INDIAN JOURNAL OF PRACTICAL PEDIATRICS

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DEVELOPMENTAL PEDIATRICS

DEVELOPMENTALLY SUPPORTIVE CARE IN THE NURSERY

**** Chitra Sankar***

Abstract: *Developmentally supportive care is an approach that involves the use of a range of medical and nursing interventions in the NICU to decrease the stress of the preterm infant. Behavioral signs of stress first described by Heidi Als provide a framework for observation of preterm stress responses. Reduction of noise, cycling of light, avoidance of bright and harsh lights are environmental modifications to reduce stress. Flexed positioning, cluster care, postural supports, Kangaroo mother care, non-nutritive sucking, oromotor stimulation and massage are other developmentally supportive care practices widely employed. Developmental care helps the infant to self regulate own behaviour and allows longer periods of rest and sleep. Short term benefits like better physiologic stability, behavioural organization, improved weight gain and shorter length of stay have been observed in infants receiving developmentally supportive care. More research is required to evaluate the long term neurodevelopmental benefits of developmental care practices.*

Keywords: *Developmentally supportive care, Kangaroo mother care, Non-nutritive sucking, Preterm infant massage, Noise and light in NICU.*

* Consultant Developmental Pediatrician, Manipal Hospital, Bangalore.

Developmentally supportive care has been widely accepted as standard practice of care in most neonatal intensive care units all over the world. The immature preterm infant experiences tremendous stress in the noisy, bright, chaotic and cold environment of the NICU. Developmentally supportive care is an approach that uses a range of medical and nursing interventions to decrease the stress of preterm infants in NICU. Specific simple interventions are carried out to modify and control the environment to promote neurobehavioral organization and support the normal development of the preterm infant.

The preterm infant being born at a critical period of brain development is not in a position to tolerate the NICU environment. The immature infant is subjected to a range of medical interventions like intubation, intravenous and arterial lines, suctioning, heel sticks, lumbar punctures, venepuncture, etc in order to be stabilized. There are other nursing interventions that continuously disturb the infant. The noxious NICU environment places a tremendous overload of sensory experiences and this results in persistent exposure to stress. The preterm babies therefore have to be taken care of in an environment conducive to their comfort, well - being and optimal development.

Preterm infant's signs of stress were first described by Heidi Als who studied preterm infant's behavioural cues. Preterm infant's behaviours are grouped into five subsytems of functioning as motor, autonomic, state, attention / interaction and self-regulatory.[1] In the preterm infant, these systems are not fully developed.

Table I. Signs of stress in preterm infant

Autonomic signs	Color changes, changes in heart rate, respiratory rate, blood pressure, visceral responses such as vomiting, gagging, hiccups, sneezing, yawning
Motor signs	Generalized hypotonia, finger splaying, hyperextension of extremities
State signs	Diffuse sleep states (twitching, grimacing, restlessness) Glassy-eyed (appears to be "tuning out") Gaze aversion, staring (a locked gaze, usually wide open eyes) Panicked look, irritability (hard to console)
Attention / interaction signs	Inability to integrate with other sensory input
Self regulatory behaviours	These are attempts to deal with stress and regain control. Change in position, hand-to-mouth, grasping, sucking, visual locking, hand clasping

Therefore preterm infants are unable to manage the environmental inputs and tolerate these poorly. Preterm infant's behaviour is characterized by disorganization and when the infant is unable to handle the sensory inputs, displays signs of stress. The signs of stress by subsystem are given in Table I. It is essential for all personnel handling and caring for preterm infants to be familiar with these signs of stress.

Noise in NICU

Environmental sources of stress are noise, brightness and light. Excessive levels of these interfere with the infant's comfort and sleep. Sources of noise are conversation in the NICU, noise from ventilator machines, bubbling in ventilator tubing, opening and closing of incubator doors, telephone ringing, monitor alarms and beeps. It has been found that the average noise level in the NICU ranges between 70 - 80 db while the noise levels desired for sleep is less than 35 db. Continuous exposure to high levels of noise has been found to have a deleterious effect with some studies documenting hearing loss in children cared for in the NICU. Several studies have reported that changes in heart rate, hypoxemia and apneic episodes occurred in infants in response to sudden loud noise of approximately 80db. High levels of noise significantly interfere with infants' sleep. The American Academy of Pediatrics (AAP) recommends maximum noise levels of 45 db in the NICU.[2,3] Ramesh, et al[4] have shown that simple cost effective measures are effective in controlling noise.

Measures have to be taken to monitor and reduce noise levels in the NICU. The following measures are recommended

1. Installation of decibel meters in the NICU.
2. Posters requesting silence may be put in the NICU and the corridors.
3. Alarms and beeps to be responded to promptly.
4. Use of rubber caps on furniture legs to minimize noise.
5. Replacement of metallic objects such as trays and folders by plastic substitutes.
6. Simple measures such as careful closing of incubator doors, soft shoes, avoidance of placing containers or writing on top of incubators, avoiding speaking in loud voices have to be implemented.

7. The volume of the alarms should be tuned down to a maximum of 55db and where possible visual mode option is to be used. Volume of phone ringer kept at minimum audible volume.
8. Staff awareness on deleterious effects of noise and training is a must. Holding discussions, classes in a separate room, avoidance of shouting across distances also reduce noise.
9. Use of sound absorbing materials for sound absorption such as thick padding aid noise control.

Light and brightness in the NICU

Most NICUs have bright lights through day and night. Spot lights for procedures and phototherapy units provide much higher illumination. Treatment lamps in the NICU average upto 350 foot candles (ftc) and bilirubin lights may be as high as 10,000 ftc. Appropriate and safe light levels in NICU have not been established. However, AAP guidelines recommend an illumination of 650 lux (luminous intensity) for observation and 2000 lux for procedures. Research into optimal lighting for preterm babies has shown that neither continuous dim lighting nor continuous bright lighting is beneficial. Especially for infants of 32 weeks of gestation and beyond, cycled lighting is better.[5]

Recommendations for light in NICU

1. Avoid direct light on infants except for procedures.
2. Light levels should be monitored through out the day.
3. Provide reduction in light by using incubator covers.
4. Eye shields are a must during phototherapy and other procedures.
5. Balance between adequate light for infant observations and the need to avoid excessive exposure of preterms to light sources.
6. Provide for day / night cycling with lower lights during night time hours.
7. Provide cycled lighting for infants with a minimum of 1-2 hours during the daytime.

Developmentally supportive care practices that are commonly accepted and practiced as beneficial to the preterm infant are kangaroo care, non-nutritive sucking, oromotor stimulation, positioning and nesting, cluster care and management of pain.

Kangaroo care

Originally started in South America as an inexpensive method for providing thermoregulatory care to premature infants, this practice has been widely accepted as a practice with benefits to both mother and infant. In Kangaroo care the infant is held skin to skin with the mother in a prone upright position between the mother's breasts. This posture supports the weak muscles of the infant's chest wall, allows the abdominal contents to shift downwards by gravity and improves ventilation thereby easing the work of breathing, decreases risk of reflux and aspiration. Maternal benefits noted include better bonding with improved parental infant attachment, reduction in maternal stress, increased maternal milk production, exclusive breast feeding, longer duration of breast feeding, positive impact on parenting process and affect and better adaptation to infant cues.[6]

The timing of initiation of KMC varies from soon after birth to several days later depending on the medical status of the preterm infant. KMC can be initiated in babies above 1800g birth weight if they are stable. In babies less than 1800g, it is better to wait until the baby has cardiorespiratory stability to initiate KMC.

The practice may be continued after discharge until the baby tolerates it or until 40 weeks postconceptional age. The duration of KMC should be at least one hour to minimize handling of the baby. Oxygen supplementation and IV fluids are not a contraindication to KMC if the infant is otherwise stable. KMC has positive physiological effects, behavioral effects such as reduced crying during KMC, increase in length and amount of sleep, and enhanced breast feeding and increased weight gain. A study into the positive influence of KMC on neurodevelopment indicates that babies who received KMC were socially more alert and Bailey scores at 6 months were higher in mental and motor domains compared to those who did not receive KMC.[7,8]

Touch and massage

A substantial body of research into the effects of massage has supported the use of massage as a regular practice of developmental care in NICU. The positive effects of massage include weight gain, improved sleep/wake states, decreased stress, early discharge from NICU, improved skin integrity, increased development of the sympathetic nervous system and enhanced parent-infant bonding. However, medically unstable, ventilated infants, infants with BPD and cardiac involvement have to be handled as gently as possible. Rough handling and massage in such infants may result in behavioral and physiologic disorganization and should be avoided. Touch and massage should always be accompanied by observation of infant cues of stress. Incorrect handling, stroking or massage may cause the infant to become irritable, tachycardic, tachypneic and may even increase oxygen requirement. It can disorganise the infant to such an extent that the infant can develop aversion to touch, hypoxia, intra-ventricular hemorrhage and sleep problems. Infant massage in a stimulating manner should not be carried out in unstable or fragile preterm babies. Infants between 24 weeks to 32 weeks may be given gentle touch such as hand grasping or 'supportive holding' with a hand on infant's head and feet or body. Physiologically stable infants around 32 weeks may be massaged as tolerated. Sleeping infants should not be disturbed for the sake of massage. It is important to be mindful of the infant's sleep - wake cycles. Only physiologically stable infants who are ready for discharge should be subjected to stimulating touch such as massage by parents. Parents should be taught the right way of massage and touch and to observe the behavioral cues and module the touch accordingly.

Cluster care

Grouping of care activities: for example activities such as blood sampling, x rays and head scans are grouped with basic care giving such as nappy change and feeding so that the preterm baby is not disturbed repeatedly. This provides infants longer periods of rest and promotes growth and development.

Non-nutritive sucking and oromotor stimulation

These measures are introduced around 32 - 34 weeks gestation and facilitate effective nutritional sucking. Non nutritive sucking (NNS) has been associated with improved weight gain, positive effect on strength and coordination of sucking process and reduced response to pain, significant decrease in length of stay in preterm infants receiving a NNS intervention, transition from tube to breastfeeds and better breast feeding performance.[8] No negative outcomes were reported in any of the studies.. Based on the available evidence, NNS in preterm infants would appear to have some clinical benefit. It does not appear to have any short-term negative effects.

Swaddling, containment, nesting and body flexion

Premature infants are generally hypotonic

and left unsupported for postural maintenance ie lie with straight arms and legs. Flexed, tucked in positioning helps the baby to organize himself and to be comfortable. Use of simple blanket rolls, proper positioning in a nest or a roll under the knees and along the sides help to achieve this. These measures promote longer periods of REM sleep, diminish stress, decrease crying and improve self regulation.[8] Preterm infants are also prone to develop positional plagiocephaly and dolicocephaly. Plagiocephaly is seen in infants who are positioned in supine positions for long time with head to one side and dolichocephalism heads due to prolonged positioning in prone. Developmentally supportive positioning should include strategies to prevent positional cranial deformities from occurring. While in intensive care, infants have to be placed in alternating positions, rotating the head from one side to the other; in the hospital nurses can support alternative midline positioning by using positioning devices (e.g., gels, wedges, blanket rolls, nesting or other means of containment) to support the head in the midline position and redistributing mechanical forces on the occiput.

Managing infant pain

Administration of oral sucrose via the anterior portion of the tongue is being recommended for mild minor procedural pain caused by venepuncture, heel sticks, etc. Tucked in positioning, Kangaroo care, non nutritive sucking, facilitated tuck, swaddling and nesting are some nonpharmocological measures that are advocated to reduce infant pain during procedures in NICU. Number of painful procedures in care should be minimized as much as possible and NICU's should have an established protocol for pain management. Pain due to procedures such as intercostal tube insertion and removal, post operative pain, etc must be adequately addressed.[9]

Developmental care practices are universally accepted as beneficial in the management of preterm infants. Evidence is more towards short term benefits than long term. Long-term benefits of developmental care on the neurodevelopment are not clear and more research is required in this area.

Points to Remember

- ***It is possible to recognize stress in preterm babies by being aware of the behavioral cues and observing the infant's behavior***
- ***Active steps have to be taken to monitor and reduce noise and light levels in NICU.***
- ***Kangaroo mother care is beneficial to both mother and infant.***
- ***Preterm baby endures a lot of pain in NICU and simple strategies such as oral sucrose, swaddling, non nutritive sucking and kangaroo mother care reduce pain and have to be readily practiced.***

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DEVELOPMENTAL PEDIATRICS

RISK STRATIFICATION OF NEONATES AT-RISK OF NEURO DEVELOPMENTAL DISABILITY

**** Naveen Jain***

Abstract: *Stratification of sick babies based on anticipated outcomes could possibly identify a group of babies at maximal risk and thus help to initiate timely early focused therapy. Babies at lowest risk could be referred back to primary care and require less frequent assessment. The risk approach will allow optimal utilization of limited, labor intensive, follow up services and minimize the early stimulation therapy to those babies at lowest risk.*

Most of the previously published tools are either lab / radiology (neurosonogram) dependant or require examination by trained personnel. These are not available at most centers caring for sick neonates in India. We evolved a simple tool for Indian NICUs that can prognosticate the outcome of these at-risk infants and guide parents, health care planners and medical personnel involved in perinatal care.

A single centre study from India has identified gestation < 28 weeks, need for extensive resuscitation at birth, prolonged ventilation, symptomatic hypoglycemia and abnormal neurosonogram as predictors in babies ≤33 weeks. 87.5% babies were identified as low-risk and 12.5% as high-risk; major disability at one year was 4.5% vs 18%. A multi-site study has been initiated under guidance of CDC and KIMS, Trivandrum to validate the risk stratification model.

Keywords: *Neurodevelopment outcome, Risk prediction.*

Survival of preterm and very sick babies is exponentially increasing world over for a few decades now. Some of these sick babies have adverse neurodevelopmental outcome (cerebral palsy, mental retardation, blindness, deafness), but most will not. In most NICUs, especially in developing countries, neonatal interventions and data bases are focussed on improving quality of medical care and survival of neonates. Attention to long-term neurodevelopmental consequences and minimizing disability is essential.

Many of these disabilities can be modified by early stimulation (ie) before the disability is established or specific interventions (ie) after the disability is identified. The follow up assessment of these babies is currently not structured / standardized in most neonatal units. Also, the number of babies is far greater than the manpower and infrastructure for assessment and intervention. Stratification of sick babies based on anticipated outcome could possibly identify a group of babies at maximal risk and thus initiate timely early focused therapy and babies at lowest risk who could be referred back to primary care and require less frequent assessment. The risk approach will allow optimal utilization of limited, labor intensive, follow up programme services and minimize the early stimulation therapy to those

* Associate Professor of Neonatology, Kerala Institute of Medical Sciences, Trivandrum.

Table I. Levels of follow-up program intensity

Level 1	Level 2	Level 3	Level 4
Telephone interview to screen: developmental screeners; Ages and Stages and CAT/CLAMS	In-clinic single visit: growth; neurologic exam; screen; developmental screeners; Ages and Stages and CAT/CLAMS developmental screeners: BINS	Single visit: comprehensive assessment; growth; neurologic exam; developmental assess-ment (behavior, other reduced comprehension or comprehension)	Serial comprehensive assessments: growth; neurologic exam; developmental assessment, behavior (may include videotapes) MRIs, actigraphy, parent IQ telemedicine, biochemical parameters, genetics
Refer for diagnostic or intervention services as needed	Refer for diagnostic or intervention services as needed	Refer for diagnostic or intervention services as needed	Refer for diagnostic or intervention services as needed
Collect data Clinical	Collect data Clinical	Collect data Clinical / Research	Collect data Clinical / Research

babies at lowest risk. Levels of follow up programme intensity[1] proposed in Pediatrics in 2004 (Table I) in a supplement dedicated to follow up.

Strategies for such stratifying at-risk babies have been based on single clinical criteria like gestation, weight.[2] A graphical tool for predicting survival in very preterm births (PREM tool) and risk scores like Clinical risk index for babies (CRIB 72) and ultrasound, brain imaging (USG, MRI), risk factor count of associated major illness like BPD, NEC, ROP etc are useful. Some have used multiple clinical intra-uterine and neonatal risks like Neuro biological risk score (NBRS),[3,4] perinatal risk inventory (PERI),[5] etc. The brain imaging using USG seems to be a powerful single predictor especially for cerebral palsy. In a developing country like India use of a test that is operater dependant is limited by standardization issues. Many of the tools like CRIB, PERI and NBRS use lab criteria. These again limit its applicability in India. Screening neurological examinations at discharge (Hammersmith neonatal neurological examination) have been evaluated that predict outcomes with reasonable accuracy. These require trained personnel.

We could find no published follow up data addressing this "risk concept" from our country. We need a simple tool for Indian NICUs that can prognosticate the outcome of these at-risk infants. This will help to guide parents, health care planners and medical personnel involved in perinatal care.

In a pilot study, from India, a single hospital cohort of 225 babies born <33 weeks (301 admissions, 43 died, 20 excluded from study and 13 lost to follow up) discharged from a referral teaching NICU of India over a period of four and a half years (2005 - 2009) was followed up prospectively on a structured follow up protocol for a minimum of 1 year corrected age (or last available outcome, if more than 1 year).[7] A risk stratification model was evaluated for its ability to predict major neuro developmental disability (NDD). Mean gestation and birth weight were 30.6 +2 weeks and 1425 + 375grams. 6.2 % babies had any one or more major Neuro developmental delay (NDD) - CP or MR (motor

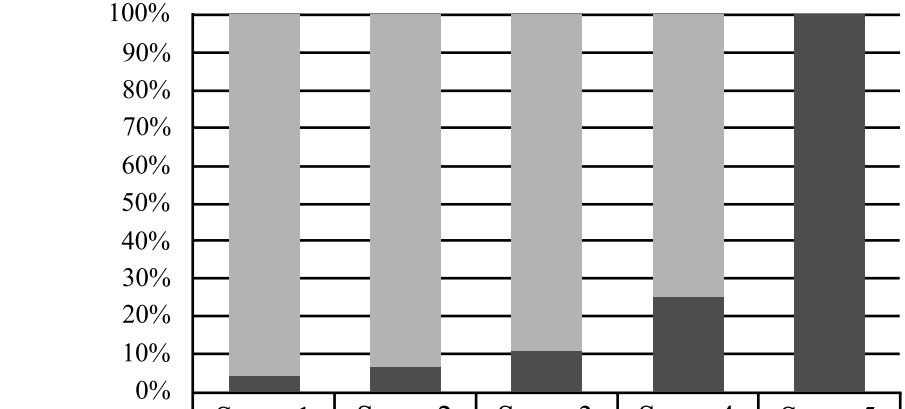
OR mental DQ < 70 on DASII), deafness or blindness. Gestation < 28 weeks, need for extensive resuscitation at birth, prolonged ventilation > 7 days, symptomatic hypoglycemia and abnormal neurosonogram at discharge had correlation with abnormal outcomes. Each clinical item was scored as 0 or 1 and neurosonogram as 0, 1, 2. A score of 1-2 predicted low risk and 3-5 high risk (Fig.1).

The risk stratification model demonstrated that risk stratification identified 12.5 % babies as high risk, they had had higher disability rates of 18 % at one-year age and would benefit most by early stimulation and specific interventions. Most babies (87.5 %) had a risk of only 4.5 % (baseline) and could be assigned to primary care and limited follow up (Table II).

The NBRS was designed to assess only the biologic risk factors that occur during neonatal intensive care and does not take into account events in antenatal period. The NBRS demonstrated that blood pH was important in predicting psychomotor outcome. The Indian study from KIMS did not take blood gas measurements into account. KIMS study has not selected laboratory based risk factors due to limitations of implementation of such tests in resource limited hospitals (Table III).[6]

The limitation of the study was a small sample size and wasn't tested for external validity. Hence, the protocol for a multi-center prospective trial has been finalized by 17 referral / teaching NICUs of India, in a study funded by CDC Trivandrum in March 2012. The training of personnel for data collection on uniform pattern and development assessment at 12 and 18 months age was completed in August 2012. The study is likely to be completed in 2015.

Hence the proposed risk categories for neuro developmental outcome as given below can be of help to stratify the risk groups and so much so to stratify the intervention (Table IV).



	Score 1	Score 2	Score 3	Score 4	Score 5
Normal	96	93.8	89.5	75	0
Abnormal	4	6.3	10.5	25	100

Fig.1. Prediction of major neurodevelopmental disability at last follow up visit using risk score

Table II. Categorising the babies, before discharge, into low / high risk for major neurodevelopmental disability based on the risk score

Score	Normal outcome	Abnormal outcome	Total
1 and 2	188 (95%)	9 (4.5%)	197
3, 4 and 5	23 (82.2%)	5 (17.8%)	28

(unpublished, thesis submitted to NBE – titled, from "prediction of neurodevelopmental outcome of very preterm babies using perinatal and neonatal risk factors" from Kerala Institute of Medical Sciences, Trivandrum)

Table III. Comparison of KIMS study with previously published prediction tools for outcomes of very preterm/VLBW infants.

	Neonatal Neurobiologic Risk Score (NBRS) Brazy etal	KIMS Study	Perinatal Risk Inventory Schemer etal
Population	d<1500 gms n = 68	d< 33 wks n= 225	d<1500 gms/d<32 wks N= 148
Risk factors	Apgar score, PaO2, ventilation, apnea, hypotension, PDA, seizures, IVH, PVL, infection, hypoglycemia, bilirubin	Prenatal risk, Gestation, birth weight, ANS, resuscitation, ventilation, shock, hypoglycemia, sepsis, IVH/PVL, other illnesses	Apgar, EEG, seizures, ICH, hydrocephalus, CNS findings, Growth <10th centile, weight for age, dysmorphic features, ventilation, head growth, polycythemia, meningitis, hypoglycemia, congenital infection, hyperbilirubinemia, ROP, BPD, NEC
Duration of follow up (months)	24	One year or last test outcome Mean 21.8±11.5	Last test score 36
Abnormal Outcomes studied	Tone abnormalities, BSID<85, severe visual or auditory impairment	DASII Mo or Me score <70, blind or hearing impaired	Cerebral palsy, BSID < 79

Table IV. Proposed risk categories for neurodevelopmental outcomes

	Mild risk	Moderate risk	Severe risk
Gestation *	33 -34 weeks	30- 32 weeks	< 30 weeks
Birth weight**	>1501 gm	1251 - 1500 gm	<1250 gm
Intra-uterine insults		Fetal growth 3rd – 10th centile Abnormal NST BPP < 5 Maternal fever PLROM Dichorionic twins	Fetal growth <3rd centile Severe maternal pre-eclampsia (seizures) Monochorionic twins / triplets or higher order Clinical chorioamnionitis Cord prolapse Abruption placenta Absent / reversed end diastolic flow
Antenatal steroids (ANS)		Incomplete course or 24 hours not elapsed from last dose	No ANS
Need for resuscitation at birth		Need for resuscitation (including PPV)	Need for Extensive resuscitation (chest compressions, epinephrine)
Need for ventilation * **		Ventilation with normal blood gases and no airleaks	Ventilation abnormal blood gases and air leaks
Perfusion		Shock (poor perfusion) with normal blood pressure	Shock (poor perfusion) with hypotension
Shock therapy	Saline bolus	Inotropes	Steroids
Hypoglycemia		Hypoglycemia (asymptomatic)	Symptomatic hypoglycemia
Blood sugars mg/ dL		32 – 46	<32
Days of hypoglycemia		1-4 days	> 5 days
IVH		IVH < grade III	Grade III IVH or ventriculomegaly, PVL
Infection		Sepsis	Sepsis with hypotension/ Meningitis
NNJ	Jaundice (PT)	NNT (ET)	BIND (MRI/BERA/clinical)
Hypothyroidism		Hypothyroidism	Treatment delayed (not normalized by one month)

* actual gestation will be recorded and the stratification can be changed based on best calculated cut off later.

** actual birth weight will be recorded and the stratification can be changed based on best calculated cut off later.

*** actual days on ventilator / CPAP will be recorded and the stratification can be changed based on best calculated cut off later.

Points to Remember

- ***Some sick neonates are at risk of neurodevelopment disability***
- ***Identification of high-risk babies can help initiate focused early stimulation***
- ***Identification of low-risk babies can help optimal utilization of resources***
- ***An Indian tool that is simple has been evolved and is in the process of validation***

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CLIPPINGS

Nabulsi M et al. Impact of C-reactive protein test results on evidence-based decision-making in cases of bacterial infection. BMC Pediatrics, 09/17/2012.

The routine ordering of C–reactive protein (CRP) for children with infections is based on weak evidence. The impact of the CRP test results on decision–making is rather small, and CRP ordering may contribute to unnecessary health care expenditures. Better quality research is needed to definitively determine the diagnostic accuracy of CRP levels in children with infections.

Paul R et al. Adherence to PALS Sepsis Guidelines and Hospital Length of Stay. Pediatrics, 08/13/2012.

Overall adherence to Pediatric Advanced Life Support sepsis guidelines was low; however, when patients were managed within the guideline's recommendations, patients had significantly shorter duration of hospitalization. Patients who received 60 mL/kg of intravenous fluids within 60 minutes had a 57% shorter hospital LOS (P = .039) than children who did not. Complete bundle adherence resulted in a 57% shorter hospital LOS (P = .009).

