REVIEW
OF
LITERATURE
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Perinatal asphyxia is an insult to the foetus or newborn due to lack of oxygen (hypoxia) and or lack of perfusion (Ischaemia) to various organs (Evan et al 1998) and is one of the most important cause of neonatal morbidity and mortality accounting for 20% of perinatal deaths (Ohlsson et al, 1987).

Any process that impairs maternal oxygenation, decreased blood flow from the mother to the placenta or from the placenta to the fetus, impairs gas exchange across the placenta or at the fetal tissue or has to increased fetal oxygen requirement, will exacerbate perinatal asphyxia. Such factors include: maternal hypertension, maternal vascular disease, maternal hypoxia from pulmonary cardiac or neurologic disease, maternal hypotension, maternal infection, placental infarction or fibrosis, placental abruption, cord accidents, abnormalities of umbilical vessels, fetal anemia, fetal or placental hydrops, fetal infection, intrauterine growth retardation and postmaturity. In the presence of a hypoxic ischaemic challenge to the fetus, reflexes are initiated causing shunting of blood to the brain, heart and adrenals and away from the lung, gut, liver, kidneys, spleen, bone, skeletal muscle and skin (Diving Reflex). In mild hypoxia, there is a decreased heat rate,
slight increase in blood pressure to maintain cerebral perfusion, increased central venous pressure and little change in cardiac output. As asphyxia progresses with severe hypoxia and acidosis, there is a decreased heart rate, decreased cardiac output and initially increased then falling B.P. as oxidative phosphorylation fails and energy reserves become depleted. During asphyxia, anaerobic metabolism produces lactic acid, which because of poor perfusion, remains in local tissue. Systemic acidosis may actually be mild until perfusion is restored and these local acid stores are mobilized.

The most frequent abnormalities involved the kidneys (50%), followed by the central nervous system (28%), cardiovascular system (25%) and pulmonary system (23%).

Hypoxic ischaemic brain injury is the most important consequence of perinatal asphyxia (Perlman et al 1989). Grossly the following lesions may be seen after moderate or severe asphyxia 1. Focal or multifocal cortical necrosis 2. Watershed infarcts 3. Selective neuronal necrosis 4. Necrosis of thalamic nuclei and basal ganglia (Status marmoratus). The syndrome of hypoxic ischaemic encephalopathy has a spectrum of clinical manifestations from mild to severe. We also use the Sarnat clinical
stages to estimate the severity of asphyxial insult to infants more than 36 weeks gestational age on an individual basis at the bedside.

