Magnetic Resonance Imaging Findings in Newborns with Indirect Hyperbilirubinemia: Is There a Relation Between High Levels of Bilirubin and Increased Signal Intensity on T1-Weighted Images?

İndirekt Hiperbilirubinemisi Olan Yenidoğanlarda Manyetik Rezonans Görüntüleme Bulguları: Yüksek Bilirubin Düzeyleri ile T1-Ağırlıklı Görüntülerde Artmış Sinyal Yoğunluğu Arasında İlişki Var mı?

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ABSTRACT Objective: To examine the findings of magnetic resonance imaging (MRI) in newborns with indirect hyperbilirubinemia and disclose any relationship between high levels of bilirubin and increased in signal intensity on T1-weighted images. **Material and Methods:** The study included 35 newborns with indirect hyperbilirubinemia. Clinical findings, bilirubin levels and MRI images were evaluated. **Results:** Of the study population, 20 (57.1%) were females and 15 (42.9%) were males. According to the gestational age, 30 cases were defined as term and five as preterm. An abnormal and bilaterally symmetrical increase in signal intensity was observed in the globus pallidus of 26 (74.3%) newborns on T1-weighted images. A statistically significant relation was determined between the peak value of bilirubin and increased signal intensity on the T1-weighted images (p= 0.004). Jaundice, lethargy, hypertonia, hypotonia and poor feeding were among the clinical findings. The mean serum bilurubin level was found as 38.6 ± 8.9 mg/dl (Range between 25 to 58 mg/dl). Major group incompatibility was detected in seven (20%) and Rh subgroup incompatibility in four (11.4%) of the cases. Glucose 6 phosphate dehydrogenase enzyme activity was reduced in eight (22.8%) cases. The MRI studies were performed between the days 5 and 30, following parturition. **Conclusion:** There seem to be a relationship between the peak levels of indirect bilirubin and higher T1-weighted signal intensity on MRI of the central nervous system. No relationship was determined between the levels of indirect bilirubin and the area of the central nervous system with increased signal intensity.

Key Words: Hyperbilirubinemia, neonatal; kernicterus; magnetic resonance imaging; newborn

ÖZET Amaç: İndirekt hiperbilirubinemisi olan yenidoğanlarda manyetik rezonans görüntüleme (MRG) bulgularını incelemek ve yüksek bilirubin düzeyleri ile T1-ağırlıklı görüntülerde sinyal yoğunluğundaki artış arasında herhangi bir ilişki olup olmadığını göstermek. **Gereç ve Yöntemler:** Çalışma indirekt hiperbilirubinemisi olan 35 yenidoğanı kapsıyordu. Klinik bulgular, bilirubin düzeyleri ve MRG görüntüleri değerlendirildi. **Bulgular:** Çalışmaya alınan hastaların 20'si (%57.1) kız, 15'i (%42.9) erkekti. Gebelik yaşına göre 30 olgu miad ve beş olgu preterm olarak tanımlandı.T1-ağırlıklı görüntülerde 26 (%74.3) yenidoğanın globus pallidus'unda sinyal yoğunluğunda anormal ve bilateral simetrik artış gözlendi. Bilirubinin tepe değeri ile T1-ağırlıklı görüntülerde artmış sinyal yoğunluğu arasında istatistiksel olarak anlamlı bir ilişki saptandı (p= 0.004). Klinik bulgular arasında sarılık, letarji, hipertoni, hipotoni ve yetersiz beslenme yer alıyordu. Ortalama serum bilirubin düzeyi 38.6 ± 8.9 mg/dl (25-58 mg/dl) olarak bulundu. Olguların yedisinde (%20) major grup uyumsuzluğu, dördünde (%11.4) Rh subgrup uyumsuzluğu saptandı. Glukoz 6 fosfat dehidrogenaz aktivitesi sekiz (%22.8) olguda azalmıştı. MRG çalışmaları doğumu izleyen 5 ve 30. günler arasında yapıldı. **Sonuç:** İndirekt bilirubinin tepe düzeyleri ile merkezi sinir sisteminin MRG çalışmasında yüksek T1-ağırlıklı sinyal yoğunluğu arasında bir ilişki olduğu görünmektedir. İndirekt bilirubin düzeyleri ile merkezi sinir sisteminde sinyal düzeylerinin artış gösterdiği alanlar arasında hiçbir ilişki bulunmadı.