DEVELOPMENTAL PEDIATRICS

DEVELOPMENTAL STIMULATION

**** Bhuvaneswari Venkatesan***

Abstract: *Developmental stimulation involves stimulating development during the early years through touch, movement, play, language, music and emotional bonding. The emphasis is on zero to three years of life because of the 'windows of opportunity' that are available then, for 'wiring' the essential motor, cognitive-perceptual, social-emotional skills. The role of a stimulatory environment rules over the genetic inheritance as the synapses that code information come from the interactive experience that the child has with its environment. Parents/caregivers play the key role in this process. In case of deviations, 'early intervention' during this period is critical. Maintaining medical notes and updates are beneficial.*

Keywords: *Developmental stimulation, Windows of opportunity, Wiring and pruning, Parentese.*

The early years

The developmental process of clusters of cells forming specialized structures involves mystery of Science, whereas, the process of developing into a unique individual involves a mastery of skill. At birth, the infant possesses the basic hardware and further, requires enriched environments to enable 'wiring' in the higher centers to lay the foundation for his motor, sensory, cognitive, social-emotional and language development. The fact that, between zero and three years of life an estimated 1,000 trillion synapses occur through the child's 'experiences', which is twice as many as adults, stresses the need for 'effective' early stimulation.[1]

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The software designed by 'wiring and pruning'

In most regions of the brain, there are no new neurons formed after birth, but there are trillions of synapses occurring between the neurons. These lay the pathways of information between the various regions of the brain, which is essentially referred to as 'wiring'. The information for early wiring is acquired through interaction with the surrounding and the outcome of that worldly experience. This helps the child function in every little way, from his daily activities to academic capacities to self-regulation to social interaction. Hence, the child's level of functioning largely depends on qualitative interaction with the environment and consequently on positive experiences.[2]

The brain continues its development by keeping those synapses that have a purpose and discarding those that are not doing anything, by a process called 'pruning'. Pruning actually increases the efficiency with which the brain can do what it needs to do. On the other hand, when the brain is deprived of the normal stimulation or stimulatory experience, an 'over-pruning' of these connections can occur according to its 'use it or lose it' rule. This explains as to why the child struggles to do what would have come more naturally otherwise.[3]

The brain, hence, develops through a continuous process of interaction between nature and nurture, with the former being compared as the 'hardware' and the latter as the 'software'.

Although, the general neurological structure is bestowed by the genes, the function is dictated by what the brain learns from its environmental interaction. Hence, if there are differences in experiences, even identical twins are not wired the same!

Why Early?–'Windows of opportunity'!

There are fertile or sensitive periods, referred to as 'Windows of opportunity' during which the wiring for specific skills takes place at its optimum. This is the period where the brain absorbs information at its best, like a 'super sponge'and hence, development gallops![4] Though the greatest enhancement occurs throughout childhood and until puberty, the wiring opportunity is at its best during the first 3 years of life. For example, the windows of opportunity for motor development, vision and language is 0-24 months and for social development, emotional intelligence and thinking skills is 0-48 months.[1]

Irrespective of the demographic factors of birth or even the different conditions of birth and development (prematurity, typical or delayed development), the windows still remain the same for all children. The outcome of the fertile periods depends on the experiences that the child has during these periods with positive experiences yielding positive outcomes and negative ones rendering negative outcomes.[1]

Strategies to support developmental stimulation

Touch means trust

Touch is one of the primary sensory systems to develop in utero. A fetus will pull away from an object that touches its face at 8 weeks and by 14 weeks can feel with most of its body. Its neural pathways for pain are fully developed at 26 weeks.[5] Touch is the first language between the parent/ caregiver and the child that forms the base for further learning in a trustworthy way.

Massaging, cuddling, rocking, feeding, diapering, bathing, holding children on the lap or between legs and hence avoiding prolonged periods of staying in the crib, hugging, snuggling, rough-and tumble play, bear-hugs, handshakes or high-fives, finger/ hand games, texture play, sensory activities are all opportunities for tactile experience for children between zero and three years old.

It helps both, the infant and the parent/ caregiver in forming a sense of trust and bonding, enhancing communication and understanding cues, promoting self-esteem and acceptance. Tactile stimulation also assures certain physiological benefits like reduced stress, sleep regulation, body awareness and improved muscle tone.[6] Hence, touch is described as the infant's lifeline to security, attachment and reassurance.[7]

Massive movement and powerful play

The first sensory system to fully develop and myelinate by five months after conception is the vestibular system, which controls the sense of movement and balance.[8] The sensory experiences form the base for sensory-motor exploration, helping the baby form its first concepts.

Simple daily living and motor tasks like riding a bicycle, buttoning, handling knife and fork, coloring with a crayon, tying shoe laces, sitting still in classroom, require sensory-motor integration during the foundational years. This foundation is laid when 'massive movement' and 'powerful play' experiences are interwoven together. Apart from physical development,

movement establishes body awareness, spatial perception, cause-effect relationships, praxis, sense of independence and self-confidence. Play is no play, but a powerful medium to enable a child's learning in all the developmental areas. As long as play is fun and engaging, it is productive. A child could even learn some of the intricate social-emotional concepts like sharing, abiding rules, taking turns, frustration-tolerance, team-working and 'experiencing' success.

General movement and play activities appropriate during these years are tummy time, rolling over, crawling and creeping, action games, dancing, finger feeding, finger games and self care activities themselves. Some basic things to remember while facilitating such experiences are, ensuring safe environment, allowing the child to lead the play, talking to guide them through the process, like, "we bring our hands together to clap", instead of saying "clap!", constructing developmentally appropriate experiences and helping the child accomplish success at his attempts, as positive experiences alone render positive learning!

Language - just not letters, even listening to music!

Listening to music commences in utero, as the fetus is immersed in vibrations from the mother's heart beat, breathing, voice and other internal sounds. At five months, the fetus responds with movement to phonemes that it hears through the amniotic fluid, spoken by the mother and by six months, it responds to music by blinking its eyes.[8] Music and language are partners in the brain and awareness to music is critical to language development in babies.[1] They not only introduce children to words, but help them learn rhythm, sequences, spatial and math skills.[7]

Receptive language paves way to expressive language, hence, more 'listening' guides the brain to assemble sounds for speech production. Experts recommend using 'parentese' while talking to babies. 'Parentese' is the high-pitched, sing-song way of talking to a baby using actual words, exaggerated facial expressions and elongated vowels and consonants. For example, saying "you are my little baby" as "yooo are my li-i-tttle baybee". It is a great stimulus to the cochlea and brain as it elicits more awake, alert, connected response from the baby.[8] Early language stimulatory activities include, playing music, singing, telling stories and reading to them. While talking to a younger child, using techniques like, parallel-talk ("you are playing with the doll"), self-talk ("I am reading a book"), descriptive expressions ("the tub is big"), repetition (repeating the child's words with correct articulation), asking open-ended questions, helps them learn to talk.

Employing simple strategies like, carefully listening to them, giving them eye-contact and attention while talking, using gestures and facial expressions, taking turns to speak, giving them time to finish and helping them with specific vocabulary helps them learn the social aspects of communication.

Emotional and social development – Tender loving care creates the bond!

As per Maslow's model of hierarchy of needs[9], the human brain requires the physiological, safety, belongingness and love, esteem needs to be first satisfied in order to achieve self actualization.

For example, ignoring infant's cries for food, responding to its cues in an unpredictable manner, using harsh language and showing non-atachment is perceived as intense anxiety by the infant, which, in turn results in stress related responses. On the other hand, when the infants' communicative behaviors are reciprocated, infants perceive the relationship as attuned and they distinguish that the adult is not only "like me" but

also "with me".[10] Early relationships affect wiring, with loving atmospheres yielding better outcomes and stressful ones leading to worse outcomes.[1] Emotional regulation is foundational for social behavior and relationships. Between 18 and 24 months of age, children develop their first emotion words (happy, sad, mad, and scared), which helps them comment on their own experience and show better empathy towards peers.[11] Research shows that most children are capable of feeling good or bad about themselves between one and two years of life - the early roots of their emerging self esteem.[12]

Some ideas to promote healthy emotional and social development are sustaining a 'safe' environment, maintaining predictable routines, having 'quality' time (uninterrupted and complete engagement), actively participating in your child's activities, providing ongoing encouragement, role-playing imaginary situations, creating opportunities for peer play, exploring emotions by acting and talking about them.

Parents' own upbringing, faith system, parents' abilities to balance the competing responsibilities of life and the resulting fatigability influence their way of child-rearing and eventually their interaction with their child.[12] Hence, parents'/ caregivers' emotional well-being is equally important for the child's secure base.

Who can help?

Anyone and everyone! Any person and every person in close relationship with the child should be aware of the basic principles of 'relating' to the child. If the child has to benefit from the 'windows of opportunity' in his life, it becomes important to identify the responsibilities of the persons related to the child and ensure coordination between them.

Parents or the primary caregivers play the key role in their child's life; hence they hold the lion's share of responsibility. Awareness about their child's development is important for them to build the bridge between their child and the rest of the world. For example, knowledge about the milestones would help them understand whether their child is achieving the expected skills at the right age or is deviated. This knowledge would help them represent their concerns accurately to the pediatrician, which would in turn, save time and cost by facilitating immediate and the right help. Other people who could assist in the process are the baby-sitters, crèche or kindergarten staff, grandparents and other significant adults in the child's life by reporting what they observe and as well as implementing the developmental techniques. The medical community comprising of pediatricians and other specialists, occupational therapist, physiotherapist, sleep language therapist (OT/PT/SLT) and pediatric nurses play a pioneering role in diagnosing, treating and imparting information to the parents to guide them further.

The most important aspect is the coordination amongst those related to the child, which could be achieved through proper documentation. Suggestive methods to achieve this coordination are keeping a milestone diary, video-taping and photographing the child's efforts, maintaining medical notes and updates and sustaining a multi-disciplinary team approach.

As we sow, so shall we reap!

In conclusion, it is again emphasized that the first three years are the foundational years in every child's life. Depending on the foundational sensory input; the sensory-motor, perceptual-motor and academic performance would take form in the future years.[13] Specific skills need to be stimulated during the respective 'windows of opportunity', to ensure positive development. When deviations in the development are noted, the key is 'early intervention', again during the foundational years, owing to the brain's plasticity.

A word of caution in this regard is about the possibilities of the child getting over-stimulated, especially, sensitive children. It is imperative that the parent/ caregiver reads the cues of the child and grades stimulation accordingly. The infant's signs of getting stressed could mean either deprivation or over-stimulation, which then should be attended to, accordingly. Thus, ensuring safety, fun and active involvement becomes critical in developmental stimulation!

Points to Remember

- ***The first three years of life are critical to stimulate holistic development owing to the wiring opportunity.***
- ***Touch, movement, music and play experiences coupled with emotional bonding helps the child develop its skills.***
- ***Creating a positive, loving, safe environment and protection against abuse and neglect is important for healthy development.***
- ***The primary caregivers play the key role in nurturing the child.***

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DEVELOPMENTAL PEDIATRICS

HEARING LOSS IN NEONATES AND INFANTS - NEED FOR EARLY DETECTION

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Abstract: *Hearing loss in infants has been linked with lifelong deficits in speech and language acquisition, poor academic performance, emotional problems and personal - social maladjustments. Significant bilateral hearing loss is present in 1 to 3 per 1000 newborn infants in the well baby nursery population and in 2 to 4 per 100 infants in the intensive care unit population. It is an established fact that if hearing loss is present it should be detected and remediated before the baby is 6 months old. Such an identification is possible only through newborn hearing screening programmes already existing in developed countries. Neither a high risk screening nor a universal screening exists in majority of hospitals in our country. This article projects the need for early identification of hearing loss, risk factors and a practical, replicable centralized new born hearing screening protocol, evaluation and intervention.*

Keywords: *Auditory brainstem response (ABR), Otoacoustic emission (OAE), Centralized screening facility, Universal newborn hearing screening (UNHS).*

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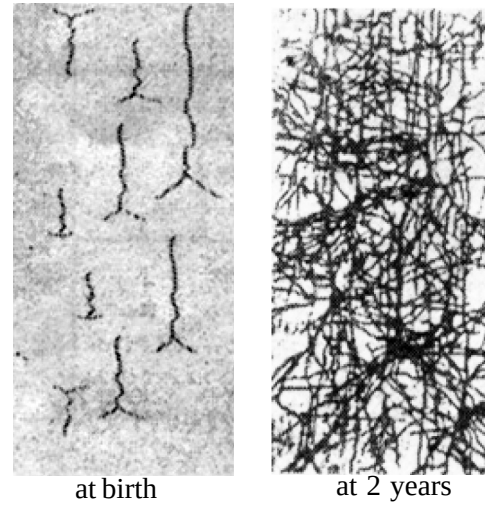
Hearing loss has considerable impact on the overall development of the infant - language, cognition and development of social and emotional competence. The first year of life is a critical period for brain development, especially development of the auditory pathway.[1] Auditory experience during this period has profound influence on functional development of auditory system and lack of auditory experience can have detrimental effects. At birth, the brain has 100 billion neurons and they form about 50 trillion connections.[2] The only way the connections can be strengthened is by stimulation - both auditory and sensory. The connections that are not used or stimulated, wither away. This emphasizes the need for constant auditory stimulation right from birth for optimal development of auditory system, a prerequisite for optimal development of speech and language (Fig.1).



at birth at 2 years

Fig.1. Synaptic connections

It is established that unidentified hearing loss can adversely affect optimal speech and language development, acquisition of literacy skills and academic, social and emotional development. Neonatal hearing loss and its developmental consequences are measurable before the age of 3 years.[3,4,5] If these are not remediated through early intervention, they impact the child for life.[6] There is robust evidence that identification and remediation of hearing loss, when done before 6 months of age for newborn infants who are hard of hearing, enables them to perform significantly higher on vocabulary, communication, intelligence, social skills and behavior necessary for a successful life later.[7-9] We have now readily available technology that provides rapid and accurate identification of hearing loss in newborns and also improved assistive listening devices (hearing aids, frequency modulated systems, cochlear implants) that can provide markedly improved hearing to the needy children. American Academy of Pediatrics (AAP) in 1999 advocated universal newborn hearing screening programme (UNHSP) and remedial intervention which is being practiced in most of developed countries. Significant bilateral hearing loss is present in 1 to 3 per 1000 newborn infants in the well baby nursery population and in 2 to 4 per 100 infants in the intensive care unit population.

In a developing country like India, simple and practical measures for universal screening need to be developed for this purpose. At present in majority of the hospitals in India, there is neither a universal neonatal screening nor a high risk screening for hearing, as a routine.

Universal new born hearing screening programme (UNHSP)

American Academy of Pediatrics Task Force on newborn and infant hearing recommends UNHS by 3 months of age with intervention by 6 months of age. The joint committee on infant hearing (JCIH) position statement provides guidelines that include newborn hearing screening (NHS) soon after birth, before discharge from hospital or before 1 month of age, diagnosis of hearing loss through audiological and medical evaluation before 3 months, and intervention through interdisciplinary programme for infants with confirmed hearing loss before 6 months of age. This screening involves all newborns, with special attention to the high risk group which include the following:

(i) family history of hereditary childhood sensori-neural hearing loss

(ii) in utero infection such as cytomegalovirus, rubella, syphilis, herpes and toxoplasmosis

(iii) craniofacial anomalies, including those with morphological abnormalities of the pinna and ear canal

(iv) birth weight less than 1500 gms

(v) hyperbilirubinemia at a serum level requiring exchange transfusion

(vi) ototoxic medications, including but not limited to the aminoglycosides

(vii) bacterial meningitis

(viii) apgar score 0 to 4 at 1 minute, or 0 to 6 at 5 minutes;

(viii) mechanical ventilation lasting 5 days or more and

(ix) stigmata or other findings associated with the sensori-neural and / or conductive hearing loss.

Centralized new born hearing screening programme (CNBHSP)

At present few hospitals in our country do hearing screening for newborns born in their hospital and in some instances, babies that are

Fig.2. Hearing Screening Equipment

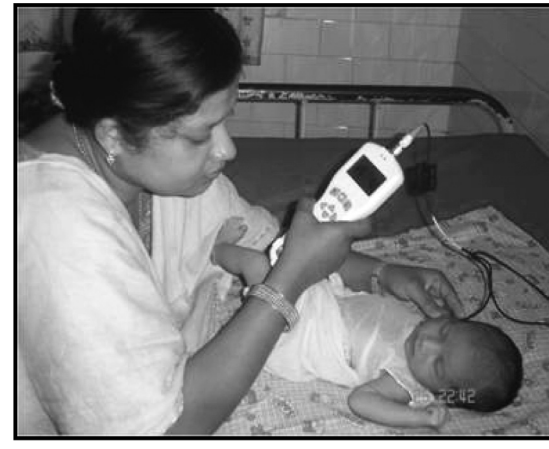


Fig.3. Testing procedure

brought for hearing screening to their tertiary hospitals. In a developing country like India, a hearing screening equipment facility in every hospital with a maternity unit may not be a viable proposition.

A centralized newborn hearing screening programme with a two stage screening protocol with otoacoustic emission (OAE) as the first screen, followed by auditory brainstem response (ABR) for those who fail the first screen will be more practical. In this 2 tier screening program (the second tier being the more expensive ABR), ABR will be required only for a selected few - thus making the program more practical and viable. The trained personnel can report to a particular hospital at a particular time and day of the week. This protocol will make the screening cost - effective and acceptable, avoiding the need for transporting the neonates to a screening facility and thus significantly preventing dropouts. This overall practicability will make it relevant for our country; making it a potential model screening program. Personnel with basic knowledge in computer and good communication skills may be given basic training in hearing screening and entrusted the task of screening (Fig.2&3).

The treating pediatrician can appraise the parents of the infant about the procedure and its need. As per guidelines, the neonate gets screened before discharge from the hospital. If there is an abnormal result, repeat test is done on the day of the infant's next scheduled visit for immunization. If the repeat test also is abnormal, the baby is referred for ABR. Babies with abnormal ABR are referred for comprehensive evaluation and remediation. The evaluator can record the medical history from the discharge card / inpatient file of the infant, to identify the high risk factors recorded. High risk infants who miss screening may be screened on subsequent scheduled follow up visit. OAE screening will take only about 3-4 minutes, if the baby is in the natural sleep. Older babies may require sedation. Babies requiring repeat test may be given specific dates by the hospitals for the scheduled follow up visits, so that it will coincide with the visit of the screener. This centralized NBHSP is in practice in the city of Cochin since 2003 and is functioning well giving excellent results.

OAE, ABR and automated ABR (AABR) testing have all been used in newborn hearing screening programs. ABR assesses auditory function from the eighth nerve through the

auditory brainstem. Both tests are necessary to differentially diagnose an infant's hearing impairment. OAEs are used to assess structural integrity and are physiologic measurements of the response of outer hair cells of the cochlea to acoustic stimuli. They serve as a fast objective screening test for normal cochlear function. OAE tests are used to assess the outer, middle and inner ear portions of the auditory system. ABR testing helps in assessing the whole system, from periphery to the auditory nerve and brainstem. If an infant has normal OAE and abnormal ABR, he may be having auditory neuropathy or auditory dyssynchrony. The ABR and OAE are tests of structural integrity of the auditory pathway and not tests of hearing; therefore, even if ABR and OAE test results are normal, hearing cannot be considered definitely normal until a child is mature enough for a reliable behavioural audiogram.

All infants, regardless of newborn hearing screening outcome are recommended to receive ongoing monitoring for development of age-appropriate auditory behaviours and communication skills. Any infant who demonstrates delayed auditory and/or communication skill development, even if he or she passed newborn hearing screening should receive an audiological evaluation to rule out hearing loss. These are also communicated to the parents by the pediatrician.

UNHSP has become a national practice in most of the developed countries. The identification of all newborns with hearing loss before 6 months has now become an attainable realistic goal in almost all the developed countries. The prevalence of permanent congenital hearing loss (PCHL) is higher than other neonatal screenable conditions put together. Eventhough the incidence of PCHL is more than 10 times in the high risk group as compared to the well baby nursery population, high risk screening is not enough, given that as many as 50% of infants born with hearing loss have no known risk factors and hence UNHS is needed.

Pediatricians should take a proactive role in developing NBHSP and also in the initiation of follow up programmes to provide a continuity of care for these infants; pediatricians should be the team leaders in the multidisciplinary approach to management of hearing impaired children. They can also play a major role in promoting acceptance of hearing aids, encouraging constant usage of aids and providing information regarding early intervention services.

Points to Remember

- ***The incidence of bilateral congenital hearing loss in general population is 1 to 3 per 1000 and is 10 times more in neonatal intensive care units. This incidence is more than other neonatal screenable disorders put together.***
- ***Hearing loss, if present, should be identified and remediated before the baby is 6 months old, to prevent disabilities in speech, language and cognition in the child's development.***
- ***A two stage screening protocol with otoacoustic emissions (OAE) as the first screen, followed by auditory brainstem response (ABR) for those who fail, is more practical. This will obviate the need for more expensive and time consuming test like ABR for the majority of infants, thus making it more practical, viable and replicable.***
- ***Pediatricians have to take a proactive role in developing newborn hearing screening programme in their respective city / town and in the initiation of followup programmes.***

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NEWS AND NOTES

PEDIATRIC PULMONOLOGY UPDATE - 2012

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Pediatric Pulmonology Foundation

Date: 2nd December, 2012

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*Registration Fee	Up to 2nd October 2012	After 2nd October 2012
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DEVELOPMENTAL PEDIATRICS

DEVELOPMENTAL ASSESSMENT - WHEN AND HOW?

**** Nair MKC***
***** Deepa Bhaskaran***
****** Babu George***

Abstract: *The improvement in perinatal care has led to increase in survival as well as morbidity in sick newborns. These babies need to be followed up regularly to assess growth and neurodevelopmental outcome and for early stimulation and rehabilitation. Perinatal risk factors and course of neonatal illness define a group of neonates at increased risk of neurodevelopmental disability. Timely and appropriate intervention can prevent or modify many of these disabilities. Several simple screening tests are available for detecting developmental delays at the earliest. Some of these screening tests can be done by field workers also.*

Keywords: *Developmental delay, Screening.*

Improving perinatal and neonatal care has led to increased survival of infants who are at-risk for long-term morbidities such as developmental delay and visual/hearing problems. A proper and appropriate follow-up program would help in early detection of these problems thus paving the way for early intervention**.** Regardless of complications at birth, some children will not show any serious developmental problems over time. Some children may develop well initially and slowly reveal problem areas as they mature. Other children may have initial problems that will resolve as they get older. Prompt identification and treatment of delays is thought to be the key to successful intervention.[1]

Developmental delay is diagnosed if a child does not achieve certain skills (or developmental milestones) by a predicted age. Developmental delay generally affects a child's gross motor skills, fine motor skills, communication, speech and language development and/or personal and social skills.

The common areas of developmental delay include gross motor, fine motor, personal social, cognitive, receptive and expressive language. Some children may have delays in more than one area of development, the so called "global developmental delay". Children with developmental delays are more prone to develop disabilities later on. So early detection of developmental delays and early intervention for them are of prime importance.[2]

Early detection

Generally speaking, in the first year delay in gross motor milestones like head holding, sitting and standing predominate, in the second year fine motor delay predominates, in the third year speech, language and cognitive delay predominate and after that behavior problems like hyper activity predominate. The common manifestations of developmental delay are

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Physical Signs

- Achieve developmental milestones later than the predicted age
- Stiffened upper and/or lower limbs
- Reduced tone (or floppy) trunk/posture compared with other children of a similar age
- One side of body is used significantly more than the other
- Very clumsy compared with other children of a similar age

Visual signs

- Difficulty following moving objects with the eyes
- Frequent rubbing of the eyes
- Turns or tilts head in an unusual position when looking at objects
- Difficulty in locating and picking up small objects (after the age of 12 months)
- Closing of one eye to look at distant objects
- Crossed or turned eyes and dancing eyes

Hearing signs

- Vocalizes in a very loud or very soft voice
- Turns head to direct one ear towards sound
- Does not startle with loud noises
- Unable to produce sounds or pronounce words that would be appropriate in other children of a similar age
- Does not respond when called from across the room

Behavioural signs (older children)

- Difficulty staying focused on an activity for as long as other children of a similar age
- Focuses attention on unusual objects rather than interacting with others
- Reduced eye contact compared with other children of similar age
- Gets easily frustrated on attempting to perform simple tasks compared with other children of similar age
- Shows aggressive and stubborn behaviour compared with other children of similar age
- Has periods of inattentiveness, rocking of the body or talk to themselves more than other children of the same age
- Reduced emotional response towards parent / family / care takers

Early identification of developmental delay is made a simple process by the use of screening tools which can be administered with minimum time and equipments. Some of these tools can be used by the mother, while some need a minimal amount of training and could be administered by community level health workers. Developmental delay is evaluated by professionals through two types of play based assessments.[3]

(i) Developmental Screening

(ii) Developmental Evaluation

A developmental screening test is a quick and general measurement of skills. Its purpose is to identify children who are in need of further evaluation. A screening test is only meant to identify children who might have a problem. The screening test may either over-identify or under-identify children with delay. As a result, a diagnosis cannot be made simply by using a screening test.

If the results of a screening test suggest a child may have a developmental delay, the child should be referred for a developmental evaluation.

Developmental evaluation is a long, in-depth assessment of a child's skills and should be administered by a highly trained professional,

such as a developmental therapist. Evaluation tests are used to create a profile of a child's strengths and weaknesses in all developmental areas. The results of a developmental evaluation are used to determine if the child is in need of early intervention services and/or a treatment plan.

Tools and techniques to assess developmental delay

- CDC grading for motor milestones
- Trivandrum Developmental Screening Chart (TDSC)
- Language Evaluation Scale Trivandrum (LEST)
- Amiel- Tison Passive Angles for neurological evaluation
- Denver Developmental Screening Test (DDST)
- Developmental Assessment Scale for Indian Infants (DASII)

1. Developmental observation card (DOC)

Developmental Observation Card is a self-explanatory, simple card that can be used by the parents. The DOC has been developed at Child Development Centre,Thiruvananthapuram. This can be used to screen for developmental delays by parents and by anganwadi workers. The large majority of developmental delays can be identified by using cut off points for 4 simple developmental milestones namely social smile, head control, sitting and standing (Table I).

DOC - major milestones-details

Social Smile - achieved by completed 2 months. (Baby smiling back in response to your smile)

Head holding - achieved by completed 4 months (Keeping head steady when baby is held upright)

Table I. Developmental observation card

Developmental milestones	Attained age
Social smile	2 months
Holds head steady	4 months
Sits alone	8 months
Stands alone	12 months
Make sure that baby does **see, hear and listen**	

(Lifts head and shoulder supported on fore arm in prone position)

Sitting alone - achieved by completed 8 months. (Baby is able to sit alone with back straight, no support).

Standing alone - achieved by completed 12months. (Baby is able to stand bearing weight on both legs with minimal or no support).