**SARNAT STAGING OF HYPOXIC ISCHEMIC ENCEPHALOPATHY**

<table>
<thead>
<tr>
<th>Stage</th>
<th>Stage 1 (mild)</th>
<th>Stage 2 (Moderate)</th>
<th>Stage 3 (Severe)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of consciousness</td>
<td>Hyperalert</td>
<td>Lethargic</td>
<td>Stuporous, comatose</td>
</tr>
<tr>
<td>Neuromuscular control:</td>
<td>Uninhibited, overactive</td>
<td>Diminished spontaneous movement</td>
<td>Diminished or absent spontaneous movement</td>
</tr>
<tr>
<td>Muscle tone</td>
<td>Normal</td>
<td>Mild Hypotonia</td>
<td>Flaccid</td>
</tr>
<tr>
<td>Posture</td>
<td>Mild distal flexion</td>
<td>Strong distal flexion</td>
<td>Intermittent decerebration</td>
</tr>
<tr>
<td>Stretch reflexes</td>
<td>Overactive</td>
<td>Overactive, disinhibited</td>
<td>Decreased or absent</td>
</tr>
<tr>
<td>Segmental myoclonus</td>
<td>Present or absent</td>
<td>Present</td>
<td>Absent</td>
</tr>
<tr>
<td>Complex reflexes:</td>
<td>Normal</td>
<td>Suppressed</td>
<td>Absent</td>
</tr>
<tr>
<td>Suck</td>
<td>Weak</td>
<td>Weak or absent</td>
<td>Absent</td>
</tr>
<tr>
<td>Moro</td>
<td>Strong, low threshold</td>
<td>Weak, incomplete high threshold</td>
<td>Absent</td>
</tr>
<tr>
<td>Oculovestibular</td>
<td>Normal</td>
<td>Overactive</td>
<td>Weak or Absent</td>
</tr>
<tr>
<td>Tonic neck</td>
<td>Slight</td>
<td>Strong</td>
<td>Absent</td>
</tr>
<tr>
<td>Autonomic function:</td>
<td>Generalized sympathetic</td>
<td>Generalized parasympathetic</td>
<td>Both systems depressed</td>
</tr>
<tr>
<td>Pupils</td>
<td>Mydriasis</td>
<td>Miosis</td>
<td>Midposition, often unequal; poor light reflex</td>
</tr>
<tr>
<td>Respiration</td>
<td>Spontaneous</td>
<td>Spontaneous, occasional apnea</td>
<td>Periodic, apnea</td>
</tr>
<tr>
<td>Heart rate</td>
<td>Tachycardia</td>
<td>Bradycardia</td>
<td>Variable</td>
</tr>
<tr>
<td>Bronchial and salivary Secretions</td>
<td>Sparse</td>
<td>Profuse</td>
<td>Variable</td>
</tr>
<tr>
<td>Gastrointestinal motility</td>
<td>Normal or decreased</td>
<td>Increased diarrhea</td>
<td>Variable</td>
</tr>
<tr>
<td>Seizures</td>
<td>None</td>
<td>Common focal or multifocal</td>
<td>Uncommon</td>
</tr>
<tr>
<td>EEG finding</td>
<td>Normal (awake)</td>
<td>Early: generalized low voltage, slowing (continuous delta and theta) Last: Periodic pattern (awake); seizures focal or multifocal; 1.0 to 1.5 Hz spike and wave</td>
<td>Early: Periodic pattern with isopotential phases Later: totally isopotential</td>
</tr>
<tr>
<td>Duration of symptoms</td>
<td>&lt;24 hours</td>
<td>2 to 14 days</td>
<td>Hours to weeks</td>
</tr>
<tr>
<td>Outcome</td>
<td>About 100% normal</td>
<td>80% normal; abnormal if symptoms more than 5 to 7 days</td>
<td>About 50% die; remainder with severe sequelae</td>
</tr>
</tbody>
</table>
Cardiac effects of birth asphyxia

Myocardial ischaemia can be diagnosed clinically, in majority of cases where perinatal stress is followed by respiratory distress, cardiogenic shock, congestive cardiac failure, murmur of tricuspid and mitral regurgitation in varying combination with abnormal ECG and echocardiography will further strengthened by good degree of correlation with pathological studies of myocardium, muscle enzyme studies and myocardial perfusion scans.

Apgar Score

Virginia Apgar devised the Apgar scoring system in 1953. It is a quick method of assessing the state of newborn. It was developed to quickly identify the newborn in need of resuscitation (Apgar, 1983). The Apgar score comprises of five components – heart rate, respiratory effort, tone, color and reflex stimulation. Each of these components can be given a score of 0,1 and 2.

An Apgar score of 8-10 is normal, 5-7 indicates mild asphyxia, 3-4 indicates moderate asphyxia and 0-2 indicates severe asphyxia. The neonate is evaluated at 1 minute, 5 minutes, and 10 minutes.

A low one minute Apgar score less than 6 has been coded as asphyxia in the international classification of diseases, revision
9. It actually neither indicates substantial hypoxia has occurred nor has much prognostic significance.

   Apgar score at 5 minutes indicates the infant who needs continued resuscitation.

   An Apgar score that continues to be 3 or less at 10 minutes indicates that infant has remained hypoxic despite resuscitative efforts.

   **Carlin et al, 1986** noted that apgar score partially depends upon the maturity of newborn. Immature infants are more likely to be hypotonic, to have cyanotic extremities and to have decreased responsiveness. Therefore a score of 7 may be maximum for a normal premature infant.

