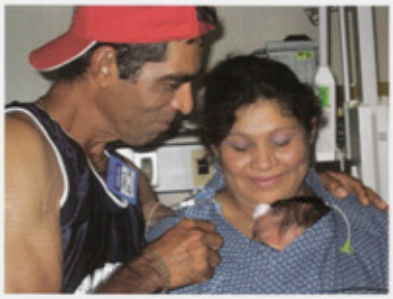
(Dr Lee Salk, child psychologist)

This new understanding of the brain and its development can profoundly improve neonatal care. Mother's presence is an absolute requirement for OPTIMAL development. The focus of this is not survival, but emotional (amygdala) and social intelligence (frontal lobe, also called executive function), these being central to the sensitive circuits developing around birth. But this emotional and social development builds on a biological perception of safety, the warmth, nutrition and protection provided by mother's chest.

The well-known intervention popularly called Kangaroo Care (KC) can be shown to make significant benefit in terms of thermoregulation, cardio-respiratory function and metabolism.[36-38] However benefit is only evident if practised for more than one hour, corresponding to the sleep cycle required to consolidate neural circuitry. But KC fails primarily because separation is the culturally accepted default, the incubator is biologically an unsafe PLACE. Kangaroo Mother Care (KMC) is something different, being a total care strategy defined by the WHO.[38,39] There are several components, starting with "continuous or prolonged maternal-infant skin-to-skin contact" (supplemented by father or other attachment figure). Other components include breastfeeding, and early discharge.[39] KMC also fails in that current clinical evidence is not seen as requiring that this skin-to-skin contact must start at birth.

The scientific rationale here presented is founded on "maternal-infant skin-to-skin contact" from birth. Its antithesis is "separation"; in mammalian neuroscience "separation tolerance" is measured in minutes.[40,41] Current best practice already includes SSC for all newborns in the first hour of life, until the baby has had its first latch on the breast.[42] Current care then separates baby for baths and care routines, none of that separation has any evidence base[43]

It is however in the context of **prematurity** that this neuroscience is critically important. The preterm infant is the least resilient, and the most in need of support of its basic biology. Premature infants have brains that are ready, but bodies that are not. They need technology, but this was not designed with the thought that mother should be the PLACE of care. Technology can adapt far more readily than the human brain, so ingenious solutions are usually required. Then, even with mother present, the sensations from the environment must not be intrusive or stressful, bright light and noise are the most common stressors[44-46] Our care routines should change in one key respect, which is to ensure the protecting of sleep cycles.[26] Maternal-infant skin-to-skin contact can be - and is being - provided from 23 weeks gestation onwards. Ideally this should be round the clock, for this both parents are needed. We often give lip service to the idea, but mother and father must be conceptually and physically central to the care team.



Mother and father must be central to the care team. 32 week gestation infant; Banner Desert Hospital, Phoenix, Arizona.

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