Make sure that the child can see, hear and listen

Using cut off points for these four simple developmental milestones a large majority of developmental delays can be detected. Those who fail these simple milestones must have a formal developmental assessment.

2. CDC Grading for major motor milestones

The grading for 3 major motor milestones developed by CDC is widely used for developmental assessment.

CDC Grading for motor milestones (head control, sitting, standing).

Head holding grading : Assessed at completed 4 months

Grade 0 : No head holding at all

Grade I : Head erect and steady momentarily

Grade II : Dorsal suspension - lifts head along with body

Grade III : Prone position - elevates on arms, lifting chest

Grade 1V : Holds head steady while mother moves around.

Grade V : Head balanced at all times.

Sitting grading : Assessed at completed 8 months

Grade 0 : No sitting at all.

Grade I : Sits momentarily

Grade II : Sits 30 seconds or more leaning forward

Grade III : Sits with back straight

Grade IV : While sitting, can turn around and manipulate a toy

Grade V : Raises self to sitting position

Standing grading: Assessed at completed 12 months

Grade 0 : Not standing well

Grade I : Stands holding on to a furniture momentarily

Grade II : Take few steps with both hands supported

Grade III : Can stand alone with legs apart

Grade IV : Comes to standing position by throwing weight on arms

Grade V : Without support takes a few steps.

Interpretation of CDC grading

Grade 0, I, II - Abnormal for that age

Grade III, IV, V - Normal for that age.

Grade 0 means poor developmental status

Grade V means better developmental status.

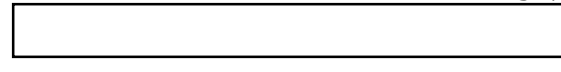
If a baby has apparently Grade-III head holding (only lifting head without rising on arms) without Grade-II, this is to be considered abnormal, because this may be due to neck extensor hypertonia. Occasionally it may be possible that Grade-IV standing is achieved before the child is able to stand alone (Grade-III) and this is not abnormal

3. Trivandrum Developmemtal Screening Chart (TDSC)

This is a simple developmental screening test designed and validated at the Child Development Centre, Trivandrum.

Age range 0 - 2 years and time required 5 to 7 minutes

There are 17 test items in the chart, carefully chosen after repeated trial and error. The age range for each test item is taken from the norms given in the Bayley Scales of Infant Development (BSID). The left hand side of each horizontal dark line represents age at which 3% of children passed the item and the right end represents the age at which 97% of the children passed the item. There are 24 vertical lines in the chart which represents age in months. Inbetween 2 lines there are 10 small lines. Each line indicates 3 days. Hence 10x3 = 30 days. TDSC can be used both in clinical and community set up.



Administration

A vertical line is drawn or a pencil is kept vertically, at the level of the chronological age of the child being tested. If the child fails to achieve

any item that falls short on the left side of the vertical line, the child is considered to have a developmental delay. Any obvious abnormality or asymmetry is also considered abnormal.

Interpretation

Delay/ Normal

4. Developmental assessment scale for Indian Infants (DASII).

This scale consists of 67 items for assessment of motor development and 163 items for assessment of mental development. Motor scale assesses control of gross and fine motor muscle groups. Mental scale assesses cognitive, personal and social skills development. Both mental development index and psychomotor development index can be calculated by DASII[4]. The age placement of the item at the total score rank of the scale is noted as the child's developmental age. This converts the child's total scores to his motor age (MoA) and mental age(MeA). The respective ages are used to calculate his / her motor and mental development quotients respectively by comparing them with his chronological age (CA) and multiplying it by 100. (DMoQ = MoA/CA x 100 and DMeQ = MeA/CA x 100).

The composite DQ is derived as an average of DMoQ and DMeQ.

A good correlation between developmental quotients (DQ) (DASII) and social quotients (SQ) (Malin's Vineland Social Maturity Scale [VSMS]) has been shown.[5]

5. Language evaluation scale Trivandrum (LEST)

Delay in aquiring language may be a pre runner of Pervasive developmental disorder (PDD) or Learning disability (LD). Hence, early detection and follow up of speech and language delay is of prime importance. LEST is a scale designed to detect developmental delays between 0 and 3 years.

The LEST is divided into 6 sections for 0-3 year old children with interval of 6 months. Each section contains age appropriate developmental milestones pertaining to expressive language and receptive language. If the child fails a single item in the age group he is considered to be at risk for developing speech and language delay and he has to be subjected to-REELS evaluation.

6. Nursery evaluation scale Trivandrum (NEST)[6]

NEST is used for

1. Functional assessment of pre school children (4-6 years)
2. A guideline to pre-school teachers regarding individual child's holistic development.
3. A screening tool to identify pre-school children who need one-to-one instructions.
4. A vehicle for intervention.
    - NEST cannot be used to assess the intelligence of the child; instead can be used to assess the skill development of pre-school children.
    - NEST is not designed to find out the brighter kids in the pre-school and hence should not be used as screening test for admission to class I.
    - NEST does not concentrate on the emotional development of the child, as it is considered as a part of overall development of the pre-school child.
    - NEST was formulated at the Child Development Centre, Thiruvananthapuram based on existing child

development and educational theories and years of clinical experience.

- NEST was originally standardized on 613 Preschool children (4-6 years)
- Originally NEST had 181 items. Item reduction was done by factor analysis and the items numbers were brought down to 69 under 6 domains.

Domains covered under NEST – Total 69 items.

Gross motor development	:	13 items
Fine motor development	:	14 items
Cognitive development	:	12 items
Personal social development	:	11 items
Expressive language development	:	7 items
Receptive language development	:	12 items

NEST - Percentile

There is a table showing the 3rd, 50th, 97th percentiles of age in months of preschool children who completed the specific items of NEST. The 50th percentile value is to be taken as cut off point and intervention has to be offered as per the guidelines described. If a particular child cannot complete one item and if his chronological age in months is more than the 50th percentile value of the research study, that child needs intervention. (For example, if a child's age is 55 months and the child cannot do the item "Pedals tricycle-turning corner' he needs intervention as 50th percentile age of the research sample is 49 months).

7.Denver Developmental Screening Test–II (DDST-II)

Age range : 2 weeks to 6 years. This is a screening tool to detect developmental delays

Description

This instrument was designed to be a quick and simple screening tool to be used in clinical settings by people with little training in developmental assessment. The test is comprised of 125 items, divided into four categories:

- Gross Motor
- Fine Motor/Adaptive
- Personal Social
- Language

The items are arranged in chronological order according to the ages at which most children pass them. The test is administered in 10 - 20 minutes and consists of asking the parent questions and having the child perform various tasks. The test kit contains a set of inexpensive materials in a soft zippered bag, a pad of test forms and a reference manual. The manual includes instructions for calculating the child's age, administering and scoring each item and interpreting the test results.

The test items are represented on the form by a bar that spans the age at which 25%, 50%, 75%, and 90% of the standardization sample passed that item. The child's age is drawn as a vertical line on the chart and the examiner administers the items bisected by the line. The child's performance is rated "Pass", "Caution", or "Delay" depending on where the age line is drawn across the bar. The number of delays or cautions determine the rating of "normal" or "suspect".

8. Neurological evaluation

Generally in children who present with symptoms of cerebral palsy, the earliest manifestation is abnormalities in the muscle tone. It may be either hypertonia or hypotonia. The variations in tone can be picked up early by

the method of evaluation devised by Amiel-Tison. It has simplified the approach to motor difficulties, grouping them within a simple framework with a dual goal: to simplify the explanations to the family who want to understand, for example, why cerebral damage would lead to orthopedic treatment of the hips; the second, to simplify the classification of motor problems for the doctor and the physiotherapist. Repeat neuro developmental assessments at 2 year, 3 year, 5 year, 7 year, etc only can give the complete picture of all possible abnormalities including problems at school.[7]

The major advantage of following the method of Amiel-Tison in preference to other neurological evaluation techniques is that there is an individual objective for each baby in terms of monthly evaluations and corrective therapy. At the end of one year no attempt is made to give any score. The babies are grouped into:

a. Normal babies.
b. Babies with patterns of transient abnormalities.
c. Babies with patterns of persistent abnormalities.

Amiel-Tison passive angles[8]

i) Adductor angle: With the infant lying supine, the legs are extended and gently pulled as far apart as possible. The angle formed by the legs at this point is called the adductor angle. Asymmetry between the right and left leg should be noted.

ii) Heel to ear: With the infant lying supine, the legs are held together and pressed as far as possible towards the ears. The pelvis must not be lifted from the table. The angle is represented by the arc extending from the infant's heel to the table. Increased resistance on one side is an indication of asymmetry, but it might be difficult to apply equal pressure to both sides.

iii) Popliteal angle: The thighs are flexed laterally at the hip along both sides of the abdomen. While holding the infant in this position, the examiner presses the lower leg as far as possible towards the thigh. The popliteal angle, which is formed by the calf and the thigh is estimated in both legs simultaneously. In contrast to the maneuvers described above, it is easier to apply equal pressure to both sides when examining the popliteal angle; therefore, estimation of asymmetry is more objective. Significant asymmetry is indicated by a difference of 10 to 20 degrees between the right and left angles.

iv) Dorsiflexion angle of the foot: The examiner holds the infant's leg straight and flexes the foot towards the leg. This is accomplished by applying pressure with the thumb to the sole of the foot. The dorsiflexion angle is formed by the dorsum of the foot and the anterior aspect of the leg.

v) Scarf sign: The infant is held in a semi reclining position supported by the examiner's palm. At the same time, the examiner takes the infant's hand and pulls the arm as far as possible across the chest towards the opposite shoulder. Four positions are possible in describing the position of the elbow in relationship to the umbilicus.

a) The elbow does not reach midline (not cross)
b) The elbow across the midline (cross)
c) The arm encircles the neck and the elbow reaches axilla.
d) the arm encircles the neck like a scarf and elbow is beyond axilla.

9. Oto-acoustic emission (OAE)

This records acoustic feedback from the cochlea through the ossicles to the tympanic membrane and ear canal following a click stimulus. It is quicker to perform than BERA but is more likely to be affected by debris or fluid in

the external and middle ear and is unable to detect some types of sensorineural hearing loss including auditory dyssynchrony.[9]

The severity of hearing loss is profound (70 dB or more of hearing loss), severe (50dB - 70 dB), moderate (30 dB - 50 dB) and mild (15 dB - 30 dB).

The audiological testing should be done at 3 months of age. Infants with true hearing loss should be referred for early intervention to enhance the child's acquisition of developmentally appropriate language skills. The child should be provided with hearing aids and if there is severe to profound hearing loss cochlear implants should be considered by 12 months age. Fitting of hearing aids by the age of 6 months has been associated with improved speech outcome. Initiation of early intervention services before three months age has been associated with improved cognitive development at 3 years age.[10]

Points to Remember

- ***A good neurological examination helps to pick up the tone abnormality at the earliest.***
- ***Early detection and appropriate intervention can modify many disabilities.***
- ***Several simple screening tests are available for detecting developmental delays at the earliest.***
- ***Commonly, in the first year, delay in gross motor milestones, in the second year delay in fine motor milestones and in the third year, delay in cognition and speech and language predominates.***

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DEVELOPMENTAL PEDIATRICS

DEVELOPMENTAL ASSESSMENT SCALES FOR INDIAN INFANTS (DASII)

**** Bindu Patni***

Abstract: *The neonatal care in India has improved considerably in the last two decades. Babies who would not have survived in the earlier decades are surviving defying Darwins Law of "Survival of the fittest" due to neonatal care and this has resulted in emergence of new generation. But as a result a new generation of 'high risk infant' is emerging. Among the widely used development tool, "Developmental assessment scales for Indian infants (DASII)" has emerged as a very effective comprehensive and useful tool which is standardized on Indian babies. Assessing an infant with the DASII scale consists of guided play activity with the baby. It is as much of an art as a science and needs training to administer, score and interpret it effectively.*

Keywords: *High risk infant, Developmental Assessment, DASII*

Specialized follow up management of high risk babies is the most logical extension of neonatal services with an aim to reduce postnatal morbidity and improve quality of life. Early and effective means of monitoring later cognitive development is crucial in these neonates. Frequently, mental subnormality, cerebral palsy, learning problems and adaptive behavior deficits resulting from damage to the brain are preceded by developmental delays.

The assessment of these babies is a complex process and must include a multidisciplinary approach. Developmental assessment is an integral part of intervention and management in order to detect early delays. Most developmental tests attempt to measure the unfolding of the developmental sequence.

In pediatric practice it is common and practical to use screening tools. Developmental screening tests are brief procedures to identify developmental delay children who should receive more detailed assessment. The primary goal of screening is to identify developmental delay and intervene at the earliest in order to lessen the impact on the child and family and improve the outcome. In our country, routine formal screening of all babies is neither feasible nor cost effective. However, screening should be done in all high risk infants at an age as early as 3-6 months and screening should ideally be done either by a pediatrician or a nurse or a community health worker. Such a screening test should be simple, brief, convenient to use and cover all areas of development. Most importantly it should be culturally sensitive.

Some of the widely used screening tools are:

Denver developmental screening test (DDST II)

Covering age range 0-6 yrs and assessing gross motor, fine motor, social and language

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development. DDST II includes more language items and is better for detecting milder delays.

Clinical adaptive test (CAT) and Clinical Linguistic Auditory Milestone Scale (CLAMS)

Covering age range 0-3 yrs

Screening tests for Indian babies are

Trivandrum Developmental Screening Chart (TDSC)

Covering age range 0-2 years and assessing motor and mental development and screens for hearing, vision and cognitive skills.

Baroda Developmental Screening Test (BDST)

Covering age range of 0-2.5years and assessing gross motor, fine motor and cognitive skills.

The advantage of screening tools is that they are easier to use, some of them do not need any standardized kit or material nor does it require specialized training. However, screening tools have limitations. They can miss out milder delays and give no idea of the type or areas of developmental problems. Any child failing the screening test must be assessed in details using scales like DASII which are generally administered by developmental pediatricians or trained psychologists.

DASII

Developmental Assessment Scales for Indian Infants (DASII) is an Indian adaptation of the Bayley Scales of Infant Development (BSID) originally devised by Nancy Bayley. In India, the pioneering work of adaptation was done by late Dr. Pramila Phatak who published it first in 1970 as Baroda Norms. This was the outcome of longitudinal growth studies of children between 1-30 months, undertaken by the Child Development Department of M.S. University of Baroda. A final report of the study and established norms were published as second edition in 1987.

The DASII Scale in its present form is a revision of the Baroda norms with a major modification, where indigenous test materials are used for standardization and published in 1996.

The contents of the DASII are the same as used in the original study. The general approach in administration is retained. It also allows calculation of mental age and motor age of infants between one month upto 30 months of age and also gives a developmental quotient (DQ). In addition, the unique feature of DASII is the cluster profile and analysis which is a standardized method of comparing infants' development in various areas of functioning including mental and motor development.

The scales

The DASII scale is divided into motor scale and mental scale. The motor scale consists of 67 items and mental scale consists of 163 items. The motor development items cover the child's development from supine to erect posture, locomotion and basic locomotive skills such a climbing, jumping, skipping, etc. It also includes a record of manipulatory behavior such as reaching, picking up things, handling, pulling or throwing them in directed manner. The mental scale items record the child's cognizance of objects in the surroundings, perceptual pursuit of moving objects, exploring them to meaningful manipulation. It also covers the development of communication and language comprehension, spatial relationship and dexterity, imitative behavior and social interaction. Testing of infants with DASII requires standardized test materials as well as standard size furniture, a testing room, preferably sound proof and fitted with one way

mirror for observation.In short, it is very comprehensive tool that does not ignore any basic area of development during infancy.

Psychometric properties

(a) Validity: A cursory glance at the test items indicates their face validity. The increasing mean score as the chronological age increases, is noted as developmental validity of the scales. The motor and mental development during infancy progresses simultaneously. Hence the intercorrelations between the scores of the two sub scales are calculated as validity. The range of these correlations over 30 months was noted to be 0.24 to 0.62.

(b) Reliability indices (i) Test - retest reliability was tested by calculating coefficients of correlation between scores of consecutive month age groups, for both motor and mental scales. The coefficient for motor scale scores and mental scale scores range from 0.12 to 0.83 and 0.15 to 0.88 respectively. (ii) Split half reliability for mental and motor scores over 30 months varied from 0.49 to 0.95 and 0.70 to 0.95 respectively. The medial reliability index for motor scale is 0.88 and it is 0.91 for mental scales.

Norms

(i) Norms for use are presented by arranging the items in the scale in ascending order of median age placement (50%) of the items 3% and 97% age placements are also mentioned for each item as they indicate outer age-limits of item performance.

(ii) A developmental quotient is calculated for both motor score and mental score by using the formula Performance Age x 100
Chronological Age

(iii) Deviation quotients equivalent to total raw scores are listed for age group 1 to 30 months.

(iv) Percentile scores for boys, girls and the total group at each month are presented.

Description of scales

DASII scale is a point scale with items arranged in ascending order or age placement for both motor and mental scales.

The items in the two scales are classified into content clusters under different areas of development. There are five clusters of motor items and 10 clusters of mental items.

Motor clusters

I. Neck control

II. Body control

III. Locomotion I (Coordinated movements)

IV. Locomotion II (Skills)

V. Manipulation

Mental clusters

I. Cognizance (Visual)

II. Cognizance (Auditory)

III. Reaching, manipulation and exploring

IV. Memory

V. Social interaction and imitative behavior

VI. Language I (Vocabulary and comprehension)

VII. Understanding of relationship

VIII. Differentiation by use, shapes and movements

IX. Manual dexterity

The content clusters have great utility in clinical practice. They may be used in analyzing the child's performance in each area of development obtaining a profile of development with indication of areas of delay in development. It helps to plan intervention strategy with reference

to child's strengths and weaknesses. It aids in effective counseling of parents for home based stimulation program.

Differential diagnosis with DASII

It is possible not only to identify delays and areas of delays with DASII but cluster analysis can also help in differential diagnosis.

A Down's syndrome baby will have better motor than mental profile.

A high functioning autistic child will have almost normal motor profile and relatively low on mental but, especially low on language, social interaction. He is likely to do better on memory, understanding of relationships or form boards.

A cerebral palsy child will score low on motor items, imitative, skills but better on language development, especially receptive language. He may do poorly on timed items, like manipulation and manual dexterity clusters.

A child with low stimulational and early deprivation may show adequate score on motor but lower on mental clusters.

Thus, in trained hands, the DASII is a very comprehensive and effective tool often considered the gold standard for developmental assessment. It should be an integral part of any developmental clinic where effective intervention is planned.

Points to Remember

- ***Developmental assessment should be an integral part of NICU (Neonatal intensive care unit)***
- ***Developmental screening be done in all high risk infant as early as 3-6 months of age***
- ***DASII (Developmental assessment scales for Indian infants) is a very effective comprehensive and useful tool which is standardized in Indian babies***

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DEVELOPMENTAL PEDIATRICS

CLINICAL BASES FOR NEURO-DEVELOPMENTAL MONITORING OF PRE-SCHOOL CHILDREN

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***** Anna Mathew***

Abstract: *All children with neuro-developmental challenges would need screening to identify their abilities and needs. There are some clinical bases which this article proposes for neuro-developmental follow up of pre-school children. Some clinical issues in neuro-development, which need definition and explanation are also discussed here.*

Keywords: *Neurodevelopment, Clinical bases, Monitoring, Pre-school children.*

Every child has a neuro-developmental pathway starting from fetal life, influenced by the genetic, biological, environmental and epigenetic factors. A pediatrician is under obligation to perceive the neuro-developmental process in a child by understanding the clinical findings, which are of diagnostic or prognostic value. Most children who have neuro-developmental needs would have suffered from a cascading effect of the adverse factors. The causal pathway leading to the neuro-developmental adversity varies from one child to another, even when they have a common clinical profile. The clinical findings can clarify the causal pathway, which in turn can help to have a projection about the neuro-developmental course of a pre-school child. For the family, the clinician, the therapist, teachers and others closely involved with a pre-schol child, some clarity of the likely neuro-developmental journey would offer an added advantage in evolving an intervention plan and mode of therapy. As a child with neuro-developmental needs would require regular developmental examination, it is necessary to use measurable clinical indicators to monitor the developmental process.

The authors have used some clinical practices for the neuro-developmental monitoring of pre-school children, which are listed below:

Antecedental events, morphological state, head size, shape, sutures, infant behaviour, muscle tone, co-morbidities and bio-chemical screening and neuro-imaging.

1. Antecedental events

It has been observed that, some events occurring prior to pregnancy, during pregnancy, at child birth and during early and late neonatal periods affect the neuro developmental outcome.

The primary infertility and subsequent natural or assisted conception or repeated history of fetal losses in the first trimester are some historical events, we often pay attention to, while gathering the developmental history of a pre-school child. The parental age of 40 years or around it raises two challenges in clinical practice. The pregnancy and the child birth can be stressful for many

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mothers, needing intense antenatal care or intervention. The early infant-parent attachment process poses a challenge for the elderly parents as their parenting style is subject to many adaptations and adjustments that they anticipated least.

There is evidence to suggest that prematurity, low birth weight, intrauterine growth restriction, and birth asphyxia form a variety of neuro-developmental risk factors.[1]

When enquired from the parents about the consolability of these preterm infants around 6 months of age, it was found that parents hardly notice any difference in the response of their babies whether their mothers or someone else carried them. Early weaning also has adverse nutritional and developmental implications.

There is much awareness and care about reducing the risk of hyperbilirubinemia during the neonatal period. This is most commendable. In a retrospective review of data by the authors of 42 pre-school children referred for hyperactivity, the history of hyperbilirubinemia was present in 11 (26%) of them.There were some who received treatment such as phototherapy, blood transfusion or exchange transfusion.

During an examination for soft neurological signs of 249 pre-school children at 4 years of age, 12% children had three or more soft neurological signs in whom the birth weight was less than 2kg. where as only 6.3% of children above 3.5kg birth weight had the same.[2] There was significant association between the class room performance and the presence of cluster of three or more soft neurological signs in pre-school children. The soft neurological signs found to have a co-relation with neuro-developmental outcome were, mirror movements, dysdiadochokinesis, motor impersistence and choreiform movements.[3] When a random of thirty children from the earlier age group of 4 years, who had cluster of at least three soft neurological signs were re-examined at 8 years of age, 7 (23%) had persistence of three or more of the soft neurological signs and all of them were at the bottom of the class in activities which involved motor dexterity, attention and regulated behaviour.[4] There is a lot we still need to explore as to what contributes to a full compensation of the neuro-motor risk of pre-school children who were born preterm.

The antecedent events during the intrauterine and neonatal periods and support services of care for the new born are dependable indicators which can affect the neuro-developmental outcome during the pre-school years.

2.Morphological state

There are some morphological features which need more attention during the clinical examination of a pre-school child. The mid facial changes such as widely placed inner canthi, depressed nasal bridge, prominent philtrum, shape of the lips, mandible and the mouth are the commonest variations in those with different neuro-developmental disorders. These changes are common in most dysmorphic syndromes. But their presence should also alert us to look for other signs of facial sutural stenosis, branchial arch malformations or positional impact during the intra-uterine period. When these changes are associated with malformations of the hallux, pinna and tragus of one ear or both ears, there is heightened suspicion of something atypical. Absence of these in the parents or in the siblings or presence of other atypical morphological features in the trunk, hands and feet, genitalia or over spine in a pre-school child would call for a search for an intrauterine insult during the period of embryogenesis or organogenesis.

It is desirable to subgroup children with morphological variations into 3 categories.[5] Dysmorphological features, which are isolated variations usually confined to one part of the body alone. Dysmophological state, which refers to variations scattered in different parts of the body.

Dysmorphic Syndrome, when there is a constellation of features which corresponds to an already described syndrome or calling for a new syndromic description.

A common association we have come across is a "double hit" state. An examination of all the infants (145) who visited during a three year period, who suffered birth asphyxia, or neonatal infection, or hyperbilirubinemia revealed that 28 (19.3%) of them had features of a dysmorphic state. Only 4% of 564 preschool children of 3-5 years of age had a dysmorphologic state in a study conducted to look for presence of minor neurological dysfunction.[6] This difference is significant. It is an indication that the infants had suffered an insult during the intrauterine period and birth anoxia was an additional insult. A dysmorphologic screening during neuro-developmental examination becomes mandatory.

Morphological evaluation can be a pointer to what were to occur neuro-developmentally later in life !

3. Head size, shape and sutures

The Indian Academy of Pediatrics has widely popularised during the last 20 years, the seminal role of growth monitoring through anthropometric recording. Almost all pediatricians keep a record of the head circumference.

a. Shape of the skull. Any asymmetry of the head needs careful evaluation. Even the change in the shape of the skull caused by the preferred head positioning of the infant is significant, as that points to the paucity of the voluntary movements of the head, often due to muscle tone dysfunction. We photograph the shape of the head for comparison during the subsequent follow up visits, with the concurrence of parents.

b. Scalp skin. Normally it is not possible to pinch the scalp skin between the fingers except in some pathological conditions. But if it could be pinched easily or there were visible folds of skin over the occipital region, we associated it with slow or arrested growth of the head or a dysmorphological state. This could be co-related to the head size measurements.

c. Skull sutures. The sutures are not palpable over the scalp in infants and toddlers. If any of the sutures is palpable, it ought to be viewed with suspicion.

d. Anterior fontanalle. This is another sign which can be co-related well with the head size and premature closure of suture. In neuro-developmental examination it is necessary to measure the size of the anterior fontanalle and compare the measurements with the subsequent readings.