   Studies conducted by **Row et al, (1925), Kapur et al, (1970)**, have revealed that 90% of asphyxial insult occur in the antepartum or intrapartum period as a results of placental insufficiency. While the remainders are postpartum, usually secondary to pulmonary, cardiovascular, or neurological insufficiency; **Brown et al (1974)** concluded that hypoxia occurred primarily antepartum in 51%, Intrapartum 40%, and postpartum 9%.
LDH catalyses the reversible conversion of Lactate to pyruvate in the presence of nicotinamide adenine dinucleotide as an oxidisable reductible coenzyme for the reaction. LDH is widely distributed in the body and is present in high concentration in cardiac muscle, liver, RBC's, skeletal muscle, brain and Kidney. Stevenson in 1943 and Jones and Mccance in 1949 observed that the serum LDH level in the newborns were different from that in the adults. Zimmerman (1958) noted a higher value of serum LDH in the cord blood samples. Stewart and Birkbeck (1962) suggested that LDH was higher in premature newborns and it could form the basis of biochemical definition of maturity.

Ranck et al (1959) have shown that asphyxia at birth may result from many conditions. The mechanism of intrauterine or birth asphyxia common to these may be appreciated from a consideration of placental transfer of O₂ from mother to fetus and thus initiation and maintenance of respiration at birth. The duration of fetal hypoxia is also very important.

The human placenta is haemochorial in type, foetal capillaries come into direct relationship with a pool of maternal blood thereby creating a large interface for exchange of oxygen and carbon dioxide.
Bartels et al (1962) have given a schematic representation of fetal and maternal circulation within the uterus. They demonstrated that oxygen tension in the fetal blood is very much lower than that of maternal or uterine venous blood. This led to the suggestion that the fetus lives under conditions of oxygen deficiency. The apparent disadvantage of a low Po$_2$ is partially offset, however, by the high oxygen capacity of the fetal blood and the Bohr effect.

According to Guyton et al (1964), intrauterine hypoxia could result from a decrease in the amount of oxygen available for gaseous exchange, limitation of the area available for gaseous exchange, imbalance between maternal and umbilical blood flow, decreased tissue utilization of O$_2$. Several of tissue factors might act concurrently.

All the factors occurring during birth anoxia combines to lead to failure in cerebral perfusion and in turn to a number of cerebral circulatory lesions, the location of which according to Towbin et al (1969) was governed in part by vascular pattern and in part by the gestational age of the foetus at the time of the hypoxic insult.

Boyle (1970) established that the ability of animal to survive in an environment free of oxygen varies with age. Younger and
more immature the infant is, greater is the tolerance to total deprivation of oxygen. This increased resistance of the foetus to anoxia has been related to the adequacy of cardiac glycogen stores and possibly to additional source of energy to foetal tissue.

