Serial Neuroimaging and Term-equivalent Age Neurodevelopmental Outcomes of Very Preterm Infants Receiving Tailored Neuropromotive Support in the NICU

Sriya Roychaudhuri[1], Danielle Sharon[1], Gabriel Cote Corriveau[1,2], Elizabeth Singh[1], Tina Steele[1], Yvonne Sheldon[1], Deborah Cuddyer[1], Patricia Flynn[1], Jessica Pacheco[1], Katherine Gibson[1], Elizabeth Kling,[1], Mohamed El-Dib[1,3], Roberta Pineda[4], Terrie Inder[1,3,5], Carmina Erdei[1,3]

1 Department of Pediatric Newborn Medicine, Brigham and Women's Hospital, Boston, MA, USA; 2 Department of Pediatrics, Sainte-Justine University Hospital, University of Montreal, Montreal, QC, Canada
3 Harvard Medical School, Boston, MA, USA; 4 Chan Division of Occupational Science and Occupational Therapy, University of Southern California, Los Angeles, CA, USA;
5 Division of Neonatology, Children's Hospital of Orange County and University of California, Irvine, Irvine, CA, USA

Background

- Infants born very preterm (VP) undergo rapid brain growth and development prior to term-equivalent age (TEA) while in the neonatal intensive care unit (NICU),[1] a critical window for intervention.
- Early MRI imaging, at 30-34w gestational age (GA), has the potential to identify infants with neurological injury and help tailor early neuropromotive interventions to optimize neurodevelopmental outcomes.
- The Supporting and Enhancing NICU Sensory Experiences (SENSE) program is a sensory-based care bundle with tailored weekly multisensory plans[2,3] intended to be implemented by parents with support from staff and developmental therapists.[4]
- Exploring relationships between rehabilitative strategies, such as SENSE[2,3,4], total and regional brain growth and short and long-term outcomes of preterm infants may uncover useful clinical information.

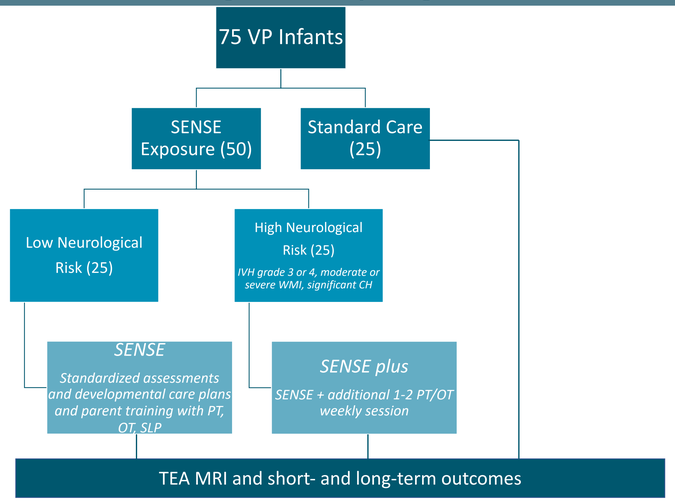
Objective

- Use early MRI to stratify VP infants into low-risk or high-risk groups based on degree of brain injury and tailor rehabilitative intervention according to risk category.

Methods

- Prospective cohort study aiming to enroll 75 infants born < 33 weeks GA.
- Infants assigned to the SENSE group are stratified into low- and high-risk groups based on early MRI and compared with a standard care group (Figure 1). Infants in the high-risk group receive an enhanced version with additional motor and other developmental therapy.
- Serial MRIs are obtained at least three times including TEA, along with routine cranial ultrasound (CUS) per unit guidelines.

Figure 1: Study design



IVH, intraventricular hemorrhage; WMI, therapist white matter Injury; CH, cerebellar hemorrhage; PT, Physical therapist; OT, occupational therapist; SLP, Speech and language pathologist

Results

- To date, 38 infants have been enrolled and completed the NICU stage of the study: 14 SENSE (9 low-risk and 7 high-risk) and 22 standard care (13 low-risk and 9 high-risk). Data collection is ongoing.
- Implementation and tailoring of the neuropromotive SENSE exposure was feasible (Table 1).
- Infants underwent neurodevelopmental assessments at TEA (TIMP and HNNE) per Table 2.
- 110 MRI scans have been completed; 42 were early (30-34 weeks GA), 31 were at an interim time point (34-36 weeks GA), and 37 were at TEA (37-42 weeks GA).
- Early MRI scans identified 11 high-risk infants while only 7 of these infants were identified as high-risk based on cranial ultrasound (CUS), primarily for improved WMI detection.