4. Infant behaviour

There are some behaviours of infants, we should value most, while observing their neuro-developmental pattern.

a. Attachment behaviour

All infants indicate an attachment pattern to the immediate care giver around 4 to 6 months of age, excepting the preterm or the low birth weight infants. When this has not evolved and infant cannot be easily consoled while being carried by the mother, it is rather unusual. The delay in developing attachment behaviour was also observed in infants who later developed cerebral palsy, visual insufficiency, hearing impairment, microcephaly or myoclonic epilepsy of infancy.

b. Sleep-wake behaviour

The sleep–wake behaviour of an infant has a predictable pattern and is common to most infants. A triology in infants of, state of disturbed sleep at night, frequent crying spells and fretfullness during the day and completely altered sleep-wake duration posed a challenge to find its

origin. A pleomorphic background rhythm, absent or sparse sleep spindles and asymmetrical voltage of discharges were noticed in the EEG of infants along with sleep disturbances. The common sleep related disturbances include sleep initiation dysfunction, frequent waking up with crying, regular body movements, jerky movements of body parts and crying spells. Infants have disturbed sleep-wake rhythm due to muscular hypertonia, visual insufficiency, electrical rhythm disturbance of the brain activity, behavioural disorders such as separation anxiety and autistic behaviour, etc. There seems to be some association with sleep-wake rhythm disturbance and electrical rhythm disturbance.

c. Play pattern

From about 4 months, the infants have a fascination for the mother's face, and also toys which produce visual or auditory or tactile stimuli. Most infants play interactively starting with an animated response to peek-a-boo from about 6 months of age. Soon they move on to reach out for objects, explore them visually or by mouthing them. By 6-9 months most infants are interacting actively with the environment, exploring by crawling around or playing reciprocally. There is a group of infants who show behaviours such as, playing constantly with their body parts and preferring to be left alone in the bed to being carried or playing socially or engage in exploring the environment. While interviewing parents of pre-school children, who have visual insufficiency or hearing impairment or autistic behaviour, epilepsy, etc, we have frequently heard parents talk about habitual self play of their children during infancy.

These are some behaviour indicators, which alert us about what is likely to emerge later.

d. Visual and auditory behaviour

There is a need to be definitive about the visual and auditory behaviour of the infants as they are critical developmental domains which will impact the evolution of other developmental sequences of infancy. While, ordering for evoked potentials for vision and hearing, which have become a standard practice in the new born follow up programme, they need to be interpreted in the context of clinical observation and other screening tests that are available. Catford Visual Acuity test to look for optokinetic nystagmus is most valuable, while screening an infant for cortical visual impairment. A fundus examination is necessary to understand a lot about optic nerve head, macula and retina. The acoustic emission testing is another valuable screening tool during the late new born period for hearing evaluation. Often a distraction test by using calibrated sound makers is enough to screen a 4 month old infant for hearing status.

5. Muscle tone

The muscle tone of infancy and toddler period can tell a lot about the neuro-developmental evolution of a newborn. Those newborns who are floppy or hypotonic and stay in that state, can have spinal or cerebral causes for hypotonia. The spinal hypotonia can be due to an anterior horn cell disease, neuromuscular disorder such as myasthenia gravis, muscle disease such as myopathy or due to peripheral nerve diseases. In all of these clinical conditions, the deep tendon reflexes are not elicitable or depressed. Where as, when there is cerebral hypotonia, which is the initial phase following an upper motor neuron insult, the deep tendon reflexes are still elicitable or exaggerated.

The persistent cerebral hypotonia extending into late infancy or toddler period would warrant examination for arrested myelination or demyelination of the central nervous system or a silent traumatic injury to the cervical cord or presence of spinal dysraphism. It is necessary to do the MRI of brain, test the somato-sensory

evoked potential and do nerve conduction velocity and EMG and order for biochemical and metabolic screening, when an infant is persistently hypotonic.

The state of cerebral hypertonia is lot more easier to assess, treat and interpret. The hypertonia can be either spasticity or rigidity or both. An interim phase of the dystonic posturing of the limbs is a phase before the emergence of spasticity in some infants who would go on to show signs of cerebral palsy later.[7] This needs to be separated from dystonia manifesting as an involuntary movement, associated with an injury to the extrapyramidal system. The dystonic phase of spasticity often manifests during voluntary movement, unlike the dystonia of extra pyramidal system, which is present except may be during sleep.

A third category of infants are those who have transient hypertonia of the newborn.[8] There is therefore a subgroup of infants with transient cerebral hypertonia, who would show partial or full recovery of tone over a period of time. However, even this group should receive muscle relaxants, splinting of the ankle joints, positional support for better posture and muscle relaxation exercises.

There was a surprise finding awaiting us at the end of a double blind study in 1999, when using a single bed time dose of diazepam as a muscle relaxant in a group of randomly chosen children below five years, who had spasticity due to cerebral palsy.[9] There was a remarkable improvement in the range of movements at the ankle joints of those who received diazepam, which was statistically significant.[10] These findings show that pharmacological intervention is needed right from the start. Muscle relaxants and exercise regime would aid recovery or offer some respite from spasticity and promote well being of infants.[11] It seems that any therapeutic intervention to counter spasticity during the period of neuro-matuarational phase in children fosters better recovery.

The examination of the state of the muscle tone of infancy is a dependable clinical method for neuro-developmental monitoring. A goniometer (an instrument for measuring angles) is all that one would need to keep a record of the range of movements at the ankle joints.

6. Co-morbidities

There is an increasing awareness about the adverse effects of seizure activity, gastro-oesophageal reflux disease, hypo-thyroidism, protein energy malnutrition, anemia, rickets, etc. on the developmental evolution of pre-school children.

The pre-school children with cerebral palsy can be classified into two groups: the first group with, cerebral palsy, electrical rhythm disturbances and co-morbidities such as behavioural dysfunction, sleep dysfunction and any other co-morbidity except epilepsy and the second group with only cerebral palsy and electrical rhythm disturbances and no other co-morbidity.

Children who have electrical rhythm disturbances, parental anxiety on account of the behaviour of their pre-school children for 4 months or more and persistent clinically stationary neuro-motor findings but developmentally stagnant could be the three possible criteria for starting the anti-convulsant therapy initially for 6 months in pre-school children. The decision about duration of treatment or continuation of treatment has to be based on initial response to the treatment.

The second group of the pre-school children who have had only electrical rhythm disturbances and cerebral palsy with no co-morbidities have also been similarly reviewed to arrive at a rational approach.

The screening of co-morbidities in pre-school children with neuro-developmental needs commences with high degree of suspicion.

7. Biochemistry and neuro-imaging

There are some relatively easy laboratory tests, we have found useful while screening pre-school children for neuro-developmental disorders. A regular estimation of the thyroid stimulating hormone (TSH) once in 6 months, when children have obesity, constipation or are on treatment with sodium valproate or show sudden decline in growth velocity. It is advisable to screen TSH in children with Down's Syndrome once in every six months. There is a need to estimate IgE level in all children who have airway disease or autistic spectrum disorder,[12] which may help in screening the source and impact of allergy in the body. There is an undisputable association between atopic state and hyperkinesis or impulsivity or both in children with or without autistic spectrum disorder. The metabolic screening and hormonal assays are more demanding, which too have significant application in neuro-developmental disorders.

The neuro-imaging of brain, MRI, in developmental follow up of pre-school children has come to stay as an essential screening and diagnostic tool in our practice.[13] There is a need to use MRI spectroscopy, functional MRI imaging, volume studies, etc more widely and circumspectly to interpret the long term impact of the neuro-developmental disorders in the developmental profile of pre-school children. The finding of mesial temporal sclerosis in the MRI of a child with refractory seizure disorder would call for surgical option in the treatment of epilepsy. There is an increasing application of MRI brain in screening of children for learning disorders. The positron emission tomography with its wider scope to study the neuro-metabolism has yet to find its application in pre-school children in India.

Points to Remember

- ***The neuro-developmental monitoring of pre-school children would need a scheme and a plan***
- ***There is a need for more organized care of children with neuro-developmental needs by a dedicated team of specialists as all other sub-specialities in pediatrics have moved on to develop a short or long term training programme to create a cadre of specialists in their respective subspecialties.***

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CLIPPINGS

Neul SK, et al. Health-related quality of life functioning over a 2-year period in children with end-stage renal disease. Pediatric Nephrology Oct 2012.

This study reports the first data on longitudinal change in global and disease–specific health–related quality of life pediatric end stage renal disease patient and proxy ratings over four assessment periods spanning approximately a 2–year period. Patient ratings on global health and physical activity, emotional, and social and disease–specific worry and communication domains were higher than parent–proxy ratings, confirming the importance of obtaining both sources of information. Patients on dialysis longer, particularly females, reported worse emotional functioning; females also reported more physical appearance concerns.

Kizilca O, et al. Risk Factors for Community-Aquired Urinary Tract Infection with ESBL-Producing Bacteria in Children. Pediatrics International. 08/17/2012.

Recognition of the risk factors for extended–spectrum beta–lactamases [ESBL]–producing bacteria may be helpful to determine new policies in management of urinary tract infection. These results suggest that recurrence of UTI should be prevented especially in the first year of life and prophylactic use of cephalosporins should be avoided. Age below 1 year, high recurrence rate of UTI, long duration of prophylaxis, using cephalosporins for prophylaxis, having been hospitalized in the past 3 months and intermittent catheterisation were found to be significant risk factors for ESBL producing bacteria.

DEVELOPMENTAL PEDIATRICS

CO-MORBIDITIES OF CEREBRAL PALSY AND DEVELOPMENTALLY CHALLENGED CHILDREN

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***** Naveen Sankhyan***

Abstract: *Most children with developmental disability have lifelong impairments. The pediatrician caring for these children has to ensure multidisciplinary liaison and a systematic evaluation of impairments and the various co-existing co-morbidities which often cause limitation of activity. The common co-morbidities that are encountered in these children include; epilepsy, behavioural and psychological problems, gastrointestinal problems such as gastroesophageal reflux, poor nutrition, sensory deficits such as vision and/or hearing loss, poor bone health, sleep problems and others. A systematic screening and management of these problems is essential for improving the functional status of the child, and ensures optimum participation and integration of these children in the family and community.*

Keywords: *Rehabilitation, epilepsy, impairments, activity limitations*

Developmental disabilities are a diverse group of severe chronic conditions that are characterized by impairment in the various sectors of development of a child and are associated with mental and/or physical impairments. People with developmental disabilities have problems with major activities such as language, mobility, learning, self-help and independent living. Developmental disabilities begin anytime during development and usually last throughout a person's lifetime. The term "developmental disability" encompasses intellectual disability but also includes physical disabilities. Some developmental disabilities may be solely physical, such as blindness from birth. Others involve both physical and intellectual disabilities stemming from genetic or other causes, such as Downs syndrome and fetal alcohol syndrome.[1] Many developmental disabilities have no permanent cure, but a lot can be done to reduce the impairments resulting from the underlying condition. For the purpose of this review we would focus on the common co-morbidities seen in children with cerebral palsy. The problems encountered by these differently-abled children depend on their underlying disorder. However, the principles of management are generally similar across different developmental disabilities. It is important to be aware of the definitions used in relation to understanding and managing disabilities.

Definitions

'Impairments' are defined as "problems in body function or structure as a significant deviation or loss". The definition for 'Activity limitations' is "difficulties an individual may have in executing activities" and 'Participation restrictions', refers "problems an individual may experience in involvement in life situations".

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Epidemiology

Co-morbidities in cerebral palsy (CP): Depending on the type of cerebral palsy, 25-80% of children with CP have additional impairments (Table I). A large proportion has some level of intellectual impairment; the prevalence varies with the type of CP and especially increases when epilepsy is present. Epilepsy is present in 20-40%; it is most common among children with hemiplegic or quadriplegic CP. Up to 80% have at least some impairment of speech. Low visual acuity is reported in almost three-quarters of all children. Half of all children have gastrointestinal and feeding problems. Stunted growth occurs in a quarter, while under or overweight problems are present in half of the children. Chronic pain is reported by more than a quarter of the adults.[2,3]

Co-morbidities in intellectual disabilities: In a recent systematic review of 31 studies, the prevalence rates of chronic health conditions in populations of children with intellectual disability was provided. The 6 most prevalent chronic health conditions in children with intellectual disability were epilepsy (22.0/100), cerebral palsy (19.8/100), any anxiety disorder (17.1/100), oppositional defiant disorder (12.4/100), Down syndrome (11.0/100), and autistic disorder (10.1/100).[4]

Epilepsy

Epilepsy is one of the most common comorbidities seen in children with cerebral palsy or intellectual disabilities. It is seen in about a third of children with CP [3]. The type and severity of epilepsy correlate with the type of cerebral palsy. It is often difficult to treat particularly in children with associated mental retardation. Early and adequate treatment of epilepsy can result in better intellectual outcomes in those children who are affected. A high degree of suspicion is required in infants who can have varied manifestation of

Table I. Common co-morbidities in children with cerebral palsy

Neurological system
Intellectual disability
Epilepsy
Behavioral problems
ADHD
Gastrointestinal system
Palatopharyngeal in-coordination
Drooling
Dysphagia
Gastroesophageal reflux
Constipation
Nutritional
Under nutrition
Obesity
Ophthalmological
Strabismus
Refractive errors
Visual impairment
Hearing, Speech and Language
Hearing loss
Articulation problems
Language delay
Musculoskeletal
Contractures
Bony deformities
Poor bone health
Genitourinary
Urinary tract infections
Miscellaneous
Sleep disorders
Dental caries
Recurrent infections
Psycho-social problems
Social isolation
Poor self esteem

seizures like infantile spasms or myoclonic jerks. The principles of treatment of epilepsy in children with disabilities remain the same as in those without disability. Ideal treatment for developmentally-disabled children with epilepsy entails maximal seizure control without any significant adverse effects from the anti-epileptic drugs and good quality of life. Antiepileptic drugs related cognitive and behavioral adverse effects tend to occur more frequently in these children. Careful selection of the appropriate medication and close monitoring for drug adverse effects is important.[5] However care has to be taken to avoid drugs which results in excessive sedation like phenobarbitone and benzodiazepines. In children with drooling use of benzodiazepines has to be avoided.

Behavioural problems and ADHD

Children with intellectual disabilties, pervasive developmental disorders and genetic syndromes frequently have comorbid behavioural problems and/or attention-deficit/hyperactivity disorder (ADHD) or ADHD-like symptoms. Early preventive measures include guidance of the parents to promote a positive-parent child relationship. Involvement of a child psychologist can help assess and address these developmental and behavioral issues early in life.

While there are no pharmacological cure for these developmental disorders, co-existing ADHD and ADHD like symptoms that contribute to difficulties in psychosocial functioning can frequently be managed with pharmacotherapy.[6] The agents used to treat ADHD in normally developing children appear to have some degree of benefit when given to pediatric patients with developmental disorders. However, a cautious approach of starting with a low dose medication and a slow upward titration is recommended, particularly owing to the vulnerability of the population and the relative paucity of data.[6]

Gastrointestinal problems

These are encountered in at least one third of children with cerebral palsy (CP). These include feeding and swallowing disorders (with associated chronic pulmonary aspiration), regurgitation and vomiting, abdominal pain and constipation(Table II). Dysphagia is a problem in more than half of children with CP. It is closely related to the severity of the neurological impairment.[7] Oral motor dysfunction is a major contributing factor to limited food intake and clinically significant malnutrition in children with moderate to severe CP.[8] Nutritional impairment from limited food intake is frequently further aggravated by a host of other factors including impaired communication, immobility, medication, constipation and excess fluid and electrolyte losses following vomiting and gastro-esophageal reflux. A feeding gastrostomy should be considered in severely impaired children who have an unsafe swallow, are unable to maintain a satisfactory nutritional state by oral feeding alone, have an inordinately long (> 3 h/d oral feeding time) or are dependent on nasogastric tube feeding.[9] Drooling and aspiration pneumonia are other direct consequences of oral motor dysfunction. Uncoordinated swallowing increases the risk of pulmonary aspiration which may or may not be heralded by recurrent coughing and choking with feeds. Drooling can be a very difficult management problem. A range of treatments have been tried including medications such as anticholinergic drugs (benztropine, glycopyrrolate and benzhexol hydrochloride), botulinum toxin and surgery to alter or eliminate salivary gland function.[10] Gastroesophageal reflux (GER) is common in children with cerebral palsy and occurs in 19-75% of cases.[11] Central nervous system dysfunction is the prime cause of this high incidence of GER in children with CP while additional contributory factors include hiatus hernia, prolonged supine position and increased intra abdominal pressure secondary to spasticity,

Table II. Gastrointestinal co-morbidities in children with cerebral palsy

Problem	Management options
Drooling	• Anticholinergic drugs • Intraglandular botulinum toxin • Surgery
Gastroesophageal reflux disease	• Appropriate posture • Small volume frequent thickened feeds • Proton pump inhibitor therapy • Surgery
Constipation	• Ensuring adequate fibre and fluid intake • Judicious use of stool softeners such as lactulose • Sodium citrate or sodium acid phosphate enemas for dis-impaction with or without topical lignocaine

scoliosis or seizures. The consequent esophagitis often becomes a chronic symptom and may progress to mucosal ulceration and stricture formation. Appropriate posture, proton pump inhibitor therapy to reduce acid content, small volume frequent thickened feeds and use of whey predominant enteral milk formulae are interventions which can help.[12]

Constipation is another common comorbidity in children with severe CP. Contributory factors include prolonged immobility, skeletal abnormalities, extensor spasm or generalized hypotonia, as well as abnormal bowel motility associated with neurological lesions. Dietary factors such as low fibre and fluid intake (often due to associated feeding difficulties) are important contributors. The use of anticonvulsant, opioid, antispasmodic, antihistamines or aluminum antacid medications in disabled children may also predispose to constipation.[13] Management of chronic constipation aims to evacuate retained feces followed by maintenance therapy to ensure defecation is regular and painless. In children with constipation, the approach is to ensure the regular passage of soft stool. Initial attention should be directed towards dietary manipulations. Once dietary issues have been addressed, a stool softener such as lactulose may be used. The use of preparations containing polyethylene glycol or mineral oil should be avoided in children with concomitant neurological abnormalities and gastroesophageal reflux due to the significantly increased risk of aspiration.[14] In children with rectal impaction and megarectum, disimpaction should be attempted first. The use of sodium citrate or sodium acid phosphate enemas is an effective way to clear the rectum before commencing stool softeners and stimulant medication. In children with an anal fissure, treatment should first relieve constipation with the use of stool softeners. Topical lidocaine may lessen pain on defecation.

Visual problems

The severity of visual dysfunction in cerebral palsy may be quite variable, which can range from mild to severe. Half the children have strabismus, refractive errors; some children may have nystagmus and optic atrophy. Among the refractive errors hypermetropia and astigmatism are most common It is important to correct any significant refractive error, especially hypermetropia, since it is common and related to reduced ability of the focusing system. Reduced visual acuity can be helped by;

- Increasing the size and/or proximity of text and images
- Limiting distraction while interacting and teaching
- Using short teaching sessions to avoid tiredness
- Using thick tipped pen or pencil to match the acuity
- Using toys and educational material that are bright, colorful with clear boundaries and good contrast

Many children with cognitive problems have visual dysfunction due to damage to areas processing visual information. Dysfunction manifests as impaired reaching, knocking over object, impaired perception and impaired identification of moving objects. Hence these children should not be shown TV programmes with rapid movements like cartoons. Educational material must be adapted accordingly, care should be taken when these children encounter traffic and cross roads. These children function well in familiar environments. Strabismus is another frequent co-occurrence and management of strabismus can aid the visual functions as well as the appearance of the child. An early detailed ophthalmic assessment and continued liaison with an ophthalmologist helps in optimizing the visual function of these children.

Hearing impairment

Variable loss of hearing can accompany CP and other developmental disorders. It can result from senori-neural impairment (intrauterine infections, kernicterus, meningitis) or from central auditory impairment (kernicterus). An assessment of hearing in early infancy is indicated in all infants with risk factors for hearing loss. All infants and children with a significant hearing loss must be fitted with hearing aids by trained audiologists. Periodic checking of hearing aids to ensure that a constant appropriate level of sound is being heard by the child is very important. Serial monitoring of hearing is required as the hearing loss may progress postnatally (in certain conditions such as CMV infection) .Carefully selected patients can be offered cochlear implants. Cochlear implantation should be considered promptly as early as the age of 6 months if the hearing loss is severe or profound. The implants have to be supplemented with hearing and speech rehabilitation. Cochlear implant unit requires close monitoring of calibration and performance and children require intensive long-term speech and language training if they are to achieve good speech comprehension and output.

Bone health

Children with CP have poor bone mass. This is secondary to multiple factors such as spasticity, immobilization, weakness, drugs and contractures. Associated epilepsy requiring prolonged anti-epileptic drugs that affect bone mass further contribute to reduced bone density. Encouraging physical activity, ensuring adequate nutritional status and use of Vitamin D and calcium supplements have been shown to improve bone health in these children.

Sleep problems

Sleep problems are common in developmentally disabled children. The various contributing factors may include airway obstruction, nocturnal seizures, spasticity, pain, inappropriate orthosis, gastroesophageal reflux and blindness. In a recent study nearly half of the children with CP had sleep problems.[15] Children with spastic quadriparesis, dyskinetic CP and severe visual impairment are significantly more likely to have sleep problems. The evaluation and management have to be individualized. In most children addressing the underlying cause of the sleeping problem (eg. management of pain, seizures, reflux, etc) is the most important step to improve sleep.

Conclusions

Most children with developmental disability have lifelong impairments. The primary physician caring for these children is at the core of care provision. A multidisciplinary liaison and a systematic evaluation of impairments and the often co-existing co-morbidities are essential. This enables the reduction in activity limitation and ensures optimum participation and integration of these children in the family and community. All these efforts result in the maximal enablement of the disabled.

Points to Remember

- ***Most children with developmental disabilities have additional co-morbidities depending on their underlying disorder***
- ***The common co-morbidities include; epilepsy, gastrointestinal problems like gastroesophageal reflux, poor nutrition, sensory deficits like vision and/or hearing loss.***
- ***A systematic screening of these problems is important to identify these, often hidden problems***
- ***Most of these co-morbidities when properly managed can significantly improve the quality of life of both the child and the care givers.***

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CLIPPINGS

Zinc for the common cold

The common cold is often caused by the rhinovirus. It is one of the most widespread illnesses and is a leading cause of visits to the doctor and absenteeism from school and work. Complications of the common cold include otitis media (middle ear infection), sinusitis and exacerbations of reactive airway diseases. There is no proven treatment for the common cold. However, a medication that is even partially effective in the treatment and prevention of the common cold could markedly reduce morbidity and economic losses due to this illness.

Zinc inhibits rhinoviral replication and has been tested in trials for treatment of the common cold. This review identified 15 randomized controlled trials, enrolling 1360 participants of all age groups, comparing zinc with placebo (no zinc). We found that zinc (lozenges or syrup) is beneficial in reducing the duration and severity of the common cold in healthy people, when taken within 24 hours of onset of symptoms. People taking zinc are also less likely to have persistence of their cold symptoms beyond seven days of treatment. Zinc supplementation for at least five months reduces incidence, school absenteeism and prescription of antibiotics for children with the common cold. People taking zinc lozenges (not syrup or tablet form) are more likely to experience adverse events, including bad taste and nausea. As there are no studies in participants in whom common cold symptoms might be troublesome (for example, those with underlying chronic illness, immunodeficiency, asthma, etc.), the use of zinc currently cannot be recommended for them. Given the variability in the populations studied (no studies from low- or middle-income countries), dose, formulation and duration of zinc used in the included studies, more research is needed to address these variabilities and determine the optimal duration of treatment as well as the dosage and formulations of zinc that will produce clinical benefits without increasing adverse effects, before making a general recommendation for zinc in treatment of the common cold.

Zinc administered within 24 hours of onset of symptoms reduces the duration and severity of the common cold in healthy people. When supplemented for at least five months, it reduces cold incidence, school absenteeism and prescription of antibiotics in children. There is potential for zinc lozenges to produce side effects. In view of this and the differences in study populations, dosages, formulations and duration of treatment, it is difficult to make firm recommendations about the dose, formulation and duration that should be used.

Singh M, Das RR. Zinc for the common cold. Cochrane Database of Systematic Reviews 2011, Issue 2. Art. No.: CD001364. DOI: 10.1002/14651858.CD001364.pub3.

GENERAL ARTICLE

SPECIAL CONSIDERATIONS OF FLUID AND ELECTROLYTES IN PICU

*Meera Ramakrishnan

Abstract: *Management of fluid and electrolyte disturbance is an integral part of ICU care. Disturbances of electrolyte can be from the intracellular or extracellular compartment. Sodium is predominantly an extracellular cation. Alteration in serum sodium is often accompanied by change in the volume of extracellular fluid. The volume status of the extracellular space is as important in managing the different types of sodium abnormality as the serum sodium itself. This article goes over the advantages of different types of crystalloids and colloids and most common electrolyte abnormality seen in PICU.*

Keywords: *hyponatremia, hypernatremia, tonicity, osmolarity, crystalloid, colloid, osmolality, hypoglycemia,hyperglycemia, diabetes insipidus, hypovolemia, hypervolemia*

Electrolyte disturbances affect the function of various organ systems of the body. Dyselectrolytemia can cause altered sensorium, seizures, coma and death. They can affect breathing by decreasing the muscle strength, affect cardiac function and lead to shock. All these conditions are managed in the ICU and hence an intensivist has to be comfortable in the management of shock and dyselectrolytemia. This review article will go over the advantages and disadvantages of various fluids in restoring circulating volume and maintaining circulating volume. Electrolyte disturbances are too vast to be covered in a single article and hence in this review, only some of the most common problems seen in the ICU are dealt with.

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Volume expanders

Fluid management starts with assessing volume status of the patient. This is followed by correction of volume deficits and maintenance of intravascular volume.

Total body water is distributed between intracellular (40%) and extracellular (20%) compartments. Of this 20% in the extracellular space the interstitial fluid constitutes 75% and intravascular space constitutes 25% of the total water. The movement of water across cell membranes depends on the osmotic pressure and tonicity of the plasma. Hence, in order to increase the plasma volume one would need both tonicity and hence sodium and osmotic pressure and hence high molecular weight proteins (Table I). The ideal volume expander should be easily available, cheap and remain predominantly in the intravascular compartment. The search for such an ideal fluid is on despite decades of research.

Contrary to beliefs expecting a ratio of 4:1 or more for crystalloid to colloid volume need, recent studies of goal-directed resuscitation observed much lower ratios of between 1 and 1.6.[5] With all this knowledge it no longer appears to be reasonable to use colloids for resuscitation of shock.