Rowe and Hoffman (1972) published a report which intends to describe an added dimension to circulatory disturbances in the newborn infant which begin as primary disorders of lung function. This study was based upon three infants seen at the children's medical and surgical center of the Johns Hopkins Hospital. Two of them were born full term after an uncomplicated gestation, while third was born full term assisted by forceps. Each infant was delivered apparently normally at term, free of obvious malformation. Each developed cyanosis, tachypnea and heart failure during the first 24 hours of life. A notable feature of the physical examination was the presence of right ventricular thrust and weak brachial and femoral arterial pulsations. Auscultatory findings were more variable. Serial ECGs were recorded, chest radiography was performed, blood gases were analysed and cardiac catheterization was done. The heart size in chest radiographs was either in the normal range or much enlarged. The initial ECG always showed right ventricular dominance, although in
IIIrd case there was suggestive early electrical evidence of stress to the left ventricle as well. All three patients were shown to have normal cardiac anatomy. In IIIrd case, the posterior wall of left ventricle moved very poorly. In each patient, recovery as judged by normal physical signs, radiographs and electrocardiogram, was eventually complete. Therapy consisted of high ambient oxygen concentrations, digoxin and in case 3, a single dose of a diuretic agent. It seems reasonable to suppose that the various clinical pictures are quite closely related and most probably that hypoxia is the common initiating stress for all patients. To explain these events they advanced the concept of transient myocardial ischaemia. Under this supposition it was argued that the primary effect could be an exaggerated response to hypoxia by a particularly sensitive pulmonary vascular bed. This in turn would create excessive demands on the right coronary arterial supply through increasing right ventricular work. Perfusion to those areas of distribution of this artery at most risk that is subendocardial zones of the right ventricle and the posterior portion of left ventricle could thus be impaired. Thus the plea for awareness of ECG changes of ischaemia in this age group is raised by this experience.
In the study by Nelson et al (1978), M.M. Thangavel et al (1982), it was observed that infants who suffered from moderate to severe asphyxia had serum CPK-MB isoenzyme fraction higher than 5-10% due to myocardial ischaemia. The echocardiogram and Doppler study showed normal cardiac structures, but decreased left ventricular contractions, especially of the posterior wall and perhaps persistent pulmonary hypertension.

Sinha et al 1978 reported that serum LDH activity was found to be higher in the samples collected 24 hours after delivery compared to the cord blood, then a gradual fall was observed in subsequent estimation.

Observation of serial ECG tracings, correlation with myocardial histology (Dische M.R. et al, 1977) and Thallium imaging (Finley J.P. et al, 1979) suggest that ECG though not infallible tool, is a reasonable good parameter for the diagnosis. Arbitrary criteria for electrocardiographic diagnosis of ischaemic damage have been laid down taking following things into consideration. Flat or inverted T wave, ST segment depression, abnormal Q wave, and complete bundle branch block. Commonest change observed is T wave flattening and ST segment alterations which theoretically needs to be differentiated from normal T wave
changes in the first day of life, the effects of biochemical and biophysical disturbance and influence of drugs. For this reason pediatric cardiologists and pediatricians have tended to accept variable T wave polarity as normal in this age groups and have been reluctant to consider that it might reflect pathological change. Since the ischaemia is global in nature and is subendocardial, the classical changes of transmural infarction are not to be expected.

Buccirelli et al, 1977 proposed that transient tricuspid insufficiency is a previously unrecognized manifestation of myocardial dysfunction secondary to asphyxia with or without hypoglycemia. They studied 14 term neonates and two groups were made. Group I – five of these infants underwent cardiac catheterization, had only massive tricuspid valve insufficiency. Group II – Nine infants were diagnosed on the basis of a murmur characteristic of tricuspid insufficiency and on other clinical grounds. All babies in both groups had suffered significant perinatal stress, either asphyxia documented by low apgar scores and/or hypoglycaemia. In all 14 patients, a characteristic murmur of tricuspid insufficiency was heard. Congestive heart failure, manifested by tachypnea, tachycardia, diastolic filling sounds, and hepatomegaly was present in all infants in group I but in only 4 of 9
patients in group II. Chest radiograph showed cardiomegaly in all group I and in eight of nine in group II. ECG abnormalities were present in all 14 infants. Right atrial enlargement was seen in 10 of 14, while right ventricular hypertrophy was seen in 12 of 14. ST depression in the mid precordium and T wave inversion in left precordium in all newborns of group I and 4 of 9 in group II suggesting myocardial ischaemia. In all 12 survivors, there was spontaneous resolution of cardiomegaly and cyanosis and disappearance of the murmur by 2 weeks of age. ECG changes persisted for as long as two months in some infants. In 1968, Schiebler and associates reported one case of transient tricuspid insufficiency. This child had complete resolution of her signs and symptoms in the neonatal period and had a completely normal heart when recatheterized at 5 years of age. In 1975, Freymann and Kallfelter added the only other case of proven transient tricuspid insufficiency to the literature. This infant had complete resolution of all findings at 5 months of age. Schiebler et al suggested that the tricuspid insufficiency was due to sudden postnatal closure of the ductus arteriosus and foramen ovale, requiring the right ventricle to pump the entire systemic venous return through a hyper resistant pulmonary vascular bed, leading
to right ventricular hypertension and tricuspid insufficiency. Freyman and Kallfeltz emphasized the fact that the medial cusp of the tricuspid valve is not fully formed until after the fourth month of gestation and proposed that isolated retarded development of the septal leaflet of the tricuspid valve may result in tricuspid insufficiency which resolves with further development. Our 14 patients are very similar to the asphyxiated infants with congestive heart failure reported by Burnard and James (1961) and the myocardial dysfunction in infants reported by Rowe and Hoffman (1972). Myocardial ischaemia based on ECG abnormalities was a characteristic feature in our infants, as well as in those reported by Rowe and Hoffman (1972). Most prominent is the ST segment depression in the mid precordium and flattening or inversion of the T waves in the left precordium. The fact that the papillary muscles of stressed ventricles are vulnerable to such changes is supported by the work of Franciosi and Blanc (1968) who reported similar findings in 33 of 44 autopsied hearts from children with congenital heart disease. Transient myocardial dysfunction of stressed newborn is the result of hypoxemia with or without a hypoglycaemic stress. Limited glycogen stores of the newborn and the ability of the newborn to survive longer episodes of
hypoxia than older children or adults combine to produce a myocardial dysfunction syndrome limited to newborns.