Anahtar Kelimeler: Hiperbilirubinemi, neonatal; kernikterus; manyetik rezonans görüntüleme; yenidoğan

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Neonatal indirect hyperbilirubinemia, a common medical diagnosis, may result in severe neurotoxicity. Bilirubin encephalopathy was described in 1904 by Schmorl, who reported the postmortem pathological findings of yellow staining in the basal ganglia of infants associated with neonatal jaundice. In kernicterus, lesions are frequently present in the globus pallidus (GP), subthalamic nucleus (SN) and hippocampus.[1] Microscopic studies reveal that the basal ganglia, inferior olivary nuclei, hippocampus, dentate nuclei, subthalamic nucleus and cranial nerve nucleus at the floor of the fourth ventricle to be the areas of predilection for pathological bilirubin deposition.[2] Kernicterus is a rare complication of neonatal hyperbilirubinemia, resulting from the preferential deposition of bilirubin in GP, SN, hippocampus, putamen, thalamus and cranial nerve nuclei (especially III, IV and VI).[2] Factors increasing the permeability of the blood-brain barrier to bilirubin or susceptibility of neurons to its toxic effects are low birth weight, hypothermia, hypoalbuminemia, anoxia, hypercapnia, acidosis, and infection.[3,4] Phototherapy and exchange transfusions are two therapeutic options that significantly reduce the prevalence of bilirubin encephalopathy.[2,5,6]

MRI has had such an impact on the evaluation of kernicterus that the diagnosis can now be confirmed by MR imaging. The most characteristic finding is bilateral, symmetrical, high-intensity signalling in the GP on both T1 and T2-weighted images. However, most studies have relied on images obtained when infants were in the intermediate or late phase of injury, months to years after the onset of acute encephalopathy, and all these studies have placed emphasis on T1-weighted hyperintense images of GP. We do not know exactly how early changes in GP occur and whether or not they are seen in every case.[7,8] The reason for hyperintense signal changes seen in GP on T1-weighted images is not exactly known. Reported causes of T1-weighted high signal intensity GP lesions include asphyxia, liver diseases, neurofibromatosis, total parenteral nutrition and metastatic melanoma.[9] In contrast to asphyxia in which the putamenal and thalamic injury pattern is generally expected, a pallido-subthalamic injury pattern is seen in kernicterus. In asphyxia, GP involvement is usually mild and it is not imperative.[10] Conditions other than asphyxia generally do not cause any difficulty in the diagnosis in which the clinical findings help to differentiate these diseases from kernicterus. There are few studies investigating the probable relationship between an increased signal intensity on MRI scans and the serum bilirubin levels.

This prospective study aimed to determine a relationship between the level of indirect bilirubin and higher signal intensity observed in different areas of the central nervous system on T1-weighted MRI images in newborns in an early stage of indirect hyperbilirubinemia.

MATERIAL AND METHODS

All of the newborns were referred directly to our neonatal intensive care unit without having any prior therapeutic interventions for their hyperbilirubinemic state. All patients received immediate exchange transfusion and phototherapy. All of the patients had tests for whole blood count and differential, major and subgroup blood typing of the mother and baby, direct coombs test, urinary dipstick and urine culture. Neonates were tested for a full blood chemistry including total and indirect bilirubin, glucose, total protein, albumin, ALT, AST, blood urea nitrogen, creatinine, calcium, sodium, and potassium levels. C-reactive protein, thyroxine, thyroid-stimulating hormone levels, glucose-6-phosphate dehydrogenase and pyruvate kinase enzyme activities, TORCH markers, tandem mass spectrometry screening and a neurological examination were also performed. Additional tests were carried out for anemia as deemed necessary according to physical examination and clinical diagnosis. The neonates between 37 and 42 weeks of gestation were considered as term and those < 37 weeks were considered as preterm. An Aeroset automated analyzer (Abbott, USA) was used to assess the bilurubin levels. The first and fifth-minute APGAR scores were normal as determined from the history, excluding any asphyxia. Newborns with metabolic diseases, congenital malformations, respiratory distress or intrauterine infections were excluded from