Table I. Various fluids and the mechanism of action

Fluid	Mechanism of action	Advantage	Facts
Normal saline	Increases the tonicity of plasma.	Easily available, cheap	• Out of 1 litre of normal saline used only about 250 ml remains in the plasma.[1] • Indiscriminate use causes tissue edema that can affect tissue oxygenation adversely.[2] • Can cause hyperchloremic acidosis
Ringers lactate	Increases tonicity of plasma. Can correct acidosis. May improve cardiac contractility because of the presence of calcium.	Easily available, cheap. Physiologic with regards to the level of sodium	• Caution in patients with potential renal failure. • Can precipitate with citrate in blood products. • Can worsen lactic acidosis in liver dysfunction or hypoperfusion, • May increase the proinflammatory cytokine production in large amounts.[3,4]
Albumin	Natural colloid. More effective vascular volume expansion. Interaction with endothelial glycocalyx in addition to increase in osmotic pressure responsible for its effect	Safe.Expensive-6 times the cost of normal saline	• The Saline versus Albumin Fluid Evaluation (SAFE) study conducted in nearly 7000 critically ill adult patients provided conclusive evidence that albumin use did not give any overall benefit[5] • Subgroup analysis of the albumin-treated group revealed a trend towards decreased mortality in patients with septic shock, • A trend towards increased mortality in trauma patients, especially those with traumatic brain injury.
Hydroxyethyl starch	Major component is amylopectin, which has been partly hydroxyl-ethylated to increase solubility.	Less expensive than albumin	• Has been shown to have anti-inflammatory effect. • Can cause nephrotoxicity especially in sepsis[6]. Associated with coagulopathy

Maintenance fluid

Once volume expansion has been completed, it is appropriate to provide enteral nutrition as soon as feasible. Stress increases catabolism. Early feeding can to some extent reduce the complications associated with stress.

In situations where it may not be feasible to start feeds, maintenance intravenous fluids have

to be started. Holliday Segar proposed in 1957 fluid requirements for healthy children, which was based on the caloric needs. Their proposal is still followed widely as the 4/2/1 rule to calculate the hourly fluid needs of the patient. It is however not possible to have a uniform rule that applies to all. Ideally the fluid chosen should match the patient's urine output and insensible loss. Any additional fluid lost needs to be replaced with a fluid that matches the content of the fluid lost.

Nausea, vomiting, pain, stress, positive pressure ventilation, use of opiates, etc are common non-osmotic stimuli for the release of anti diuretic hormone (ADH). This leads to the retention of fluid and hyponatremia. Studies have shown that use of hypotonic fluids for more than 6 hours increases the risk of hyponatremia and if not checked early enough can cause seizures and irreversible brain damage.[7,8] The solution to this problem is using the amount of fluid that matches the patient's needs, administration of isotonic fluids, careful monitoring of patient's hydration status and monitoring serum electrolytes. 5% dextrose should routinely be added to maintenance fluids to prevent ketosis. Maintenance potassium is usually around 20mEq/L provided there is no reason for suspecting hypo or hyperkalemia.

Glycemic control

Hypoglycemia and hyperglycemia can occur in a critically ill patient and have been associated with worse outcomes.[9] The cause of hyperglycemia in critical illness is multifactorial. Insulin resistance, absolute insulin deficiency, glycogenolysis and increased hepatic gluconeogenesis all play a role in the development of hyperglycemia. Both endogenously released and exogenously administered catecholamines, cortisol, further aggravate the gluconeogenesis.[10] Hyperglycemia is associated with increased length of hospital stay, prolonged need for mechanical ventilation, worse neurologic sequelae in brain trauma and even increased mortality. In adults strict glycemic control between 80-110 mg/dL has become the standard of care. In children optimum glucose levels is still debatable. Most intensivists however will maintain glucose levels below that of the renal threshold.

Common dyselectrolytemia

Hyponatremia: It is one of the most common electrolyte abnormalities in hospitalized children. Hyponatremia is defined, as a serum sodium level less than 135mEq/L. Clinical symptoms are however not usually seen until serum sodium falls below 120 mEq/L. Symptoms are dependent more on the rapidity of change in serum levels rather than the absolute sodium level. Manifestations include altered mental status, vomiting, seizures, hemodynamic compromise and in some cases death.

In order to understand and manage different types of hyponatremia, it is important to understand about tonicity and osmolarity. Osmolarity and osmolality are often used interchangeably in clinical practice and in this article. It is defined as number of osmoles of a solute in a litre/kilogram of solvent. The extracellular fluid has an osmolarity of 275-290 mOsm/kg.

Tonicity is the ability of a fluid compartment to draw fluid to itself. Some solutes, chiefly urea and glucose can easily cross membranes and thus are ineffective osmoles.

Hyponatremia is classified both according to the tonicity of ECF and total body water (Fig 1). On the basis of the tonicity of the ECF there can be hypertonic, hypotonic or isotonic hyponatremia.[11,12]

Hypertonic hyponatremia: This occurs when there is an accumulation in the ECF compartment

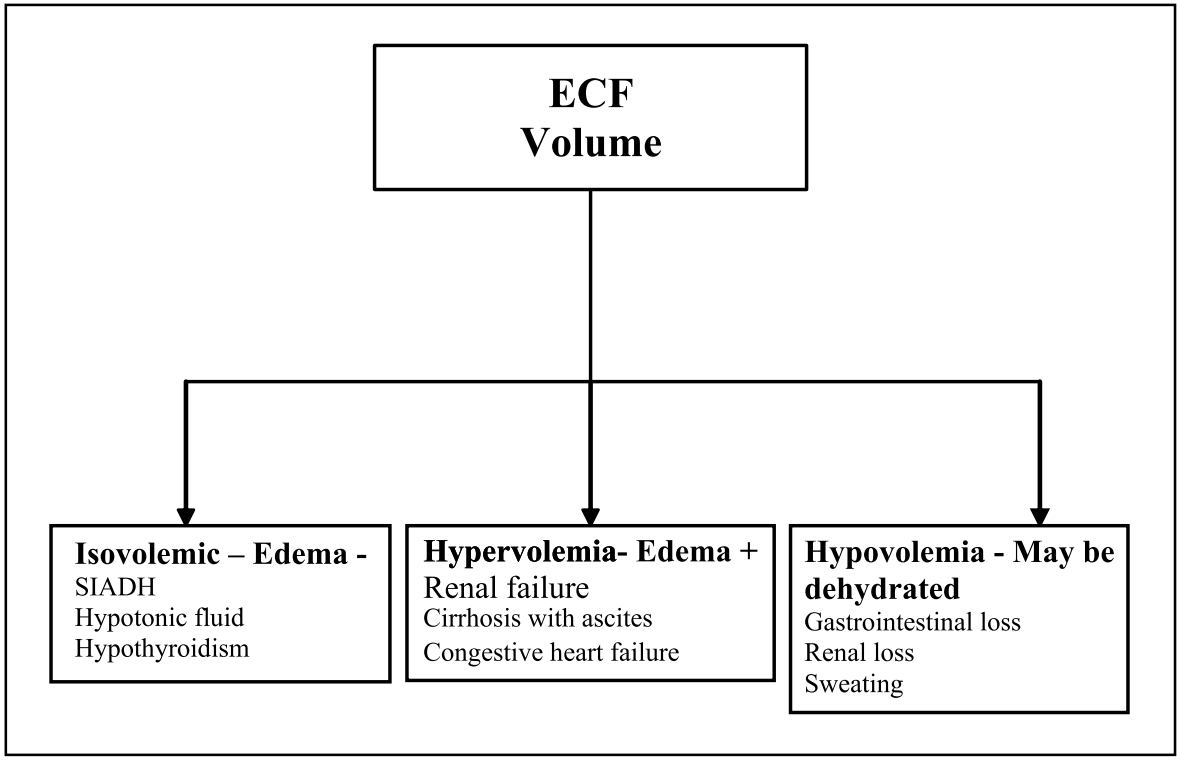

Fig.1. Classification of hyponatremia on the basis of ECF status. This is clinically categorized to these groups based on the presence of edema, dehydration or both absent

of effective solutes other than sodium that can cause a shift of fluid from ICF to ECF. For example high concentrations of glucose in diabetic patients or exogenously administered mannitol or glycerol.

Isotonic hyponatremia: In this situation there is no disturbance in body fluid tonicity and almost always occurs because marked hyperlipidemia or hyperglobulinemia interferes with laboratory techniques for measurement of serum sodium. Since the actual serum sodium is normal it is called as pseudohyponatremia. This is characterized by normal measured osmolality and low calculated osmolality. Osmolality is measured in the laboratory using freezing point depression which will be normal .The calculated osmolality using the formula-2xNa + glucose/18+ BUN/2.8 will be low, because the laboratory estimated sodium is spuriously low.

Hypotonic hyponatremia: It is the most commonly seen hyponatremia and indicates that the tonicity of the ECF is low in comparison to the ICF. Water hence goes into the cell leading to intracellular edema-the most worrisome being cerebral edema. Once hyponatremia is confirmed the volume status of the patient is assessed to determine the cause and treatment of hyponatremia.

Treatment: The treatment of hyponatremia is determined by 3 major factors: a) severity of hyponatremia, that is, the presence or absence of severe central nervous system symptoms such as lethargy, delirium, seizure and coma; b) onset

of hyponatremia: acute (within 48 hours) or chronic (beyond 48 hours); and c) volume status.

A dose of 5 mL/kg of 3% saline should be given over 10 to 15 minutes if significant symptoms such as seizures or coma are present. This should raise the sodium level by approximately 3-5 mEq/L. Raising the sodium by a few mEq is adequate to stop seizures. After acute correction of symptoms the goal is to raise the sodium level slowly at a rate of 0.5 mEq/L per hour (maximum, 12 mEq/L per day) by using 0.9% normal saline infusion

In a non-emergent setting the management should be geared towards the underlying cause of hyponatremia. Detailed history and physical examination is very important to establish the cause of hyponatremia. Laboratory values like blood urea nitrogen, creatinine, uric acid and urine spot sodium may be required to determine the volume status of the individual

Hypertonic hyponatremia : The actual sodium is calculated using the formula (1.6 x serum sugar in 100 greater than 100mg/dL) + measured sodium. For example if the patient's blood sugar is 1000 and measured sodium is 125, then the corrected sodium is 9x 1.6 + 125= 139.4

Hypotonic dehydration: In this, calculation of the sodium deficit is as follows: Na in mEq needed = 0.6 × weight (kg) × (Na desired - Na measured). The deficit sodium + maintenance sodium is given to correct the fluid deficit such that the rise of sodium is about 0.5 mEq/ L/hr. For example if a 10Kg child is noted to be 10% dehydrated and has a serum Na of 125, the correction will be as follows-

Maintenance sodium is 4mEq/kg /day = 40 mEq

Deficit sodium is 90 mEq (wt x 0.6x 15).

Total fluid deficit = 1 litre

Maintenance fluid = 1 litre

Thus we need a total of 130 mEq of sodium to be given with 2 litre of fluid. This can be best achieved using 0.45 % NS (at a rate of 80 mL/hour). This is an approximate starting point. Checking serum electrolytes every 4-6hours should be sufficient to monitor the rate of correction. The rate of administration will have to be decreased if the correction is rapid .

Hypervolemic hyponatremia: In this, the first step is to calculate the free water excess (FWE). If we assume that total body water (TBW) = 0.6 × body weight and that there is no true serum sodium (SNa) deficit, FWE can be calculated as: FWE = TBW × Wt x (140–SNa) /140.

By matching the FWE to the decrease in SNa, one can estimate how much free water removal will correspond with this 12 mEq/L in 24 hours.

For example, a 10-kg patient with a SNa of 110 mEq/L would have an estimated FWE of 1.28 litre. In order to correct serum sodium at a rate of 12mEq/day, one has to reduce this free water over a period of 2 days. Thus 0.65 liters of water has to be removed in 24 hours. This can be achieved by giving an appropriate dose of frusemide. This is usually 1-2 mg/kg given every 6-8 hours. The urine that is thus produced has approximately 70-to 80 mEq/L of sodium. Replace half the volume of urine output with normal saline thus the remaining half that is not replaced is essentially free water that is removed. Monitor the serum electrolytes every 4-6 hours to determine if the rate of correction is appropriate and also to add appropriate amount of potassium to avoid hypokalemia.

Isovolemic hyponatremia[10]: One of the most common causes of hyponatremia in the pediatric ICU is syndrome of inappropriate antidiuretic hormone (SIADH). Many illnesses like pneumonia, meningitis and multiple drugs used in ICU are associated with SIADH. If hyponatremia occurs in a setting where SIADH is suspected

then it is important to determine how concentrated the urine is. Urine and serum osmolality is simultaneously obtained. When serum osmolality is less than 275, the urine has to be maximally diluted and the urine osmolality should be less than 100. If the urine osmolality is greater than 100 in the presence of hyponatremia, SIADH should be suspected. Urine sodium should be also checked. If urine sodium is less than 30 mEq/L, there is a possibility that the patient is hypovolemic and hence volume replacement using normal saline should be tried. The treatment of SIADH consists of fluid restriction to half to two third maintenance. Using sodium to correct hyponatremia may worsen the hyponatremia by causing additional water gain. In case of life threatening hyponatremia, the management would consist of using frusemide and replacing the urine losses with one-third the volume of hypertonic saline. By this way the amount of free water loss obtained is greater.

Hypernatremia

Hypernatremia is defined by serum Na^+ of more than 145 mEq/L and is a result of excess total body sodium, limited free water intake or free water loss.[10,11,12]

Excess salt intake is due to improper administration of formula feeds, improper preparation of oral rehydration solutions and administration of hypertonic saline or excessive use of sodium bicarbonate.

Free water deficits are by far the most important reason for hypernatremia in the ICU. These are mostly due to diarrhea, sometimes due to use of diuretics and excessive renal loss of hypotonic fluid as in central or nephrogenic diabetes insipidus.

Clinical manifestations

The intravascular volume depends on the tonicity of the plasma. Since the serum sodium is high the tonicity is high and fluid is drawn by osmosis from the intracellular space to the intravasular space. The patients hence do not have shock but have dehydrated cells and hence appear to be very irritable and sick. The brain can lose up to 10-15% of its volume by way of osmosis. This leads to rupture of cerebral veins as the brain pulls away from the meninges. In addition to cerebral hemorrhage, venous sinus thrombosis and demyelinating disease can occur in the most severe cases. The brain tries to protect itself from shrinkage by the production of idiogenic osmoles. . These are produced over a few days and are metabolised also over a few days. When one rapidly corrects the serum Na, the idiogenic osmoles draw the fluid from the plasma across the blood brain barrier, leading to cerebral edema.

Management

Treatment is directed at identifying and management of the cause. Attention has to be however paid to the rapidity of correction of the sodium. In order to avoid the development of cerebral edema the rate of correction of sodium should not be faster than 0.5 mEq/hour.

If the patient is showing signs of dehydration then fluid bolus of 20 ml/kg of isotonic fluid is given over 1 hour. There is sodium loss also in hypernatremic dehydration however the free water loss exceeds that of sodium. There are many ways of correcting hypernatremic dehydration.

One such way is as follows.

If a 10 kg child has 10 % dehydration has serum sodium of 170 mEq/L and has been having diarrhea then the management is follows.

Sodium deficit is about 4 mEq /kg. = 40 mEq

Sodium maintenance = 2-4 mEq /kg = 20 mEq x3=60 (Since the sodium has to be corrected over 3 days)

Maintenance fluid is 1000 mlx3 =3000ml

Fluid deficit is 1000 ml

There is often increased amount of ADH present due to increased tonicity. Thus in order to avoid a rapid decrease in sodium the maintenance fluid used is 2/3rd of that calculated which will be 2000ml .In the case given, 100 mEq of sodium has to be given with 3000ml of fluid. This can be achieved using D5 0.2 NS. Considerable controversy exists in the type of fluid that should be used to correct hypernatremia. Regardless of the fluid chosen it is prudent to determine the rate of correction of sodium every 4-6 hours

If a child has been receiving excessive amounts of sodium then there is only free water deficit. This is calculated as follows

For every mEq of sodium greater than 145 there is 4 ml/kg of free water deficit. For the same case then there is a deficit of 4x10x25=1000ml. The sodium has to be corrected over 3 days and hence this deficit is best given as enteral water over 3 days. Again close monitoring of lab values is essential.

Hypernatremia due to free water deficit is commonly seen in diabetes insipidus (DI), as a terminal phenomenon of traumatic brain injury or post pituitary surgery. Close monitoring of the patient for increase in urine output is essential.

Presence of DI is determined by measuring serum sodium, serum and urine osmolality. The patient continues to pass hypoosmolar urine despite the increase in serum osmolality thus indicating a deficit of ADH. The management consists of starting intravenous vasopressin or intranasal desmopressin. The former has vasoconstricting properties, which may be useful in the management of shock. Till the effect of the medication is seen the excessive amounts of urine is replaced volume for volume using hypoosmolar fluid like enteral water or D5 0.2NS with KCl. Hyperglycemia is often present in patients with central nervous system injury due to the stress and in situations like brain tumor due to the concomitant use of dexamethasone.

Hyperkalemia[13]

It is defined as potassium values greater than 5 mEq/L. Values greater than 6.5 are life threatening. Hyperkalemia occurs because of tissue break down, excessive administration of potassium, inability to excrete potassium (Table II).

Hyperkalemia can cause nausea, vomiting, ileus, muscle weakness and cardiovascular changes. It is its effect on the heart that is life threatening. Electrocardiographic manifestations are peaked T waves, PR prolongation, ST segment depression, loss of P waves, QRS widening and ultimately ventricular fibrillation and asystole. The ECG changes are however not good correlates of serum potassium.

Table II. Causes of hyperkalemia

- Massive tissue breakdown rhabdomyolysis, burns, trauma, tumor lysis, malignant hyperthermia, etc
- Severe metabolic acidosis
- Renal failure
- Type 4 renal tubular acidosis
- Aldosterone deficiency, administration of aldosterone antagonists, angiotensin converting enzyme inhibitors

Management: After drawing sample for rechecking the value, it consists in mainly stabilizing the myocardium using calcium, temporarily shifting the potassium back into the cell and then removing the excessive potassium by using potassium binding resins and dialysis.

(a) 1mL/kg of calcium gluconate-maximum 20mL

(b) 1mL/kg of sodium bicarbonate

(c) 1mL/kg of glucose insulin mixture (every 10mL of D50 to be mixed with 1 unit of regular insulin) over half hour

(d) 1g/kg of potassium binding resin and

(e) Dialysis

Summary: Fluid and electrolyte management in critically ill children needs to be individualized. Intravenous fluids need to be determined in light of fluid status, urine output, basic electrolytes (Na^+, K^+, Cl^-, HCO_3^-, and Ca^{2+}) and blood sugar levels. Volume status needs to be assessed and corrected. Colloids are not better than crystalloids. Albumin may be worse in patients with traumatic brain injury. Metabolic acidosis and metabolic alkalosis are common in children and their presence does affect the management of other electrolytes such as calcium and potassium.

Points to Remember

- ***Hyponatremia and hypernatremia need to be corrected gradually. The volume status of the child and the tonicity of the plasma have to be determined before treatment is started.***
- ***Hyperkalemia is a medical emergency. The cardiac manifestations do not reflect the plasma potassium values accurately.***
- ***The volume of colloid needed to expand the intravascular space is not one third that of crystalloid. The crystalloid requirement is about 1.6 times of the colloid needed. Colloid are more expensive than crystalloid.***
- ***Fresh frozen plasma is a blood product and should not be used as a volume expander.***

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BOOK REVIEW

PROTOCOLS IN PEDIATRIC NEPHROLOGY (First Edition, 2012)

Authors: Arvind Bagga, Aditi Sinha, Ashima Gulati

Publishers: CBS Publishers & Distributors Pvt. Ltd., New Delhi 110 002

Pages: 296

Price: Rs.525/-

This book on Pediatric Nephrology protocols provides adequate information on the evaluation and management of common childhood acute and chronic kidney diseases. It has ten sections containing 45 topics covering various important issues in childhood renal care. The main book contains adequate details on CKD, hypertension and renal replacement therapy as well as on specific therapy like intravenous pulse therapy and plasmapheresis. Various guidelines formulated over the years by Indian Society of Pediatric Nephrology are included in the text. There is a clear emphasis on various key aspects of clinical management of childhood renal diseases with emphasis on contemporary practices. Approach is simple and the details are adequate. This book gives clear instructions to decide on management. One should not forget the attached appendices on various important aspects of pediatric nephrology including normal values for BP in children and drug dose modifications in renal diseases. Further, vaccination in kidney diseases and radiation dose in renal related procedures will be very useful. This book should be of immense use to postgraduate students, trainees and practicing pediatricians. The support by 'Sister Renal Center Program' of International Society of Nephrology for this book is worth mentioning and should be a pointer about the usefulness of this book. This book should not only be the property of everyone concerned with pediatric care but should also form a part of every library concerned with medical care.

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GENERAL ARTICLE

NUTRITION IN SPECIAL SITUATIONS

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Abstract: *Ingestion and absorption of nutritionally adequate diet is necessary to maintain normal body composition, growth and development in children. Malnutrition in children has great impact on child survival and outcome of disease state. Whenever possible enteral route should be the preferred one. Feeding regimen vary widely according to the nutritional needs of the child, type of enteral access, age of the child and the degree of intestinal maturation. Specific formula foods are available for children with certain diseases like malabsorption, allergic enteropathy, depending on their age and gastrointestinal maturity. Dietary management becomes more complicated in children with severe malnutrition with systemic illness. There are unique diseases in pediatric age group where dietary modification, dietary restriction, dietary elimination and diet supplementation are needed.*

Keywords : *Nutrition in children, Feeding regimen, Diet in special situations, Children, Enteral nutrition.*

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Enteral Nutrition

Ingestion and absorption of a nutritionally adequate diet is necessary to maintain normal body composition, growth and development in children. Starvation and malnutrition cause structural and functional changes in the gastrointestinal tract besides secondarily affecting all other systems. The goal of feeding is to provide the child with recommended nutritional requirements. It is generally accepted that wherever possible enteral should be the route of nutrition. Parenteral route is resorted to only when enteral mode is not feasible or inadequate to meet the nutritional needs. Additional enteral nutritional support is considered in the setting of inadequate weight gain, inadequate growth, prolonged feeding times, weight loss, a decrease in weight/age or weight/height ratios, or a persistent triceps skinfold thickness <5% for age.

Enteral nutrition requires enteral access. Oro-oesophageo-gastro route is the obvious first choice for enteral access unless it is not appropriate, because of pathology. Both temporary and permanent direct enteral access can be secured safely. In the neonatal period the nasoenteric route is usually used. A properly placed non-reactive naso/gastro/duodenal tube can take care of nutritional needs for weeks if not months. Where longer enteral access is needed, surgically, endoscopically, or radiologically placed percutaneous feeding tubes are used. When compared with parenteral nutrition, enteral nutrition has numerous potential advantages, including lower costs, reduced

infectious complications, reduction in bacterial translocation as a result of improved enterocyte integrity and decreased incidence of Total Parenteral Nutrition (TPN) associated liver dysfunction. Table I shows indications for enteral formula in different clinical conditions.

Feeding regimens vary widely according to the nutritional needs of the child, type of enteral access, age of the child and degree of intestinal maturity. Specialized formulas are available for children less than 10 years of age that differ from adult formulations. Children require a reduced renal solute load and a higher concentration of vitamins and minerals to promote growth and development. A thorough nutrition assessment, including age, history of prematurity, anthropometry, growth history, diet history, current intake, biochemical indices, current feeding regimen, activity level, degree of organ failure, underlying disease, presence of ongoing losses, absorptive capacity and stool output have to be considered before selection of formula type. There are certain specific conditions in children when enteral nutrition is needed as per Table II.

Food regimens[1]: A wide variety of feeding regimens are available that can be tailored to each child depending upon the underlying situation. The regimens can be classified as

1. Whole food diet,
2. Defined liquid formulas and
3. Oral rehydration therapy.

Table I. Enteral formula categories

Category	Subcategory	Characteristics	Indications
Polymeric	Standard	Similar to average diet	Normal digestion
	High nitrogen	Protein > 15% of total kcal	Catabolism, wound healing
	Calorie dense	2 kcal/ml	Fluid restriction, volume intolerance, electrolyte abnormalities
	Fiber containing	Fiber 5-15 g/L	Regulation of bowel function
Monomeric	Partially hydrolyzed	One or more nutrients are hydrolyzed. Composition varies.	Impaired digestive and absorptive capacity
	Elemental		
	Peptide based		
Disease-specific	Renal	Less protein, low electrolyte content	Renal failure
	Hepatic	High BCAA*, low AA, low electrolyte content	Hepatic encephalopathy
	Pulmonary	Higher % of calories from fat	ARDS
	Diabetic	Low CHO/Sugars	Diabetes mellitus
	Immune-enhancing	Arginine, glutamine, omega-3 FA, antioxidants	Metabolic stress, immune dysfunction

***BCAA: Brached Chain Amino Acids**

Table II. Indications for enteral nutritional support in children

Indications for enteral nutritional support in children	Examples of clinical conditions
Unable to suck/swallow	Ventilated patients
Unsafe swallow	Cerebral palsy, corrosive injury
Poor suck	Premature infants
Increased requirements	Cystic fibrosis, congenital heart disease, burns, trauma
Poor appetite secondary to illness	Cancer, liver disease, renal failure
Congenital anomalies	Tracheo-oesophageal fistula, oro-facial malformation
Malabsorption	Short bowel syndrome
Unpalatability of specialised feeds	Crohn's Disease
Continuous supply of nutrients required to prevent hypoglycemia	Glycogen Storage disease Type I

Whole food diet is a standard regular diet, modified as per requirement. Modification could involve consistency (clear liquid, full liquid, pureed and soft diets) or content. Diets with modification in nutrients are low residue, low fat, low sodium, low protein, high fibre diets, etc.

Defined liquid formulas: These are commercially made products with a known or defined nutrients and classified as

1. Feeding modules, 2. Monomeric formulas, 3. Oligomeric formulas, 4. Polymeric formulas and 5. Disease specific formulas.