Finley et al (1979) conducted a study on seven newborns with a clinical diagnosis of myocardial ischaemia and reported that the echocardiogram was abnormal on at least one determination in five patients, normal in one and technically unsatisfactory in one. Abnormalities ranged from very poor left ventricular function with asynchronous wall movement and ejection fraction below 50% in the two patients with the severest birth difficulties, to an enlarged left atrium (18mm, normal <13) in another. Mitral valve prolapse was present in one infant. The systemic pre-ejection to ejection time ratio was abnormal (PEP/ET= .43, Normal<. 38) in another.

Daga et al (1983) said that myocardial ischaemia can be accurately diagnosed clinically in majority of instances where perinatal stress is followed by respiratory distress, cardiogenic shock, CHF, murmur of tricuspid or mitral regurgitation in varying combination with abnormal ECG was further strengthened by good degree of correlation with pathological studies of myocardium, muscle enzyme studies and myocardial perfusion scans. Dische et al showed correlation between myocardial histology and ECG in their retrospective study while Finley et al showed correlation
between ECG abnormalities and thallium myocardial perfusion scan CPKMB was shown to be raised as a proof of myocardial damage.

Gewilligm (1988) studied three patients with normal hearts and no pulmonary abnormality had neonatal tricuspid regurgitation causing cardiorespiratory distress and cyanosis. The signs of TR resolved over a few weeks. In the acute phase Echocardiography showed gross dilatation of the right atrium and ventricle. The interatrial septum bulged into the left atrium during the whole cardiac cycle. Doppler echocardiography showed clinically significant TR, a right to left shunt through the foramen ovale, reduced flow through the pulmonary valve, and in two patients ductal flow into the pulmonary artery. In one patient TR was so great that it impeded the opening of the pulmonary valve and produced functional “atresia” of the pulmonary valve. The presence of regurgitant blood flow through the pulmonary valve showed that the atresia was functional rather than organic. Doppler echocardiographic study is useful in distinguishing functional neonatal tricuspid regurgitation from a structural abnormality of the tricuspid valve.
Turner Gomes (1989) studied 59 term infants for determination of the sequelae of transient myocardial ischaemia. 23 were diagnosed prior to admission as cases of birth asphyxia and 36 had signs of persistent fetal circulation with ECG changes of ischaemia > 24 hrs after birth. Murmurs of atrioventricular valve regurgitation (AVVR), detected in 28 patients were confirmed in 23 of the 24 patients investigated. The murmurs resolved over a 2 day to 6 month period (median 6 days). In 3 patients, AVVR, left ventricular dyskinesia and ECG anomalies persisted for 2 months, 4 months and 48 months. Initial ECGs were abnormal in 57 patients and (of those reviewed) 60% returned to normal over a 6 day to 7 months period (median 2 months). Residual ECG anomalies included II\(^{\circ}\) Av block and persistent ST-T wave changes. 10 patients died from noncardiac causes. Neither the presence nor resolution of AVVR correlated significantly with the severity of the ischemic changes on the ECG. Although the cardiovascular sequelae of myocardial ischemia are usually transient, the data should prompt the need for careful review after the initial admission.