Figure 2: CUS versus early MRI findings



Figure 2A CUS: Normal appearing head ultrasound of a 30-week GA newborn at 7 days of life (DOL).

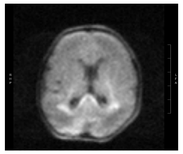


Figure 2A MRI: Diffusion weighted image of same newborn at 3 DOL showing areas of acute white matter injury with restricted diffusion.



Figure 2B CUS: Normal appearing head ultrasound of a 31-week GA newborn at 4 DOL.

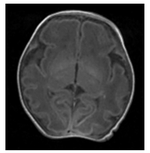
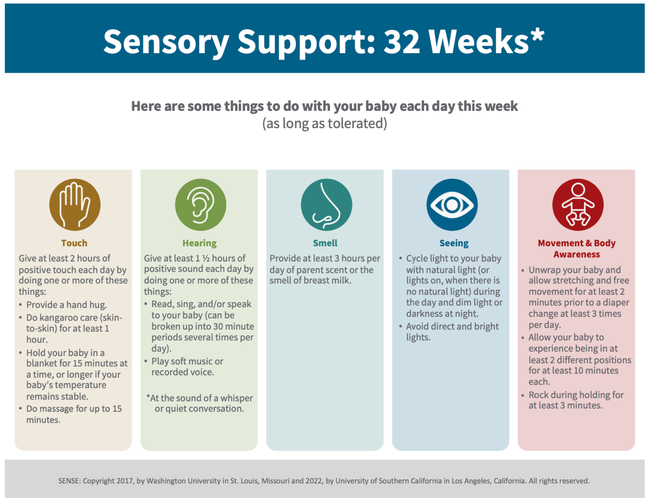


Figure 2B MRI: Axial T1 image of same baby at 15 DOL showing area of gliosis in left parietal lobe.

Figure 3: Sample of weekly SENSE Program[3]



Reproduced with permission

Table 1: Infant characteristics and SENSE exposure

	SENSE Exposure		Standard Care	
	Low risk (n=9)	High risk (n=7)	Low risk (n=13)	High risk (n=9)
Gestational age in week Mean (SD)	28.92 (1.76)	28.96 (3.08)	28.00 (2.62)	28.92 (2.74)
Birth weight in grams[a] Mean (SD)	1207.78 (294.44)	1351.43 (574.78)	1122.85 (364.43)	1288.22 (416.85)
Average # MRIs per infant	3.25	3.5	2.2	3.5
SENSE exposure implementation	>100% for hearing and touch	>100% for hearing and touch	--	--

Table 2: Short term outcomes

	SENSE Exposure		Standard Care	
	Low risk (n=9)	High risk (n=7)	Low risk (n=13)	High risk (n=9)
TIMP at TEA n(%) in each score category	Average 9(100)	Average 5(72) Low average 1(14) Below average 1(14)	Average 6(75) Low average 2(25)	Average 6(67) Low average 3(33)
HNNE at TEA Median (IQR)	32 (2)	32 (1)	33 (1)	28 (0)
Kidokoro score Median (IQR)	2 (4)	11 (3.5)	3.5 (3.25)	8 (6)

Implications and Next Steps

Our preliminary results show that early and serial brain MRI could offer valuable information for detecting and classifying brain injury in the preterm population. This can be implemented to guide neuropromotive experiences in the NICU, such as the SENSE program[3,4], during a critical period of brain development prior to term age.

References

1. Pineda, Smith, J., Roussin, J., Wallendorf, M., Kellner, P., & Colditz, G. (2021). Randomized clinical trial investigating the effect of consistent, developmentally-appropriate, and evidence-based multisensory exposures in the NICU. Journal of Perinatology, 41(10), 2449–2462.
2. Pineda, R & Smith, J. (2017) [Parent Education PPT] Washington University in St. Louis, Missouri. Retrieved from https://chan.usc.edu/research/clinical-tools/sense/content
3. Pineda, R & Smith, J. (2017) [USC-SENSE Week-By-Week Guide] Washington University in St. Louis, Missouri. Retrieved from https://chan.usc.edu/research/clinical-tools/sense/content
4. Pineda, R, Wallendorf, M, & Smith, J. 2020. A pilot study demonstrating the impact of the supporting and enhancing NICU sensory experiences (SENSE) program on the mother and infant. Early Human Development. 144: 1-8.