Feeding modules consists of single nutrients like protein, carbohydrate, or fat. They can be used as a supplemental feeding, for inadequate intake or as part of modular enteral feeding in which, several nutrient modules are combined to meet specific requirements. Protein modules contain either intact protein, hydrolysed protein or crystalline amino acids. Carbohydrate modules consist of glucose polymers or hydrolysed products of starch (maltodextrins, oligo-saccharides, polysaccharides) and they are inexpensive, watersoluble, readily mixable with other formulas. Fat modules include formulas with either long chain triglycerides (LCT) containing more than 12 carbons in length, (eg. from safflower and soyabean oil), medium chain triglycerides (MCT) which contain 6 to 12 carbons in length (eg. from coconut oil). MCTs are water soluble and do not require bile salt activated lipase for absorption which can be used in chronic cholestatic liver disease and steatorrhea due to pancreatic or small intestinal diseases. However, essential fatty acid deficiency could occur when on exclusive MCT feeds.

Monomeric formulas also known as "elemental" diets contain nitrogen in the form of free amino acids, carbohydrates as glucose and

glucose polymers and minimal amount of fat as LCTs, usually accounting for 3% or less of total calories. The presence of free aminoacids and limited fat content make these preparations hyperosmoloar, unpalatable, requires flavouring agents and they are expensive.

Oligomeric formulas are also called as "semi-elemental diets". The protein in these formulas are hydrolysed casein, whey or lactalbumin and some free aminoacids. Carbohydrates are included as simple sugars, glucose polymers or starch and fat as either LCTs or LCTs with MCTs.

Polymeric formulas contain nitrogen in the form of modified whole proteins, carbohydrate as glucose polymers, and lipid as LCTs or mixture of LCTs and MCTs. These can be used as a dietary supplement to increase nutrient intake to meet complete requirements. These are categorized into blenderised food formulas, milk based formulas and lactose free formulas. Polymeric formulas are generally more palatable, but large volumes may be required in older children and may be difficult to push large quantities by mouth.

Blenderized food formulas contain beef and milk as a protein source, cereal, fruits, vegetable as carbohydrate source and beef puree, corn oil, soy oil as fat source with good fibre content. They require wide bore tube for delivery because of poor palatability and high viscosity.

Milk based formulas usually contain milk as source of protein and fat, with additional corn syrup solids and sucrose as carbohydrate source.

Lactose free formulas are commonly used polymeric formulas. They usually contain casein or soy as a source of protein. Corn syrup solids, hydrolysed cornstarch, glucose polymers, sucrose are usual source of carbohydrates and corn oil, soy oil or MCTs are the fat source.

CHO: Carbohydrates

Elemental or predigested formulas are used for patients with malabsorption, allergic enteropathy or gastrointestinal impairments. Age specific formulas exist for premature infants, term infants, toddlers and infants upto 10 years of age. In general, for children above 10 years adult formula can be used. Home made blenderized formulas can be administered through low profile gastrostomy tubes. However, home made preparations tend to be more viscous, may block the tube and may not be balanced. The risk of contamination is high and close supervision by a dietetian is needed.

Techniques of feeding

Tube feeding: This method involves feeding through tubes placed in the intestine for providing nutritional support in children who cannot eat but have functioning GI tract. This can be used for short term or long term feeding. Provision of enteral nutrition requires prolonged access to either the stomach or the proximal small intestine. Delivery routes for enteral nutrition include nasogastric, nasoduodenal, nasojejunal, gastrostomy and jejunostomy routes, so named, depending on the site where the feeding tube enters the body and the point at which the formula is delivered. Patients who require such feedings for longer than 4 weeks are candidates for a surgically, endoscopically, or radiologically placed feeding tube that rests in proximal small bowel. The gastrostomy was found to be more acceptable than a nasogastric tube for long term feeding and is associated with minimal complications. Most endoscopically placed gastrostomy tubes last for up to 3 years. Early enteral nutrition (EN) instead of parenteral, in deserving cases has been shown to improve enterocyte integrity and prevent gut permeability to macromolecules and organisms. This reduces bacterial challenge to the immune system and results in a lower incidence of systemic endotoxemia. Feeding

through the gut instead of parenteral route helps maturation of immune system and setting the Th1-Th2 balance.[2]

Contraindications to endoscopic gastric tube (GT) placement

GI fistula, microgastria, gastric varices, morbid obesity, tense ascites and if it is impossible to approximate gastric wall and abdominal wall.

Complications of percutaneous endoscopic gastrostomy (PEG) placement

Peri-stomal wound infection, necrotising fasciitis, intestinal perforation, hemorrhage, perforation of hollow viscus, peritonitis, colo-cutaneous fistulas. Buried bumper syndrome occur especially when PEG tubes contain rigid internal bumpers. This occurs when, too much pressure is maintained between inner and outer bumper resulting in pressure necrosis and ulceration leading to tube migration.

Factors to be considered for selection of formula

When selecting an appropriate enteral formulation both formula characteristics and patient-specific factors should be considered. Formula variables include: digestibility/availability of the nutrients, nutritional adequacy, viscosity, osmolality, ease of use and cost. Patient variables include: nutritional status and requirements, electrolyte balance, digestive and absorptive capacity, disease state, renal function, medical or drug therapy and possible routes available for administration. For most children, a standard pediatric polypeptide enteral formula is well tolerated.

Gastrostomies do not irritate nasal passage, esophagus, or trachea or cause facial skin irritation, nor interfere with breathing. Gastrostomies are stable and more physiologic, allowing continued oral eating. There are button gastrostomies and other skin level feeding tubes that are easily hidden under a child's clothing. These require less daily care and interfere less with a child's movement. Gastrostomies use a large-bore tube, which allows a more viscous feedings and decreased risk of tube occlusion. Gastrostomy tube feeds are used for enteral nutrition for children who require tube feeding for more than 4 weeks and delivery of nutrients via the tube can be commenced within 1–2 h after placement of a PEG (Percutaneous Endoscopic Gastrostomy) system. Tube feedings can be administered by bolus feedings, continuous drip feedings or a combination of the two. Continuous drip-feeding may be delivered without interruption for an unlimited period of time each day. However, it is best to limit feeding to 18 hours or less. Feeding round the clock is not recommended as this limits a child's mobility and may elevate insulin levels contributing to hypoglycemia. Commonly, it is used for 8 to 10 hours during the night for volume-sensitive patients so that smaller bolus feedings or oral feeding may be used during the day. One advantage of continuous feeding over bolus feeding is that it may be tolerated better by children who are sensitive to volume, are at high risk for aspiration, or have gastroesophageal reflux. Continuous feeding can be administered at night, so that it will not interfere with daytime activities. Continuous feeding increases energy efficiency, allowing more calories to be used for growth. Continuous drip-feeding is delivered by either gravity drip or infusion pump. The infusion pump is a better method of delivery than gravity drip. The flow rate of gravity drip may be inconsistent and therefore, needs to be checked frequently.

Bolus feedings are delivered four to eight times per day; each feeding lasting about 15 to 30 minutes. The advantages of bolus feedings over continuous drip-feeding are that bolus feedings are more similar to a normal feeding pattern, more convenient and less expensive if a

pump is not needed. Furthermore, bolus feedings allow freedom of movement for the patient, so the child is not tethered to a feeding bag all the time. The disadvantages of bolus feedings are that they are aspirated more easily than continuous drip feedings and in some children, they may cause bloating, cramping, nausea, and diarrhea. It may not be practical to bolus feed a child when the volume of formula a child needs is large or the child needs to be fed around the clock. The volume of feeding to be initiated by enteral route is given in Table III.

Table III. Schedule to initiate enteral feeds

Age	Volume
Infants	10 ml/hour
Child 1-5 year	20 ml/hour
Child 5-10 years	30 ml/hour
Child >10 years	50 ml/hour

The volume can be increased every 4-12 hours and should be monitored carefully for tolerance. Tolerance is defined as absence of diarrhea, abdominal distension, vomiting or gagging. Medications need to be given separately, with water flushes in between to prevent clogging the feeding tube. Medications should not be mixed with feedings. If the child is on continuous drip feedings and if the medication needs to be given on an empty stomach, feeding should be stopped for 15-30 minutes before administering the drug. It is advisable to wait for one hour before resuming next feeding.

Skin care for balloon gastrostomies

The stoma site should be inspected daily for cleanliness and for signs of redness or irritation. Gentle washing of the stoma site with soap and water using a soft wash cloth followed by thorough drying should be done from time to time. The outer surfaces of the button should be dry and clean. Routine dressings are not needed unless clinically indicated. The button should be turned in a full circle daily.

Monitoring of enteral feeding

When in hospital setting, fluid balance should be recorded. Weight should be recorded at least on admission and at other times when requested. Blood urea, creatinine, electrolytes, glucose, liver profile and CBC should be monitored. When complications arise the child should be referred to specialized centre handling such problems.

Nutrition in disease states

Nutrition in GERD

GERD in infants

Breastfed babies with reflux have been shown to have fewer and less severe reflux episodes than their artificially fed counterparts. Human milk is more easily digested than formula and is emptied from the stomach twice as quickly.Thickening the formula with one tablespoon of rice cereal to 2-4 ounces of formula decreases vomiting, though it may not change the 24 hours pH monitor results. The hole in the teat will need to be enlarged. Holding the infant in a head-elevated position by placing the infant's head on the shoulder for 20-30 minutes after feeding before putting infant in a supine or semi-supine position may reduce GERD. In older children GERD is decreased in the left lateral decubitus (left side down), and elevating head of the bed to 6 inches.

Cow's milk protein allergy is known to exacerbate reflux. Elimination of cow's milk in the diet of infants with cow's milk protein allergy and GERD significantly reduces reflux. If wholly

breast-fed and still symptomatic, elimination of cow's milk products from mother's diet might help.

GERD in older children

To be avoided are: Eating food at bed time, habit of chewing gum, use of tobacco products and alcoholic beverages in adolescents and wearing tight clothing are to be avoided.

To be followed

Eating small frequent meals and elevation of head when sleeping are to be followed. If overweight, losing weight can also help.

Foods that should be avoided

The key is to stay away from foods that contain a lot of grease, fat, acid or spice, fried foods, especially deep-fried foods. Foods that are high in fat like deep fried meat take longer time to digest and can promote reflux. Reducing intake of acidic fruits and fruit juices like tomato, lemon, grapefruit, orange and cranberry will help reduce GERD. Spices, garlic, onions, caffeine, chocolate and mint too stimulate excessive acid secretion. They have to be consumed in moderation in GERD.

Food items that are well tolerated

Fruits like apple and banana, which are non-acidic, are good for GERD patients. Vegetables including carrots, beans, baked potatoes, cabbage and broccoli are all known to be safe GERD diet foods. Fish and steamed/baked lean meat can be included liberally in GERD diet.

Restricted diet and nutrient deficiencies

Restricted diets in children can increase the risk of nutrient deficiencies. However some restricted diets are medically necessary in situations like gluten free diet in celiac disease. Gluten-free diet would mean diet completely free of wheat, rye, barley or their derivatives. Oats is gluten free, but commercially available oats is always contaminated with wheat, due to common manufacturing processes.

Nutrition in inflammatory bowel disease (IBD)

Growth failure in children and adolescents is seen in 50% of those with Crohn's disease(CD), and history of weight loss is present in up to 90%, at presentation.[3] Both Crohns disease and ulcerative colitis (UC) can have a profound effect on the nutritional status of those afflicted with these diseases. This can occur as a result of decreased food intake, impaired digestion and absorption, increased requirements, altered metabolism of nutrients, increased losses and drug-nutrient interactions. Decreased food intake is commonly encountered in IBD, especially in Crohn's disease. This frequently occurs because of anorexia and association of food intake with nausea, vomiting, diarrhea or pain. Recent research efforts have investigated the possibility that proinflammatory cytokines may have a role in anorexia of IBD. An increased 5-hydroxytryptamine (5-HT) release from the hypothalamic paraventricular nucleus has been observed in a rat model of colitis by Ballinger, et al. Inflammatory cytokines, including TNF, IL-1 and IL-6, are produced by activated monocytes/macrophages and lymphocytes in response to various stimuli and cause alteration of metabolism of protein, carbohydrate and lipid, and consequent effects on nutritional status. Primary mucosal involvement of proximal small bowel can cause disaccharidase deficiency resulting in osmotic diarrhea when unabsorbed carbohydrate is acted upon by colonic bacteria. Fat malabsorption may occur due to decreased bile acid pool in terminal ileal disease in CD or due to primary sclerosing cholangitis in UC. Secondary bacterial overgrowth in CD because

of strictures or surgical resection can cause deconjugation of bile acids and fat malabsorption. Vitamin B12 deficiency can occur when terminal ileum is affected by the disease. Selenium deficiencies are of particular concern in patients with IBD, as it, along with vitamins E, A and C is an important antioxidant. Oxidative stress exacerbates IBD process.

A well balanced diet with adequate calories and protein, trace elements, vitamins and calcium supplementation is recommended in IBD with additional increments to correct deficiencies when present. Specialised dietary support is at times necessary, if IBD is complicated by presence of short bowel syndrome, fistulae and growth failure. Parenteral nutrition, administered during acute exacerbations can maintain fluid and electrolyte status and arrest catabolism of protein stores.[4]

Growth retardation also responds to enterally administered additional calories. Lean body mass is increased in adolescents with IBD after 3 weeks of increased enteral calories when protein was increased from 2.3 to 3.2 /kg body weight per day.[5] About 70% of children with IBD are iron deficient because of inadequate intake, decreased absorption and increased losses. They need close monitoring of iron intake from diet and objective parameters like hemoglobin, retic count, mean corpuscular volume, red cell distribution width, serum iron, ferritin and transferrin saturation.

Besides dietary supplementation, diet can be therapeautic in Crohn's disease. The loss of mucosal integrity in Crohn's disease allows macromolecular food antigen absorption and consequent exacerbation of autoimmune process. Elemental diet in such situations, with complete avoidance of food antigens can induce remission. Diet therapy, instead of drugs for induction of remission is popular in Europe but not followed much elsewhere because it is very cumbersome and difficult to adhere to.[6]

Diet in pancreatitis

Acute pancreatitis is a disease of variable severity and outcome. Mild disease may be treated at home, while severe disease often leads to several weeks in the ICU with mortality rates approaching 50%. Clinical investigations have shown that acute pancreatitis is a highly catabolic illness, and protein deficiency could occur before the 2nd week of illness if no feeding is given. Parenteral nutrition (PN) is effective in preventing protein catabolism, and also 'rests' the pancreas, but increases the already high risk of septic and metabolic side-effects, and worsens outcome in mild illness. Enteral feeding is superior to PN in the management of acute pancreatitis, even if it is polymeric or infused directly into the stomach. The most likely reason for the superiority of enteral over parenteral feeding is its capacity to maintain intestinal function and suppress the cytokine-mediated systemic inflammatory response and consequent multiple organ failure (MOF). Secondly, the maintenance of mucosal health and prevention of bacterial overgrowth will also suppress the systemic cytokine-generated inflammatory response, thereby reducing the risk of MOF and mortality. On the other hand, proximal feeding may exacerbate the pancreatic injury and increase the risk of aspiration pneumonia. Ideally nutrition in acute panceatitis is managed by naso-jejunal feeding tube placed either radiologically or endoscopically. The child is fed a high protein and low-fat formula until he or she is ready to commence oral intake.[7]

Nutrition in persistent protracted diarrhea

Globally diarrheal diseases account for almost one fifth of all deaths in children less than 5 years, with an estimated 2.2 million deaths occuring annually. Besides mortality, diarrhoeal diseases have the potential to become persistent and result in significant growth retardation and

long term handicap. Persistent diarrhea(PD) is any diarrhea that persists beyond 14 days in an otherwise normal child, as different from chronic diarrhea which usually occurs against a background of a basic disease like malabsorption syndromes, immunodeficiency, IBD, etc. Persistent diarrhea often results in a setting of acute diarrhea in undernourished children and can worsen undernutrition through anorexia it tends to cause. Many factors like infection, oral thrush, anemia, stomatitis, glossitis, altered taste perception, micronutrient deficiency result in anorexia in PD. Attention to rehydration, appropriate screening and treatment of systemic infections and enteral nutrition and rehabilitation with easily digestible diets are critical in managing these children with PD. Administration of zinc and vitamin A may reduce incidence of PD and also help reduce recurrences. However, the most important preventive strategies for PD are exclusive breastfeeding in the first 6 months of life, continued breast feeding for 2 years with appropriate protein and energy dense complementary feeding and optimal management of acute diarrheal episodes with oral rehydration, zinc supplementation and maintenance of nutrition.[8]

Persistent diarrhea has been associated with malabsorption of carbohydrates and to a much lesser extent fat and protein. That makes nutrional rehabilitation of PD easier. Carbohydrate malabsorption is usually due to acquired disaccharidase deficiencies like lactase, sucrase, maltase and isomaltase deficiency. Rotaviral infection is notorious to cause lactase deficiency and in the setting of under nutrition, this transient deficiency can last several weeks leading to worsening of malnutrition. Steatorrhea is rare in PD, but if present may be due to pancreatic lipase deficiency or disturbed bile acid metabolism. Presence of steatorrhoea in PD should make one suspect chronic diarrhea.

Appropriate feeding of the child becomes the most important step in treating children with persistent diarrhea. Most persistent diarrhoeas are simple disaccharide intolerances needing minimal dietary intervention. Well looking child, with no dehydration or evidence of sepsis, should do well with continuation of good home available nutritious diet with mother's milk. If not on mother's milk, the milk may be stopped and replaced by equally protein energy dense low lactose/lactose free diets as detailed below. Cereals and pulses preparation with curd is best for children above six months of age. Diets for such children can be designed using one source of carbohydrate, one source of protein and one source of fat, besides vegetables, fruits to provide micronutrients.

Lactose free diet may need to be sustained for atleast a couple of weeks and milk may then be slowly reintroduced in graded quantities. While provision of micronutrients through natural sources would be ideal, initially atleast, vitamin, iron and zinc supplementation through tablets/ syrups would be advisable. Some of the food items as source of carbohydrates, protein, fat are illustrated in Table IV.

Dietary management becomes more complicated when the child has PD with severe acute malnutrition, sepsis and dehydration and needs to be hospitalized. Such children tolerate full enteral feeds poorly and may need judicious balance of enteral and parenteral supply of nutrients till sepsis is cleared and the child's GI tract is ready for full oral alimentation. Some useful guidelines in such situations are:-

- Initial management may include provision of intact proteins as albumin or FFP infusions if significant hypoproteinemia exists.
- Simple PPN (partial parenteral nutrition) solutions incorporating additional glucose and aminoacid preparations will help.

- Initiate early oral alimentation to help villi repair. Avoid prolonged "nil oral"
- Continuous slow oral feeds to start with, through a N/G tube
- Carbohydrate rich, low protein and no fat diet is the ideal starter diet
- Increase proteins as the diarrhoeal frequency reduces
- Add fats as additional energy source as the child is weaned off PPN
- Avoid monosaccharides as energy source till bowel frequency comes down to <6/day
- Avoid proprietary lactose-free preparations till the stool frequency falls to <4/day

The usual energy density of any diet used for the therapy of PD should be around 1 kcal/g, aiming to provide an energy intake of at least 100 kcal/kg/day and a protein intake of between 2 and 3 g/kg/day to be increased gradually to full energy 110 Cal/Kg/day and protein 4-5 g/Kg/day in the form of well-cooked cereal, pulses and vegetables with vegetable oil. The current recommendation is to give initial dose of 1,00,000 units of vitamin A and daily intake of 3 to 5 mg/kg/day of elemental zinc in children with persistent diarrhea and undernutrition. Vitamin B12, folate, zinc and iron should be supplemented. One extra meal daily for a month, if tolerated will help for catch up growth after diarrhea stops. Crustaceans too may cause diarrhoea due to allergy, Dietary modules for persistent diarrhoea are given in Table V.

Lactose and sucrose free diets: Many proprietary preparations are available that provide casein or soybean protein with maltose and maltodextrins that may be used in PD after the consistency and frequency of stools improve, if mother' milk is unavailable. Most PD children do tolerate some lactose especially when given

Table IV. Food items as source of carbohydrate, protein and fat

Carbohydrate	Protein	Fat
• Rice	• Bengal gram	• MCT oil
• Potato	• Other lentils and Pulses	• Coconut oil
• Wheat	• Casein	• Other oil
• Corn	• Soya protein	• Ghee
• Other cereals	• Comminuted Chicken	• Butter
• Tapioca	• Fish	
• Glucose	• Egg	
	• Groundnuts	

Ideal Carbohydrate: Rice

Ideal Protein: Chicken, casein, Bengal gram, egg

Ideal fat: Coconut oil

Table V. Diets for persistent diarrhoea[9]

Plan-A (Milk rice diet)		Plan-B(Milk free diet – Egg based)		Plan-C (Chicken based diet)	
Ingredient	Amount (g)	Ingredient	Amount (g)	Ingredient	Amount (g)
Puffed rice	12.5	Puffed rice	13.5	Chicken	100g
Milk	40.0	Egg	11.0	Glucose	20-40g
Sugar	2.25	Sugar/Glucose	3.5	Coconut oil	40-50g
Oil	2.0	Oil	3.5	KCl (15%)	7.5ml
Water to make	100	Water to make	100	$NaHCo_3$ (7.5%)	20-30ml
				Total	1000ml
The above will yield		**The above will yield**		**The above will yield**	
Energy density	96 Kcal/100g	Energy density	92.2 Kcal/100g	Energy	720 Kcal
Protein	10.0%	Protein	9.5%	Protein	26g
Carbohydrate	55.87%	Carbohydrate	56.9%		
Lactose	1.73%				
Fat	33.9%	Fat	33.29%		
Amino acid score	1.0%	Amino acid score	1.0%		

Note: Puffed rice is ground and appropriate quantities are mixed with sugar and oil. Boiled water is then added to make a thick gruel. This feed has a shelf life of around 3 hours.	**Note:** Egg white is added to the mixture of weighed rice, sugar and oil. Boiled water is added to make a thick gruel weighing 100gm.	**Note:** (i) It is prepared by grinding the precooked boneless chicken stuff in a mixie. Glucose, oil and some water are added to it and the feed is brought to boil. Additional water is added to make a final volume of 1 litre. Finally Kcl and $NaHCo_3$ are added. To safeguard against spoilage it is stored in a refrigerator. (ii) Glucose is initially added in 2% concentration and then built up to 4% by increasing 1% every alternate day. To reduce osmolar load a mixture of glucose and sugar may be employed. (iii) Any vegetable oil may be employed in place of coconut oil.

Table VI. Low lactose diet suitable for infants between 4-12 months (Mixture of Milk with Rice)

Ingredients	Amount	Cal (%)	Protein (g%)
Milk	75 ml	52	2.6
Rice	5 g	17	0.4
Sugar	2.5 g	10	-
Water qs**	100 ml	-	-
Total		79	3.0

** Liquid consistency: 0.7 Cal/ml; vol 100 ml; lactose 4.5 g%

as milk cereal mixes. Babies with persistent diarrhea generally do not need elemental diets. They are used for severe chronic diarrhoea. Similarly, with the availability of partially/ extensively hydrolysed protein diets and elemental diets, very rarely do children with PD need TPN.

Food allergies also can cause/perpetuate PD in children though their actual incidence in India is much lower than the west. Cow's milk protein(CMP) callergy is the commonest, allergy induced PD in children. Rarely, other foods like hen's egg, soy, wheat, peanut, tree nuts, fish and disease and in transplants.[11, 12]

Malnutrition in liver disease: Chronic liver disease is usually associated with significant malnutrition due to anorexia, altered taste threshold and preference, smell disturbances, poor dietary advice, some degree of maldigestion and malabsorption, small bowel dysmotility and gastroparesis. Low protein intake, which is sometimes necessary in hepatic encephalopathy leads to exacerbation of the malnutrition. Salt restriction affects palatability.

Chronic liver disease: Carbohydrate metabolism takes a major hit in CLD. First pass clearance of sugar is poor. Peripheral insulin resistance and impaired insulin clearance by liver in CLD results in hyperinsulinemia, hypoglycemia, post prandial hyperglycemia and sometimes even frank diabetes, requiring dietary modifications. Children with chronic liver disease are at increased risk of fasting hypoglycemia because the capacity for glycogen storage and gluconeogenesis is reduced as a result of abnormal hepatocyte function and loss of hepatocyte mass.[13] Plasma levels of aminoacids are also affected in liver disease with the aromatic amino acids phenylalanine, tyrosine, tryptophan and methionine being increased, while BCAA are reduced.[14] A small crossover randomized controlled trial using a BCAA fortified formula compared with a semi elemental formula with the same caloric density showed improved short term growth, nutritional state and nitrogen balance in children with chronic liver disease awaiting liver transplantation.[15] Children with CLD should not be protein restricted and protein supplementation upto 4 gm/kg/day is generally safe and necessary for growth and increased catabolism except in the presence of encephalopathy where 1gm/kg/day is recommended.

Fats

There is increased fatty acid oxidation in children with end stage liver disease (ESLD) in fed and fasting states compared with controls, which is probably due to reduced carbohydrate availability. This, with impaired fat absorption in CLD leads to rapid depletion of fat stores. In cholestatic liver diseases impaired digestion and absorption of long chain fatty acids are affected resulting in fat-soluble vitamin deficiency and steatorrhea, which worsens malnutrition.[16] In compensated liver disease the synthetic ability of the liver is maintained, but this is impaired in periods of stress including exertion, poor nutritional intake and intercurrent illness. In CLD, especially cholestatic CLD around 30% to 50% of total fat should be provided as MCTs though compliance may be affected by palatability. Multiple deficiencies are common in CLD and need attention in formulating diet in CLD. Iron deficiency has been reported in almost 25% of patients with cirrhosis and is due to poor dietary intake or blood loss. Zinc and magnesium deficiencies have also been described in patients with chronic liver disease and may influence metabolism of neurotransmitters and their receptors, and zinc deficiency may affect nitrogen metabolism and may elevate blood ammonia level.

Decompensated liver disease

Diet Modification: To be tailored as per individual needs.