the study. There were no clinical or laboratory findings of infection in the neonates with peak bilirubin values, besides the albumin levels were within normal range and acidosis was not present. The infants with a peak serum bilirubin value of 25 mg/dl and above were included in the study. Ahlfors criteria were used for determining the indication for transfusion; bilirubin level >20 mg/dL at 24-48 hours or >25 mg/dL at >48 hours after birth.[11] Due to high serum indirect bilirubin levels (>25 mg/dL), immediate exchange transfusion was followed by phototherapy in all patients. Patients with a high serum bilirubin level despite previous exchange transfusion and phototherapy underwent a second exchange transfusion.

The opthalmological examination of the newborns failed to reveal any significant pathologies. None of the study group needed elektroencephalography, tests and all had their hearing tested by the Auto Acoustic Emission method.

A cranial MR imaging was performed with a 1.5-T unit (Signa; GE Medical Systems, Milwaukee, Wis) using a quadrature transmit/receive head coil. Our imaging protocol included transverse T2-weighted (5220/104), coronal fluid-attenuated inversion recovery (9002/104/2200[repetition time msec/echo time msec/inversion time msec]) and transverse-sagittal T1-weighted (500/16) sequences. The images were interpreted by an experienced radiologist who was blind to the data about neurological examination and the levels of indirect bilirubin of the neaonate. All areas of the brain and basal ganglia were taken into consideration for any pathological signal changes. All patients were sedated, transported and monitored by physicians who remained with the infant throughout the procedure. The infants were wrapped into blankets for immobilization and their body temperatures were maintained. All the infants were sedated throughout the MRI. The informed consent of the parents were seeked prior to the study. The study protocol was approved by the local Ethics Committee.

Power analysis was performed using Graphpad Instat statistics programme. The bilirubin levels of 15 cases were examined for power analysis. With a level of significance (α) of 0.05, power of 80%, standard deviation of 6, and clinically important difference of 8, the sample size was found to be 9.

Statistical analysis was performed using SPSS version 11.5. The normal distribution of data was verified by the Shapiro-Wilk's test. The odds ratio was calculated. The correlation between deposition on the MRI and the bilirubin level was determined by the Kendall tau test.

The categorical variables in the MRI (+) and MRI (-) groups were compared using Chi-square testing. Independent Student's t-test or Mann-Whitney U test was used for the comparison of continuous variables among the groups. Statistical significance was set to a *P* value less than 0.05.

RESULTS

We report the MRI findings of 35 patients with neonatal hyperbilirubinemia who were referred to our university hospital**.** Of the study population, 20 (57.1%) were females and 15 (42.9%) were males. According to the gestational age, 30 cases were defined as term and five as preterm. In 26 (74.3%) of all cases, increased signal intensity was observed on the T1-weighted MRI images either in GP or in SN. In nine (25.7%) cases there was no increased signal intensity. These lesions were not visible on T2A. All patients displayed symptoms of jaundice, poor feeding, hypertonia, lethargy, hypoactivity and high-pitched crying. Four patients had Rh inseven had ABO incompatibility (Table 1). Glucose-6-phosphate dehydrogenase enzyme activity was reduced in eight (22.8%) cases whereas pyruvate kinase enzyme activity was found to be normal in all of the study population. Of the 30 term cases, an increase in signal intensity on T1-weighted MRI scans was seen in GP of six (20%) and in both GP and SN of 16 (53.3%) neonates and there was no increase in signal intensity in eight (26.7%) cases (Table 1). Two of the infants have failed to attend to the follow-up (Table 1). Wedermined Cephalhematoma in two patients, sinus thrombosis in one case and subdural haemorrhage in another case. The MRI scans in nine patients were entirely normal. A cavum verge variation of the septum pellicidum was present in one case. The clinical and

TABLE 1: Clinical and MRI findings of the study group.