Gidwani et al (1990) observed a distinct correlation between degree of asphyxia and ECG changes. The subjects of this study
were 50 term neonates, out of which 25 served as control. The degree of asphyxia was graded as mild, moderate and severe if the 5 min Apgar score was 5-7,3-4 and 0-2 respectively. After detailed perinatal history and examination all relevant investigation including standard 12 lead ECG was recorded by a portable light weight “Cardio-art 108T” at birth. It was repeated at weekly interval for one month in asphyxiated neonates and only once at one month in controls. Results of this study were as follows – wide spread T wave observed in mild asphyxia. Significant Q waves in lower limb leads and ST-T wave changes in chest leads were observed in moderate asphyxia. Babies with severe asphyxia had QS pattern and ST elevation in lower limb leads and ST depression in chest leads. A distinct correlation was observed between degree of asphyxia and ECG changes.

Criteria for ECG diagnosis of ischemic damage have been laid down taking following into consideration e.g. flat or inverted T waves, ST segment depression, abnormal Q waves and complete bundle branch block. In the study of Gidwani et al, all asphyxiated neonates had higher heart rate and P wave amplitude on day 1 and similar findings have been observed by others. Significant Q waves (2-4mm) suggesting inferior wall ischemia were observed
and they disappeared in most by 14th day but persisted in two cases at one month. The sum of RV1 and SV6 and RS ratio more than 2 in V3R indicating right ventricular predominance was observed in asphyxiated babies. Widespread ST depression, flattening and inversion of T waves suggestive of inferior wall and antero septal ischemia have been observed.

Herdy et al (1998), conducted a study to evaluate the severity of cardiac complications of neonatal asphyxia. 90 babies with an Apgar score of <6 were examined in the intensive care unit during 7 years. Arterial blood pH, blood glucose, LDH and CPK-MB, together with serial ECG, Echo and chest X-Ray were obtained. The fatal cases were studies with micro and macroscopic examinations. The results documented that from a total of 90 cases, 73 were premature. Amongst these 30 (41%) were appropriate for gestational age and 43 (59%) were small for gestational age. The main cardiological findings were systolic murmur in 46 (50%), Signs of hypertrophy in 18(20%) and heart failure in 8 (9%). On ECG the main findings were ST and T wave abnormalities. The Echocardiography showed PDA in 20 (22%), Tricuspid regurgitation in 6 (7%), pulmonary hypertension in 6(7%), dyskinesia and ventricular dilatation in 4 (5%). Arterial pH
was <7.35 in 62 (69%) infants and less than 7.2 in 21(23%). Serum CPK –MB levels were significantly elevated in 26 (28%) patients having clinically evidence of heart hypertrophy and heart failure. Necropsy was performed in 23 cases and Macro and microscopic changes were found in 14 infants, the most frequent findings were- Myocite necrosis in 8 (54%), congestion, vacuolization and loss of striae in 4 (29%). They concluded that in the majority of cases, patients had a benign course. Many abnormal ECGs and echocardiograms became normal after a few weeks. Among those who had a fatal outcome, the severity of histological lesions was observed in babies who had suffered asphyxia for more prolonged periods.