Encephalopathy: High protein intake of animal origin is to be avoided. Vegetable protein is better tolerated in patients with chronic encephalopathy probably due to different amino acid composition, high fiber content that causes increased stool bulk and stool output, which can increase nitrogen loss and reduce ammonia production. Patients in coma should be placed on "no oral protein" diet till recovery starts, and such short-term protein deprivation is acceptable. Severe prolonged protein restriction however can decrease renal plasma flow and GFR, causing renal dysfunction in patients with decompensated cirrhosis. BCAA have been tried as therapy for hepatic encephalopathy with limited success, as increasing their plasma levels, inhibits the brain influx of aromatic amino acids and formation of false neurotransmittors. Patients with chronic liver disease should be encouraged to maintain adequate energy consumption. Around 35-40% of total calorie intake should be supplied as fat. Lipid intravenous emulsions depend little on the liver for metabolism, are well tolerated in patients with cirrhosis, and have a protein sparing effect. Protein intake should be in the range of 1-1.5g/kg/day in the absence of overt encephalopathy. Children, recovering from encephalopathy, receiving a semi-elemental formulation enriched in branched chain aminoacids had an increase in total body potassium, mid upper arm circumference and subscapular skinfold thickness, as compared to children receiving a standard semi-elemental formula. They also required fewer albumin infusions and IV branched chain aminoacids supplements.[15]

Goals of nutritional therapy in patients with ESLD waiting for liver transplantation(LT).[17]

- Correction of malnutrition and prevention of metabolic complications
- To educate patients and caregivers on nutrition.
- To improve quality of life
- To reduce perioperative complications after transplantation.

Vitamin and mineral support for cholestatic infants

Vitamin K - 1 mg/kg, maximum 10 mg, intra-muscular, once weekly to 2 weeks

Vitamin E - 10 mg/kg, intra-muscular, every two weeks
- 25 IU/kg, OD, oral, using tocopheryl polyethylene glycol 1000 succinate

Vitamin A - 25000 to 50000 IU, IM, every other month

Vitamin D - 30000 to 60000 IU, IM, every other month

Calcium - 50 mg/kg/day, orally

Zinc - 1 mg/kg/day, zinc sulfate, orally

Fulminant hepatitis: These patients require a continuous parenteral glucose infusion as 10-25% glucose, providing 150-200 gm glucose/day, with constant monitoring of blood glucose along with fluid and electrolyte care.

Ascites: Retention of every gram of Na (45 mEq) will cause retention of 200-250 mL of fluid causing worsening of edema. Salt restricted diet could be made more palatable by seasoning with lemon juice, onion, vinegar, garlic, pepper, mustard, salt free ketchup, salt free mayonnaise, salt free béchamel, saffron, or thyme. Water restriction in CLD is justified only in hyponatremic patients when the serum Na drops below 120 mEq/L

Diseases requiring dietary elimination

Wilson's Disease: Dietary copper intake should be restricted, and patients should avoid eating shell-fish, nuts, dried fruits, chocolates, mushroom, and liver.

Hemochromatosis: Patients, however, should abstain from iron containing multivitamin preparations, and eating liver, spinach and jaggary and other iron rich foods.

Galactosemia: Patients with deficiency of galactose-1-phosphate-uridyl transferase benefit from withdrawal of galactose/lactose containing milk and milk products from diet.

Liver diseases requiring diet modification

a) Glycogen storage diseases: Children with GSD I (glucose-6-phosphatase deficiency) are unable to mobilize stored liver glycogen. Convulsions occur due to fasting and nocturnal hypoglycemia. Continuous source of glucose to prevent hypoglycemia may be achieved by continuous nasogastric nocturnal glucose polymer drip, or by raw cornstarch feeding in the evening. Similar dietary measures may be required in the milder form Type III with debrancher enzyme deficiency.

b) Hereditary Fructose Intolerance: Children with aldolase deficiency must have sucrose and fructose restricted diets to prevent liver disease.

c) Tyrosinemia: The acute type leads to death in infancy regardless of dietary management. The chronic type may benefit from restriction of aromatic amino acids and growth may be normalized and hepatomegaly may be prevented or ameliorated. Hepatocellular carcinoma is, however, not preventable. With advent of NTBC therapy, prognosis in tyrosinaemia has markedly improved.

Points to Remember

- ***Nutrition in children has great impact on body composition, growth, development and disease outcome.***
- ***Enteral nutrition should be preferred wherever possible***
- ***Feeding regimen vary according to the nutritional needs, age of the child, feasibility of enteral access, degree of intestinal maturity in them.***
- ***Thorough nutritional assessment, age, growth history, biochemical indices, degree of organ failure, absorptive capacity and socio-economic factors need to be considered.***

- ***There are specific disease conditions unique to children where diets need elimination, restriction, modification and supplementation to have a favourable outcome.***

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DRUG PROFILE

VOLUME EXPANDERS IN PEDIATRICS

**** Jeeson C Unni***

Abstract: *Despite years of study experts are still indecisive on the ideal fluid and the recommended dosage for resuscitation in the different clinical scenarios wherein hypovolemia develops. The debate on the merits and demerits of the available colloids and crystalloids continues. In this article, an attempt is made to review the recent evidence in this field.*

Keywords: *Volume expanders, plasma substitutes, colloids, crystalloids, human albumin, dextran, gelatin, hydroxyethyl starch.*

Circulatory failure in children, leading to impaired tissue perfusion and organ failure, is often a result of hypovolemia due to a variety of causes. Maintaining intravascular volume or replenishing fluid loss is an essential intervention in the management of shock. Volume expanders are fluids uesd to expand the intravascular space. There are four types of solutions used as volume expanders which are 1. Isotonic crystalloids 2. Colloids 3. Blood products such as plasma 4. Hypertonic solutions such as hypertonic saline. But commonly used are crystalloids or colloids. Colloid solutions-IV fluids containing large proteins and molecules that tend to stay within the vascular space (blood vessels). Crystalloid solutions-IV fluids containing varying concentrations of electrolytes. Ringer lactate and Normal saline are commonly used crystalloids

There is uncertainty as to which fluid is ideal in pediatrics for this purpose. Crystalloid solutions are the most frequently chosen, by far, with 0.9% saline and lactated Ringer's both being the most frequent choices. Colloids are an alternative to crystalloids, with highly variable use depending on the clinical condition.

Clinically available colloids have generally exhibited similar effectiveness in maintaining colloid oncotic pressure due to their high molecular weight and resultant persistence in the intravascular compartment. And the selection of colloids has commonly been based on cost and convenience. But, differences in the physical properties, pharmacokinetics, pharmocodynamics and safety profile exist amongst various colloids. A review of these can help us to choose the right colloid in different clinical scenarios.

There are two types of colloids namely natural and synthetic. Albumin is the natural colloid collected from pooled donors. Synthetic colloids are dextran, gelatin and hetastarch.

Human albumin

Human albumin (HA), a natural colloid is the most expensive non-blood plasma substitute used to treat hypovolemia. A 50mL of 5%, 50mL of 10% and a 100ml of 20% solution cost around Rs. 1000, 2000 and 4500, respectively!.[1] Its role in the treatment of hypovolemia is still hotly debated and its use for this indication may be

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based on traditional practice and not on adequate supportive evidence. The validity of most of the reviews and meta-analyses on HA has been questioned regarding methodology and therefore their inferences are not unacceptable to researchers leaving the clinician in the dark regarding the absolute indications for the product. An evaluation in 53 hospitals in the US showed HA was inappropriately used for 57.8% of adult patients and 52.2% of pediatric patients.[2] The Dutch Pediatric Society does not consider HA as first line replacement solution for treatment of hypovolemia in neonates and children.[3] A Cochrane systematic review[4] of 37 trials found no evidence that albumin, compared with cheaper alternatives such as saline, reduces the risk of dying. It has not been shown to give better results than other fluids when used simply to replace volume, but is frequently used in conditions where loss of albumin is a major problem, such as liver disease with ascites. However, HA may be considered for hypovolemia if crystalloid infusion fails and for acute hemorrhagic shock along with crystalloids if blood products are not available immediately.[5]

Two published meta-analyses that compared crystalloids with colloids or crystalloids with albumin attracted considerable attention.[4,6]

Crystalloids: The advantages of using isotonic crystalloids are their low cost, lack of direct effect on coagulation, low risk of anaphylactic reaction or transmission of infectious agents. However, large amount of crystalloid infusion has been correlated with pulmonary edema, bilateral pleural effusions, intussusception, excessive bowel edema, impairing closure of surgical wounds and peripheral edema.[7,8,9] Moreover, intravascular volume expansion obtained by crystalloids is significantly shorter and less efficacious than colloids.

The ion content in various commonly used crystalloids are given in Table I.They are used to provide the daily requirements of water and electrolytes.

Plasma volume should be maintained or replaced with colloid solutions since crystalloids are rapidly lost from the plasma. It should be noted that plasma substitutes are carried in 0.9% saline. So, majority of critically ill patients require 0.9% saline infusions only for excess loss. Sodium content of 0.9% saline is equivalent to that of extra cellular fluid. A daily requirement of 70-80mmol sodium is normal although there may be excess loss in sweat and from the gastrointestinal tract. 0.9%saline is useful in term neonates with hypotension in first 24 hours[10,11] and specially so in preterms where use of HA is not found to be useful.[12,13] The Dutch recommend 0.9%saline for initial treatment of pediatric hypovolemia.[3]

Crystalloids are therefore used to reestablish cardiovascular stability[14] in critically ill children and to correct electrolyte disturbances.

Synthetic Colloids

Colloids and especially starches are known to be effective plasma expanders in the short term

Table.I. Ion content of crystalloids (mmol/L)

	Na^+	K^+	HCO_3	C1	Ca^2	Lactate
0.9% saline	150			150		
Lactated ringer	130	4		109	1.5	28

because they can stabilize hemodynamic parameters rapidly with the advantage of markedly reducing the total volume to administer.

The various types of synthetic colloids used are

- Dextran: eg. Dextran 40, Dextran 70
- Gelatin: eg. Succinylated or modified fluid gelatins (eg., Gelofusine, Plasmagel, Plasmion), Urea-crosslinked gelatins (eg., Polygeline), Oxypolygelatins (e.g., Gelifundol), Polygeline ('Haemaccel', Hoechst)
- Hydroxyethyl starch: eg. 6% hetastarch, 6 & 10 pentastarch

In dengue shock syndrome, dextran, gelatin, lactated Ringer's, and 0.9% saline were all found to be equally effective for initial resuscitation.[15] Among synthetic colloids, gelatins have been used for many years in children, also in early infancy, to treat intravascular fluid deficits.[16,17] Hydroxyethylstarch (HES) preparations, introduced recently, are being increasingly used for fluid resuscitation in children. A 20 mL/Kg bolus of HES is nowadays used for preoperative volume resuscitation in children undergoing major surgery[18,19] with negligible side effects.[19,20] An excellent review of the 3 generations of HES with discussions on the improvements achieved in the latest product -the 3rd generation HES-was recently published.[16] The advantages include increased intravascular half-life, preservation or enhancement of colloid osmotic pressure, lower incidence of kidney injury, less inflammatory response and endothelial damage, and no clinically significant changes in platelet count, PT or aPT.[21] Third generation HES can therefore be considered for plasma volume restoration even in infants and small children.[20] However, liver, kidney and coagulative function should be carefully monitored in all patients receiving HES. However, a systematic review of 3rd generation HES [HES 130/0.4] suggested that its advantages are overestimated and there is no convincing evidence of significant reduction in the serious side effects attributed to the older HES solutions by its use.[22]

Pharmacokinetics

Human albumin - THE 5% solution is isooncotic and leads to 80% initial volume expansion whereas 25% solution is hyperoncotic and leads to 200 - 400% increase in volume within 30 minutes. The effect persists for 16-24 hours.[23]

0.9% saline - It has a slightly higher degree of osmolarity (i.e. more solute per litre) than blood. However, if you take into account the osmotic coefficient, a correction for non-ideal solutions, then the saline solution is much closer to isotonic.

Dextran - Two dextran solutions are now most widely used, a 6% solution with an average molecular weight of 70,000 (dextran 70) and a 10% solution with an average weight of 40,000 (dextran 40, low-molecular-weight dextran). Kidneys primarily excrete dextran solutions. Smaller molecules (14000-18000 kDa) are excreted in 15minutes, whereas larger molecules stay in circulation for several days. Up to 40% of dextran-40 and 70% of dextran-70 remain in circulation at 12 hours.[23] Both dextran-40 and dextran-70 lead to a higher volume expansion as compared to HES and 5% albumin. The duration lasts for 6–12 hours.

Gelatin - Rapidly excreted by the kidney. Following infusion, its peak plasma concentration falls by half in 2.5 hours. Distribution (as a percent of total dose administered) by 24 hours is 71% in the urine, 16% extravascular and 13% in plasma. The amount metabolized is low: perhaps 3%.[23,24] An 70 to 80% of volume expansion occurs.[24] But duration of action is shorter in comparison to both albumin and starches.

3rd generation hydroxyethyl starches [HES][25] - The pharmacokinetic profile is complex and largely dependent on its molar substitution as well as its molecular weight. When administered intravenously, molecules smaller than the renal threshold (60,000 - 70,000 Da) are readily and rapidly excreted in the urine, while molecules with higher molecular weights are metabolised by plasma amylase prior to excretion via the renal route. The mean in vivo molecular weight in plasma is 70,000 - 80,000 Da immediately following infusion and remains above the renal threshold throughout the treatment period. The volume of distribution after IV administration of 500 ml is about 5.9 L. Plasma levels remain at 75% of peak concentration at 30 minutes post-infusion and decrease rapidly to 14% at 6 hours post-infusion. Plasma levels return to baseline levels 24 hours following infusion. Plasma clearance following IV administration of 500 ml is 31.4 mL/min with an AUC (Area under the plasma drug concentration-time curve) of 14.3mg/mL/h, following non-linear pharmaco-kinetics. A single dose of 500 ml results in elimination in the urine of approximately 62% within 72 hours. It is eliminated from systemic circulation with t1/2 of 1.4 hours and a terminal half life (t1/2ß) of 12.1 hours following administration of a single dose of 500 ml. The kinetics is similar following single and multiple dose administration. No significant plasma accumulation occurred after daily administration of 500 ml of a 10% solution containing HES 130/0.4 over a period of 10 days. Elimination rates in the urine were approximately 70% within 72 hours.

Side effects

Human albumin[1]: Nausea, vomiting, shivering, salivation and fever. Allergic reactions - urticaria through to anaphylactic shock. Overload may cause pulmonary edema, raised blood pressure and raised central venous pressure. In septic shock the release of inflammatory mediators has been implicated in increasing the 'leakiness' of the vascular endothelium. The administration of exogenous albumin may compound the problem by adding to the interstitial oedema.[26]

0.9% saline: Reactions which may occur because of the solution or the technique of administration include febrile response, infection at the site of injection, venous thrombosis or phlebitis extending from the site of injection, extravasation and hypervolemia.

Dextran: Anaphylactic reactions more severe than with the gelatins or the starches as dextran reactive antibodies trigger the release of vasoactive mediators. Incidence of reactions can be reduced by pre-treatment with a hapten.[27] Decreased platelet adhesiveness, decreased factor VIII, increased fibrinolysis and decreased coating of endothelium result in bleeding diathesis when larger doses are administered.[23,28] Interference with cross-match (dextrans coat the surface RBCs) and precipitation of acute renal failure, (more often in presence of pre-existing renal damage or reduced renal perfusion) are also reported.

Gelatin: Anaphylactoid reactions are more common than with HA.[27] Majority of studies conclude that gelatins do not influence perioperative bleeding, even in the setting of acute normovolemic hemodilution.[29] Circulatory dysfunction marked by increased plasma renin activity has been reported in patients with ascitis undergoing large volume paracentesis.[30]

HES: The first and second-generation HES (Hextend, Hetastarch, Pentastarch) lead to reduction in circulating factor VIII and von Willebrand factor levels, impairment of platelet function, prolongation of partial thromboplastin time and activated partial thromboplastin time and increases bleeding complications; high molecular weight (HMW) HES are associated with greater

accumulation in interstitial spaces and reticulo-endothelial system including skin, liver, muscle, spleen, intestine, trophoblast and placental stroma associated with pruritus; higher incidence of anaphylactoid reactions as compared to other synthetic colloids and HA; increased creatinine levels, oliguria, acute renal failure in critically ill patients with existing renal impairment. HMW HES is associated with development of osmotic nephrosis like lesions in both proximal and distal renal tubules and impaired renal function.[23]

Third-generation HES: Tetrastarch have a greatly reduced effect on the coagulation,lower blood loss than gelatin and pentastarches; decreased accumulation and therefore less pruritus and lower nephrotoxicity. However, studies investigating HES infusion in children and in neonates with impaired renal function are still lacking.

Conclusion

There are many aspects of therapeutics that need to be reviewed when discussing volume expanders in pediatrics. Each clinical situation needs to be assessed and the fluid most appropriate for that condition needs to be determined. Crystalloids are the fluid of choice in volume resuscitation. Colloids are preferred in very few selected situations as in severe dengue with hypotensive shock, fluid overload, perioperative volume therapy and in hemorrhagic shock. The 3rd generation HES appear to be effective in children and further, large scale studies need to be conducted to confirm its superiority in childhood indications.

Colloids are mainly distributed to the IVS. Even with increased capillary leakage, a greater proportion of a colloid solution will remain in the IVS compared to a crystalloid solution.

Points to Remember

- ***Administration of volume expanders to maintain or restore intravascular volume represents a common intervention for treatment of hypovolemia and shock following or during surgical procedures, trauma or infection.***
- ***Side effects and cost of human albumin restricts its use in hypovolemia when crystalloid infusion fails and for acute hemorrhagic shock along with crystalloids if blood products are not available immediately.***
- ***Advantages of crystalloids include low cost, lack of effect on coagulation, no risk of anaphylactic reaction or transmission of infectious agents.***
- ***Crystalloids in excess could cause pulmonary edema, bilateral pleural effusion, intussusception, excessive bowel edema, impairing closure of surgical wounds and peripheral edema.***
- ***Intravascular volume expansion with synthetic colloids is longer lasting and are efficacious than with crystalloids.***
- ***Dextran, gelatin and more recently, the hydroxyethyl starches [HES] have been used in pediatrics for severe dengue with shock, perioperative volume therapy and in hemorrhagic shock.***
- ***Third-generation HES: tetrastarch by virtue of less toxicity and comparable efficacy could be the volume expander of choice in the future.***

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CLIPPINGS

Guxens M, et al. Breastfeeding, Long-Chain Polyunsaturated Fatty Acids in Colostrum and Infant Mental Development. Pediatrics 2012.

Greater levels of accumulated breastfeeding during the first year of life were related to higher mental development at 14 months, largely independent from a wide range of parental psychosocial factors. Long–chain polyunsaturated fatty acid (LC–PUFA) levels seem to play a beneficial role in children's mental development when breastfeeding levels are high. A high percentage of breastfeeds among all milk feeds accumulated during the first 14 months was positively related with child mental development (0.37 points per month of full breastfeeding [95% confidence interval: 0.06–0.67]). Maternal education, social class and intelligence quotient only partly explained this association. Children with a longer duration of breastfeeding also exposed to higher ratios between n-3 and n-6 PUFAs in colostrums had significantly higher mental scores than children with low breastfeeding duration exposed to low levels.

DERMATOLOGY

STAPHYLOCOCCAL SCALDED SKIN SYNDROME

*** Vijayabhaskar C**

Syn: *Ritter's disease, Pemphigus Neonatorum*

Abstract: *Staphylococcal scalded skin syndrome(SSSS) is caused by Staphylococcus aureus with release of epidermolytic toxin A and B which leads to blistering and widespread exfoliation of skin. Children below 6 years of age are affected due to inability to excrete the toxins and inadequate antibodies formed against the toxin. The child may present with or without constitutional symptoms, irritability, poor feeding, erythematous rash, blisters over the skin and flexural areas leading to widespread exfoliation of skin. This can lead to electrolyte imbalance, temperature instability and secondary sepsis. Diagnosis is usually clinical and identifying the disease early is important to prevent mortality and morbidity. In severe cases child should be admitted and appropriate antibiotics to be started. If treated early children improve without any sequelae.*

Keywords: *Exfoliative toxin A and B, Desmoglein 1.*

Staphylococcal scalded skin syndrome (SSSS) is a blistering skin disease caused by Staphylococcus aureus producing epidermolytic toxin. The severity may vary from mild localized blistering to widespread exfoliation.[1]

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Epidemiology

SSSS is more commonly seen in neonates and young children less than 6 years of age. It is due to lack of antitoxin antibodies[2] and due to poor renal excretion of the toxins.[3] A few babies are partially protected due to maternal antibodies transferred through breast milk. This condition rarely occurs in adults who have immunosuppression, malignancy, heart disease or diabetes and chronic renal insufficiency.[4]

Infected health care workers who may be symptomatic or asymptomatic may be acting as the carriers of the epidemic strain of staphylococcus aureus and may be responsible for outbreaks of SSSS in nurseries and intensive care units. These neonates should be promptly diagnosed and treated to avoid mortality and also for further spread of the disease to other babies in the nursery. Western data shows male to female predominance as 2:1 in sporadic cases and 4:1 in epidemics.[5] Many reports are implicating Methicillin resistant staphylococcus aureus (MRSA) and community acquired methicillin resistance Staphylococcus aureus strains. One report of recurrent SSSS in a neonate has been reported.[6]

Pathogenesis

The Staphylococcus aureus produces epidermolytic or exfoliative (ET) toxins (ETA and ETB). Majority of the SSSS cases are caused by phage group 11 strains like types 3A, 3C, 55 and

71 of Staphylococcus aureus. Of late it has been shown that all phage groups are able to produce exfoliative toxin.[7] These toxins help to disrupt the barrier of the epidermis which will help the bacteria to survive and proliferate. The superficial epidermis has desmosomes which contain desmoglein 1 which is responsible for the cell to cell adhesion. The exfoliative toxin A(ETA) and B(ETB) released by the bacteria are serine proteases which has high affinity to desmoglein 1 and hence targets the desmoglein 1 which results in loss of cell to cell adhesion and leads to blister formation and peeling of skin. Relative quantity of desmoglein 1 in skin may differ with age and may partially be resoponsible for the increase in risk of SSSS in younger children.

Clinical features

It starts with fever, malaise, irritability, sore throat, severe tenderness of skin and poor feeding. It begins as a localized infection of the conjunctiva, nares, umbilicus, perineum and perioral region.Other predisposing factors are pneumonia, septic arthritis, endocarditis or pyomyositis. Initially the rash appears on the head and later large areas are involved with formation of blisters which results in denuded and tender skin. Nikolsky's sign will be positive. (when a tangential pressure is applied over the edge of the bulla the skin peels off easily due to loss of cell to cell adhesion). Flexural areas exfoliate first followed by other areas. Child shows "sad man" facies[7] with perioral crusting and radial fissures and associated edema. The exfoliation is seen for 3 to 5 days and re epithelisation occurs in 2 weeks.

When the whole body is involved thermoregulation is affected, water and fluid imbalance occurs and electrolyte imbalance could lead to mortality. The skin which is exposed will make the child prone for secondary bacterial infection and septicemia. But if managed correctly the skin heals without any scar as the cleavage of skin is superficial.

Diagnosis

Usually it is clinical. In case of doubt the confirmation is by isolation of Staphylococcus aureus. Swabs are taken from the nares, nasopharynx and conjunctiva.[8] Skin swabs are not taken as the skin is sterile and bacteria cannot be isolated from skin as the exfoliation occurs due to toxin. Blood cultures are always negative. WBC count may be normal or elevated.

Frozen section examination of the lesions, slide latex agglutination and ELISA can identify the toxins.

Differential diagnosis

The other condition which may mimick SSSS with subtle differences are toxic epidermolysis necrosis, scalding burns, epidermolysis bullosa and bullous ichthyosis.

Toxic epidermolysis necrosis: Usually follows drug intake and mucosal involvement like conjunctiva, oral mucosa and genital mucosa are important features of TEN.

Epidermolysis bullosa: It is a mechanobullous disorder.Blisters may start in utero and will be seen from birth with blisters and peeling of skin occurring over the frictional area

Bullous ichthyosis: History of colloidoin baby and ichthyosis will be seen since birth.

Treatment

Neonates, infants and children with severe disease are always admitted and in very severe cases should be admitted in the intensive care unit. Isolation of contacts is also recommended.

Saline soaks could be used on crusted impetigenous lesions and over the exfoliative skin. No topical antibiotics are recommended as skin is sterile. Fluid and electrolyte imbalance should be taken care of. Specific Treatment: Use drugs to target the staphylococcus aureus which is releasing the toxin. Cloxacillin or dicloxacillin is usually the drug of choice which has to be used for 7 to 10 days. Clindamycin is another choice and could be modified based on the culture and sensitivity report. In case of MRSA infections vancomycin would be the drug of choice.

Neutralizing antibodies which will inhibit the binding of exfoliative toxins to desmoglein 1 are under investigation.

Prognosis

Treatment started early will have 100% good prognosis. In severe case of SSSS 3% mortality is seen in children.

Prevention

Avoidance of primary staphylococcal infection that may lead to SSSS. Established staphylococcal infection to be treated appropriately. Identification and treatment of asymptomatic carriers.[8]

Points to Remember

- ***SSSS is a disease common in children below 6 years of age.***
- ***Suspect SSSS when a child has fever, irritability and skin tenderness with rash.***
- ***If diagnosed as SSSS try to find out any foci of sepsis.***
- ***Admit the child if it is severe and treatment to be started early with antibiotics which are effective against Staphylococcus aureus.***
- ***Do not allow personnel with symptomatic or carrier state of staphylococcus to enter the nurseries.***

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RADIOLOGIST TALKS TO YOU

IMAGING AND SINUSITIS

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****Malathy K**
*****Natarajan B**
*****Jaya Rajiah**
*****Kasi Visalakshi**

The maxillary and ethmoid sinuses begin to develop in the 3rd to 4th month of gestation. In the newborn the ethmoid cells are well developed. The maxillary sinuses are shallow sacs. The frontal and sphenoid sinuses are blind sacs. Though the ethmoid and maxillary sinuses are present at birth they are incompletely aerated and often appear opaque in X-ray even when the child is normal. Therefore the PNS X-ray is unlikely to show all air filled sinuses till about the age of 6 and is clinically of no help. The sphenoid sinus begins to develop at 3 years and enlargement proceeds throughout childhood. The aerated sphenoid can be seen by 5 years. The last sinus to develop is the frontal sinus which becomes visible in the PNS X-ray at about 6 or 7 years. Full size is reached at puberty and it is larger in males. Fig.1 is that of a 2 year old child showing the maxillary and ethmoid sinuses. The frontal sinuses are seen well in Fig.2 in a 9 year old child. Sinuses are large and skull bones are thickened when there is brain atrophy.