**Tapia Rombo (2000)** studied 43 asphyxiated newborn. Three were excluded. Patients were placed into two groups – Group A with transient myocardial ischemia (n=33) and Group B without transient myocardial ischemia (n=7). No significant differences were found in gestational age, birth weight, extrauterine age, apgar score, or total CPK values between the two groups. Differences were found in CPK-MB levels and in ischemic ECG changes and blockages, especially for group A. In this group, only 24 (72.7%) were cardiovascularly symptomatic.
Thus it would be useful in all asphyxiated newborn to measure CPK-MB isoenzyme activity and patients can then be submitted to an ECG for detection in order to offer opportune treatment when required.

Karunatilaka et al (2000), examined the serum levels of CPK and LDH to determine whether CPK level alone or in combination with LDH level could be used as an indicator in selecting at a very early stage, those infants at risk of developing HIE or long term sequelae such as neurological abnormality or developmental delay. Serum CPK and LDH were measured in 35 asphyxiated term infants and in 30 control group. The median values of both the CPK and LDH are significantly higher in asphyxiated newborn (CPK=1824 IU/L and LDH=2948 IU/L). 9 out of 35 (25.7%) babies in the asphyxiated group developed HIE based on Sarnet and Sarnet criteria. The CPK and LDH values of those who developed HIE are significantly higher than the rest of the asphyxiated group who did not develop HIE (CPK=5988.8 IU/L and LDH=4246 IU/L). Out of the 9 babies who developed HIE, the one who developed severe HIE succumbed on the 5th day and had CPK and LDH values, 8222 IU/L and 7653 IU/L respectively. Three had moderately severe HIE and had CPK and LDH 6066 IU/L and
5505 IU/L respectively and remaining 5 had mild HIE and had CPK 4132 IU/L and LDH 3876 IU/L; of the 31 asphyxiated infants finally assessed at one year, five showed a delay in more than one sphere of development. These included all 3 babies who had moderate HIE and one baby who had mild HIE. The other baby who showed developmental delay did not have HIE but was a product of a consanguineous marriage. One who developed moderate HIE also had mild microcephally and had cerebral palsy. Another who developed mild HIE had a convergent squint. These two babies were detected during follow up at 3 months of age and were already receiving treatment. All infants in the control group showed normal neurodevelopment, when assessed at one year. The CPK values appear to be highest among those who developed HIE and ended up having developmental delay. The CPK values of those who had normal development despite initial HIE were also significantly higher when compared to those who had normal development despite initial asphyxia. This observation was highly significant but same trend was not seen with the LDH values.

Ranjit (2000) studied cardiac abnormalities in birth asphyxia. These abnormalities were:- 1. Transient tricuspid regurgitation
which is the commonest cause of a systolic murmur in a newborn and tends to disappear without any treatment unless it is associated with transient myocardial ischaemia or primary pulmonary hypertension of the newborn. 2. Transient mitral regurgitation which is much less common and is often a part of transient myocardial ischaemia, at times with reduced left ventricular function. 3. Transient myocardial ischaemia of the newborn. This should be suspected in any baby with asphyxia, respiratory distress and poor pulses especially if a murmur is audible. Echocardiography helps to rule out critical left ventricular obstructive lesions like hypoplastic left heart syndrome or critical aortic stenosis. ECG is very important for diagnosis of transient myocardial ischaemia, and may show changes ranging from T wave inversion in one lead to a classical segmental infarction pattern with abnormal Q waves. CPK-MB may rise and echocardiogram shows impaired left ventricular function, mitral and or tricuspid regurgitation and at times, wall motion abnormalities of left ventricle. Ejection fraction is often depressed and is a useful marker of severity and prognosis. 4. Persistent pulmonary hypertension of the newborn. Persistent hypoxia sometimes results in persistence of constricted fetal pulmonary vascular bed
causing pulmonary arterial hypertension with consequent right to left shunt across PDA and foramen ovale. This causes respiratory distress and cyanosis. Clinical examination also reveals evidence of pulmonary arterial hypertension and right ventricular failure with systolic murmur of tricuspid and mitral regurgitation. Cardiac abnormalities in asphyxiated newborns are often under diagnosed and require a high index of suspicion. ECG and echo help in early recognition and hence better management of these cases.