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The commonest pathology in the sinuses is acute infection. Acute sinusitis is treated on clinical evidence alone. X-rays are not indicated to confirm a clinical diagnosis of sinusitis in children of 6 years or less. Even in children over 6 years, a negative PNS X-ray is of more value than a positive X-ray as it can be taken as good evidence that sinusitis is not the cause for clinical syndromes like exacerbations of reactive airways disease. However, the fact that the PNS X-ray is technically difficult to perform and that faulty technique can lead to erroneous diagnosis makes the paranasal sinus X-ray redundant in the management of acute sinusitis. Likewise, CT and MRI are not indicated in uncomplicated acute sinusitis because it has been found that many children undergoing scans for other problems show sinus mucosal thickening even when there are no acute symptoms. Therefore mucosal thickening alone cannot be evidence for acute infection. Abnormal findings in the PNS X-ray are opacification of sinuses and air-fluid levels.

CT should be done in those children who have persistent or recurrent infection of the sinuses not responsive to medication and in whom sinus lavage is contemplated. In these cases CT maps sinus anatomy and variations that will help the otorhinolaryngologist. CT scans are definitely indicated when a child presents with complications or suspected complications of acute bacterial sinusitis. These are orbital and CNS involvement. Orbital signs to be watched for are periorbital swelling, proptosis or reduced visual acuity. Alarming CNS symptoms are altered mental status, headache, vomiting and neck

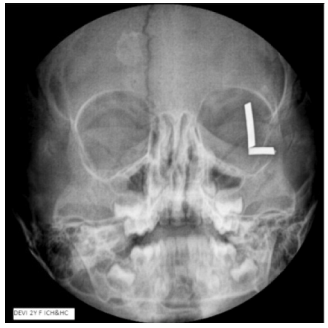

Fig.1. X-ray PNS in a 2 year old. Only maxillary and ethmoid sinuses are seen.

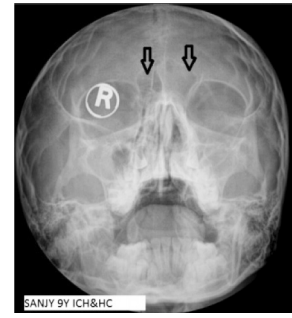

Fig 2. X-ray PNS in a 9 year old. Arrows point to frontal sinuses

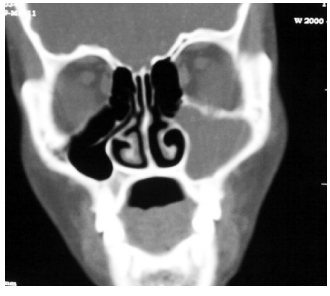

Fig.3. left maxillary antral polyp

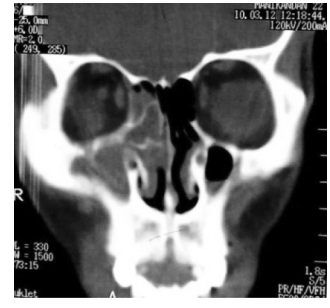

Fig.4. Sinonasal polyposis involving right ethmoid and right maxillary sinuses.

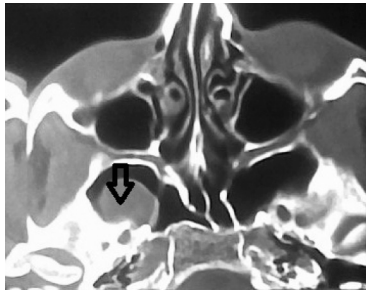

Fig.5. Retention cyst in a pneumatised greater wing of right sphenoid(arrow).

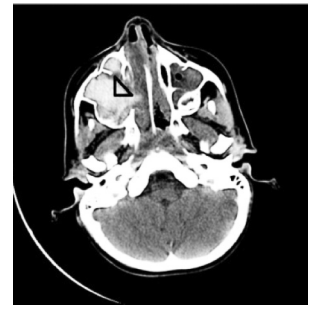

Fig.6. Allergic fungal sinusitis- Note the high density in the expanded right maxillary sinus.

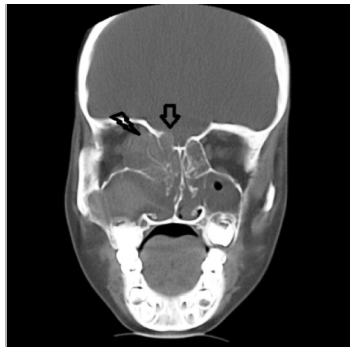

Fig.7. Coronal section in same patient as in Fig 6. Arrow points to erosion of superior wall of ethmoid on right. Arrowhead- extension into orbit. Compare with normal left orbit.

rigidity. CT is the imaging of choice as it will show the bony walls of the sinuses and spread of infection outside the sinuses. Orbital complications are subperiosteal abscess, orbital cellulitis, orbital abscess and cavernous sinus thrombosis(from orbital phlebitis). CNS complications include subdural empyema, epidural abscess, brain abscess and meningitis.

Chronic sinusitis refers to persistent sinus infection for over 12 weeks. Though the cause is multifactorial, allergy and fungal infection are important. Inflammatory thickening of the mucosa give rise to polyp formation. They slowly enlarge with repeated allergic sinusitis and prolapse through the ostium into the nasal cavity. They grow posteriorly towards the posterior choanae and the nasopharynx. The commonest is the antrochoanal polyp. Fig.3 is an antrochoanal polyp widening the ostium of the left maxillary sinus as it tries to decompress into the nasal cavity. Sphenochoanal and ethmoidochoanal polyps can also occur. Fig.4 shows sinonasal polyposis involving the ethmoidal and maxillary sinuses on the right. The ethmoid cells are separated by thin connective tissue which progressively thicken and ossify into thin bony septa. The preserved ethmoidal septae is a point in favour of inflammation . In neoplasia, there is destruction of the septae. Retention cysts are localised lobulated lesions due to obstruction of mucosal glands. Fig.5 shows a retention cyst in an otherwise uninflamed sinus in a pneumatised greater wing of sphenoid.

Fig.6 and Fig.7 are that of an immuno-competent 6 year old boy with allergic fungal sinusitis. Multiple sinuses are involved. Disease is usually bilateral and there is a large nasal component also. The axial section shows an expanded right maxillary sinus with characteristic high attenuating areas. This hyperdensity is due to the presence of iron, magnesium and manganese concentrated by the fungal organisms. The coronal section in Fig.7 shows thinning and expansion of the maxillary antral walls. The ethmoid sinuses are also distended and bulging with allergic mucin, with erosions of the superior wall on the right causing a minimal extradural extension. The lateral wall of the right ethmoid is eroded with subperiosteal extension into the right orbit. Note the preserved ethmoidal septae pointing to the inflammatory nature of the lesion.

Acute bacterial sinusitis is a clinical diagnosis. Imaging is only for complications. But for fungal sinusitis and when there is a nasal component CT and MRI are essential to map the extent of involvement before surgical debridement. CT is indicated prior to any sinonasal surgical intervention.

CASE STUDY

CONGENITAL NON-CHYLOUS PLEURAL EFFUSION

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Abstract: *Isolated pleural effusion, so called primary pleural effusion is an entity without any documented etiology such as cardiac, inflammatory, iatrogenic or fetal hydrops. Chromosomal abnormality like Down syndrome may be associated with isolated pleural effusion. The content of the effusion is mostly chylous and non chylous isolated pleural effusion in neonate is very rare. We experienced one case of non chylous exudative isolated pleural effusion present from 34 weeks of gestation and continued to be present at delivery. No cause was attributed to this. Imaging diagnosis was done by plain chest radiography and subsequent ultrasonography. The baby required neonatal resuscitation at birth including intubation. The baby was well after diagnostic and therapeutic thoracocentesis.*

Keywords: *Spontaneous congenital pleural effusion, Neonate, Non-chylous*

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Congenital pleural effusion is a rare condition, with an incidence of 1 in 12000 to 1 in 15000 pregnancies.[1] The content of effusion is usually chylous, however a minority are non chylous.[2,3,4] It has excellent prognosis following timely intervention.[5] We report a case of congenital non chylous exudative pleural effusion.

Case Report

A full term male baby weighing 2500 grams was delivered by cesarean section to antenatally registered primigravida mother. Antenatal fetal sonography revealed right sided pleural effusion from 34 weeks of gestation which continued till term. The baby cried 1 min after birth and had an Apgar score of 5 and 6 at 1 and 5 minutes respectively. He was resuscitated with bag and mask and subsequently intubated and was put on mechanical ventilation. Arterial blood gas analysis revealed respiratory acidosis with pH=7.15, PCO_2=66, PO_2=50 $HC0_3$=22. Chest radiograph obtained at one hour of birth revealed right sided pleural effusion and shift of mediastinum to left (Fig.1). The diagnosis of right pleural effusion was reconfirmed by chest sonography, which showed clear fluid without septae or loculi. Inter costal needle aspiration was done under ultrasound guidance and about 120 ml of straw coloured fluid removed. Repeat chest x-ray showed reduction of effusion and expansion of right lung.(Fig.2) Following pleural fluid drainage, gradual clinical improvement was noticed. To find out the possible etiology, the following investigations were done. Sepsis workup including blood culture were normal. There was no Rh or ABO incompatibility. Liver function test and renal function tests were

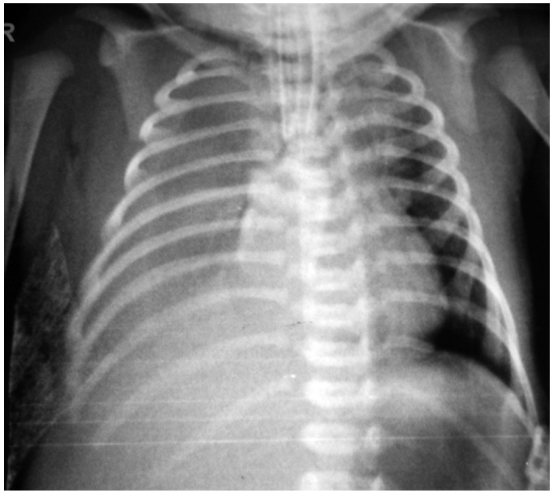

Fig.1. Chest X-ray showing right sided pleural effusion with ET tube insitu.

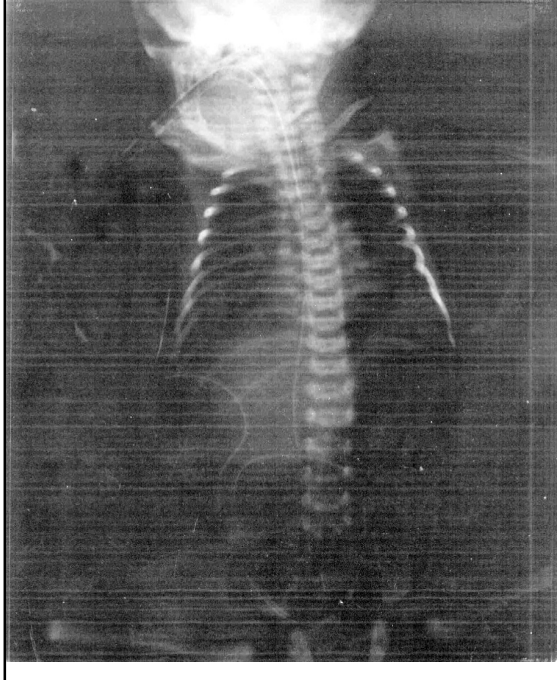

Fig.2. Chest X-ray showing very minimal pleural fluid in right,1 hr after thoracocentesis

normal. Thyroid screening was normal. Ultrasonography of brain and abdomen were within normal limits.

Echocardiography and CT thorax revealed no abnormality. TORCH screening of baby was negative. VDRL test was non reactive. Karyo typing of baby revealed normal chromosomal pattern. The pleural fluid was exudative (protein 3.9 gm/dL, glucose 75 mg dL, chloride 103 m M/L, LDH 273 IU/l, WBC 3800/mm^3, mostly lymphocytes,[4] triglyceride level was 12 mg/dL) and was sterile on culture. Low level of triglyceride in pleural fluid ruled out chylous effusion.

In addition to thoracocentesis, the baby was treated with intravenous antibiotics, fluids along with ventilator support. The baby was extubated after 36 hours. He was weaned off oxygen after 48 hours and nasogastric feeding started. The intravenous fluid and nasogastric feeding were gradually withdrawn and the baby took direct breast feeding from fifth day and was discharged on eighth postnatal day.

Follow up chest radiograph showed resorption of right pleural effusion. The baby was doing well at 6, 10 and 14 weeks of age. He has gained adequate weight and has no respiratory symptoms.

Discussion

Neonatal pleural effusion may be congenital, inflammatory, iatrogenic following line placement, secondary to congenital heart failure or as a part of fetal hydrops.[6] It is mostly unilateral and about 60 % of cases is found in right side.[2] Isolated or spontaneous pleural effusion in neonate is very rare and is diagnosed when no cause is attributed to the effusion.[6] Congenital pleural effusion may be exudative or serous. Exudative pleural effusion may be chylous or non chylous.

The isolated pleural effusion is mostly chylous, resulting from a malformation or tear in the fetal thoracic duct. Chylous effusion may be initially serous and turn into chylous only after milk feeding. Distinguishing features of chylous from serous effusion are milky white or yellow bloody colour, more than 110 mg /dL of triglyceride level and lymphocytosis. However lymphocytosis can be seen in tuberculosis and viral infection.[7] Our case had low triglyceride level and milk feeding did not cause reappearance of effusion.

In rare cases, the pleural content is serous. Some authors reported that serous congenital effusion may be associated with underlying thoracic cause such as primary lymphangiectasia, congenital cystic adenomatous malformation, bronchopulmonary dysplasia, diaphragmatic hernia, chest wall hamartoma and pulmonary vein atresia.[3,5] In our child CT scan of chest was done on fifth day and it ruled out these possibilities. Several cases of congenital or fetal pleural effusion have been reported in association with chromosomal anomaly (Down syndrome and Turner syndrome).[8,9] Most of these effusions were chylothorax or associated with hydrops fetalis.[7] Hence, karyotyping is indicated in foetus or newborn for the evaluation of associated chromosomal anomaly. However association of Down syndrome with non chylous pleural effusion is also rarely reported.[4] Our patient had normal chromosomal pattern. Like our case, exudative non chylous pleural effusion is very rare. Despite thorough workup, the exact etiology of the exudative congenital pleural effusion could not be established. However a viral etiology can not be ruled out. Hwang JY, et al had reported cases with similar findings as isolated non chylous pleural effusion.[10]

The clinical course of congenital pleural effusion is variable. Congenital pleural effusion causing pulmonary hypoplasia may be associated with high mortality[1]. However most of the cases improve with early diagnosis and treatment, like in our case. Some cases showed spontaneous resolution in utero or remain well with residual small amount of pleural effusion[5,10]. In our case the baby fully recovered with therapeutic thoracocentesis.

Summary: Congenital pleural effusion is a medical emergency at birth. This condition though very rare, is a differential diagnosis of respiratory distress syndrome at birth. Prenatal ultrasonography is helpful in the diagnosis of this condition, so that delivery can be planned accordingly. Prompt management in delivery room can be life - saving in these cases.

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CLIPPINGS

Interventions for preventing obesity in children

Strong evidence is found to support beneficial effects of child obesity prevention programmes on BMI, particularly for programmes targeted to children aged six to 12 years. However, given the unexplained heterogeneity and the likelihood of small study bias, these findings must be interpreted cautiously. A broad range of programme components were used in these studies and whilst it is not possible to distinguish which of these components contributed most to the beneficial effects observed, our synthesis indicates the following to be promising policies and strategies:

- School curriculum that includes healthy eating, physical activity and body image
- Increased sessions for physical activity and the development of fundamental movement skills throughout the school week
- Improvements in nutritional quality of the food supply in schools
- Environments and cultural practices that support children eating healthier foods and being active throughout each day
- Support for teachers and other staff to implement health promotion strategies and activities (e.g. professional development, capacity building activities)
- Parent support and home activities that encourage children to be more active, eat more nutritious foods and spend less time in screen based activities

However, study and evaluation designs need to be strengthened, and reporting extended to capture process and implementation factors, outcomes in relation to measures of equity, longer term outcomes, potential harms and costs.

Childhood obesity prevention research must now move towards identifying how effective intervention components can be embedded within health, education and care systems and achieve long term sustainable impacts.

Waters E, de Silva-Sanigorski A, Hall BJ, Brown T, Campbell KJ, Gao Y, Armstrong R, Prosser L, Summerbell CD. Interventions for preventing obesity in children. Cochrane Database of Systematic Reviews 2011, Issue 12. Art. No.: CD001871. DOI: 10.1002 14651858.CD001871.pub3.

CASE STUDY

CHROMOSOME 22Q11.2 MICRO DELETION SYNDROME

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Abstract: *Hypoparathyroidism with hypo calcemic seizures beyond the neonatal period may be the presenting finding leading to the diagnosis of chromosome 22q11 micro deletion syndrome. Awareness of this condition is necessary not only for proper case management but also for genetic counseling and prenatal diagnosis. We report a case of an eleven years old adolescent girl who presented with hypoparathyroidism with hypocalcemia and seizures and was diagnosed to have chromosome 22q11 micro deletion by FISH technique.*

Keywords: *Hypoparathyroidism, Hypo calcemia, Seizures, Chromosome 22q11 micro deletion syndrome.*

Case Report

A eleven-year-old girl presented to us with the complaints of generalized tonic clonic seizures, tingling and paresthesias for the last two years. For each episode of seizure, she was treated symptomatically in the local hospital. She was started on carbamazepine because of the recurrent seizures following which she developed Steven-Johnson syndrome.

She is the second born child to parents of non-consanguineous marriage, born at term with a birth weight of 2.5 kgs. Cyanosis was noted soon after birth and child had recurrent hyper cyanotic spells since 22 days of life. She was diagnosed to have DORV with VSD with PS and was operated at the age of six months. Thymus was reported to be absent at the time of surgery.

She had been thriving well since then and was asymptomatic till nine years of age, except for her mild scholastic backwardness. She had facial dysmorphism with prominent forehead, hypertelorism, micrognathia and mid facial hypoplasia.

On investigations, her serum calcium was 6.7 mg/dL, serum albumin was 4 gm/dL, inorganic phosphorus 8.2 mg/dL, urine calcium/creatinine ratio- 0.06, serum magnesium- 1.8 mg/dL, alkaline phosphatase 270 U/L, PTH level 17.20 pg/mL. CT scan revealed intra cranial calcification in basal ganglion, caudate nucleus and bilateral frontal sub cortical region and left Centrum ovale. Karyotyping was 46XX.

She was diagnosed to have hypoparathyrodism with hypocalcemia. She was started on calcium supplementation and capsule calcitriol 0.25 µg twice daily. She was not put on anticonvulsants. Based on her clinical profile, she was suspected to have chromosome 22q11.2 micro deletion, which was confirmed by

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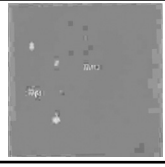
FISH INVESTIGATION FOR : DiGeorge Syndrome
METHOD : By Fluorescence in situ Hybridization (FISH)
PROBES USED : Vysis DiGeorge Region FISH Probe including and flanking N25. The TUPLE1 probe includes the 3 non-coding region of TUPLE1 (Hira). Both Probes are coupled with a LSI ARSA control probe that maps to the telomeric end of 22q (22q13).

RESULTS



	1ST HYBRIDIZATION (LSI)		NO. OF CELLS ANALYZED	INTERPRETATION
	GREEN	ORANGE		
Chromosome	22q13	22q11.2		
SIGNALS PER CELL	2	1	2	POSITIVE

2 Green and1 orange signal found in all the interphase cells studied

COMMENTS : Del(22q) found in all the interphase cells studied.
Thanks for your kind reference.

Fig.1. FISH assay confirming the chromosome 22q micro deletion

fluorescent in situ hybridization (FISH) technique. Probe used was Vysis Di George Region FISH probe including and flanking N25. The TUPLE-1 probe includes the 3' noncoding region of TUPLE (HRA). Both probes are coupled with a LSI ARSA control probe that maps to the telomeric end of 22q. Number of cells analyzed was 25. Del (22q) was found in all the metaphase cells studied.

She reported for review two months after starting calcium supplementation and calcitriol. She did not have any further episodes of seizures. Her total calcium was 9.2 mg/dL, serum albumin 4 mg/dL, phosphorus 6.7 mg/dL, Alkaline phosphatase 235U/L, and PTH 17.7 pg/ml

Discussion

Chromosome 22q11 deletion syndrome was first described in 1965 in young children with the triad of hypoparathyroidism, thymus hypoplasia and recurrent infection and was initially termed as Di George Syndrome.[1]

Micro deletion in region of 22q11 of one copy of chromosome 22 was found in the majority of cases.[2] As a consequence of the micro deletion, there is a congenital failure in the development of the derivatives of various pharyngeal arches and pouches. Two other separately described disorders; Velocardiofacial syndrome and conotruncal anomalies face syndrome were also found to be associated with microdeletion 22q11.[3] As a result, these two syndromes have now been combined with Digeorge Syndrome into one genetic entity known as chromosome 22q11 deletion syndrome.

Driscol DA, et al.[2] in their study reported a deletion of 22q11 in 83% of patients with Di George Syndrome and 68% of patients with Velocardiofacial syndrome by DNA dosage analysis, fluroscent in situ hybridization or by both methods.

Deletion of this critical region is estimated to affect 1/7500 live birth.[4] Most affected patients are diagnosed neonatally with congenital heart disease, hypocalcaemia and/or dysmorphic features.

Ryan, et al.[5] have studied the clinical data of 558 patients and have reported that eight percent

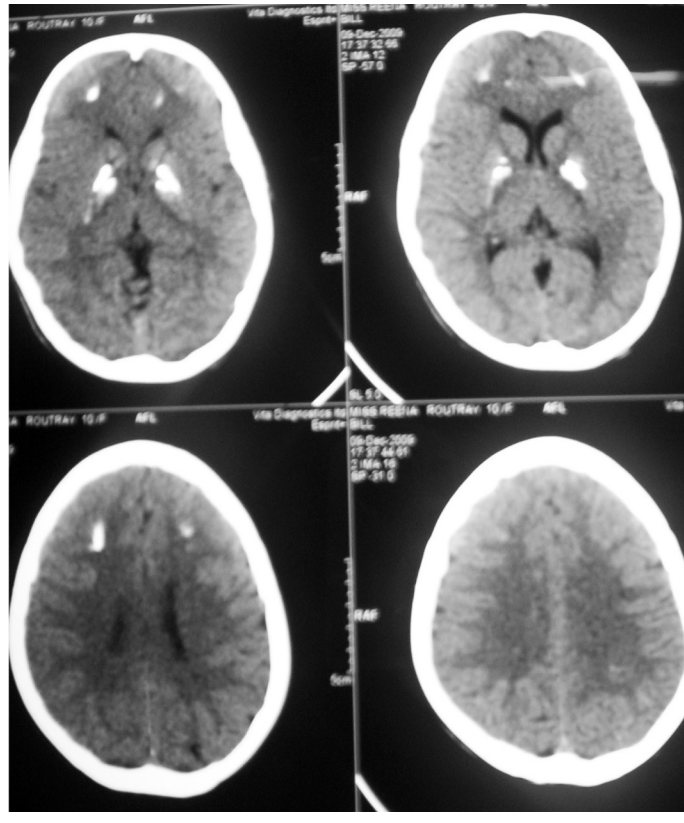


Fig.2. Intracerebral calcification seen in CT scan

of the patients had died, over half of these with in a month of birth and the majority within six months. All but one of the deaths was the result of congenital heart disease. Clinically significant immunological problems were very uncommon. Nine percent of patients had cleft palate and 32% had velopharyngeal insufficiency, 60% of the patients were hypocalcemic, 75% of patients had cardiac problems and 36% of patients who had abdominal ultrasound had a renal abnormality, 62% of surviving patients were developmentally normal or had only mild learning problem. The majority of patients were constitutionally small, with 36% of patients below the third percentile for either height or weight parameters. Height and weight was between tenth and twenty-fifth percentile for our patient and she had been growing well but for her mild learning problem.

Hieronimus S, et al.[6] have reported parathyroid dysfunction in 50% of patients with microdeletion 22q11. Hypocalcemia manifested as laryngeal stridor with in the first days of life, seizure in infancy and adolescence. The connection between hypoparathyroidism and diagnosis of del 22q11 was belated at the median age of 18 years.

Intra cerebral calcification is a facultative symptom of hypoparathyroidism in 22q11.2 deletion syndrome.[7] Late onset hypocalcemia may be the presentation of parathyroid gland

dysfunction secondary to chromosome 22q11 deletion syndrome. Awareness of this condition helps in early diagnosis, proper case management and potential benefits of genetic counseling. This micro deletion occurs denovo, although it is inherited in 10- 20% of cases. Individuals with a 22q11 deletion have a 50% risk of having an affected offspring with each pregnancy[8-10]. FISH based assays help to detect the deletion and is now commercially available. These assays also provide couples at risk the possibility of genetic counseling and prenatal diagnostic testing.

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NEWS AND NOTES

First Indian Pediatric Dialysis Training course and

Acute Kidney Injury Seminar, Gurgaon, Haryana.

Date: 15th - 16th December, 2012

Contact

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