Patient no and (sex)	Age upon admission (days)	Age upon scan (days)	Gestational age (week) / weight (gr)	Peak indirect bilirubin (mg\dl)	Clinical Signs	MRI findings
1 (M)	12	25	P (30)/1480	25	Jaundice, lethargy, hypoactivity	GP
2 (F)	5	10	T (38)/3200	46	Jaundice, lethargy, hypoactivity	GP, SN
3 (M)	3	7	T (38)/3300	43	Jaundice, hypertonia	GP, SN
4 (F)	5	12	T (39)/3700	47	Jaundice, hypertonia opisthotonos rigidity	GP
5 (M)	6	10	T (38)/3580	39	Jaundice, hypertonia, ABO incompatibility	GP
6 (F)	5	13	T (38)/3000	32	Jaundice, lethargy, Rh incompatibility	-
7 (M)	6	8	T (38)/3000	31	Jaundice	-
8 (M)	4	7	T (40)/3650	27	Jaundice	-
9 (M)	6	15	T (38)/3100	46	Jaundice, ABO incompatibility	GP, SN
10 (F)	5	8	T (40)/3120	52	Jaundice, lethargy, hypoactivity, Rh incompatibility	GP
11 (F)	12	15	P (30)/1300	42	Jaundice, lethargy, hypoactivity	GP
12 (F)	4	9	T (38)/3000	54	Jaundice, lethargy, hypoactivity, ABO incompatibility	GP
13 (F)	10	15	T (38)/2600	34	Jaundice, ABO incompatibility	-
14 (F)	10	13	T (40)/3900	40	Jaundice	-
15 (F)	12	17	P (28)/1280	25	Jaundice, G6PD deficiency, sepsis	GP
16 (M)	6	12	T (38)/3080	31.8	Jaundice,lethargy,opisthotonos, rigidity,Poor feeding, exitus	GP
17 (M)	7	9	P (28)/1010	32	Jaundice, lethargy, hypoactivity, hypothyroidism	-
18 (M)	3	8	T (40)/3100	41	Jaundice, hypertonia, high-pitched cry	GP, SN
19 (F)	5	12	T (38)/2870	38.1	Jaundice, lethargy, hypoactivity, ABO incompatibility	GP, SN, Died
20 (F)	4	11	T (38)/2900	39	Jaundice, opisthotonos, rigidity	GP
21 (F)	5	12	T (38)/2700	30.8	Jaundice, hypertonia	-
22 (F)	5	13	P (36)/2600	51	Jaundice, opisthotonos, rigidity, poor feeding	GP
23 (M)	2	8	T (40)/3100	35	Jaundice, hypertonia, ABO incompatibility	GP, SN
24 (M)	2	6	T (40)/3000	25	Jaundice, Rh incompatibility	GP, SN
25 (F)	4	10	T (40)/3000	30	Jaundice, hypoactivity, high-pitched cry	-
26 (M)	3	5	T (40)/3300	38	Jaundice, Rh incompatibil, high-pitched cry, opisthotonos, rigidity	GP, SN, Died
27 (M)	4	7	T (40)/3300	42	Jaundice, high-pitched cry, hypoactivity	GP, SN
28 (M)	5	12	T (39)/3200	37	Jaundice, high-pitched cry, opisthotonos rigidity, ABO incompatibility	GP, SN
29 (F)	5	11	T (40)/3100	45	Jaundice, high-pitched cry, opisthotonos rigidity	GP, SN
30 (M)	3	7	T (40)/3400	29	Jaundice	-
31 (F)	6	30	T (38)/2900	33	Jaundice, high-pitched cry, opisthotonos, rigidity	GP, SN
32 (F)	5	10	T (40)/3000	46	Jaundice, high-pitched cry, opisthotonos, rigidity	GP, SN
33 (F)	4	10	T (40)/3000	36	Jaundice, high-pitched cry, opisthotonos , rigidity	GP, SN
34 (F)	6	16	T (40)/3100	52	Jaundice, high-pitched cry, opisthotonos , rigidity	GP, SN
35 (F)	4	12	T (40)/2800	58	Jaundice, high-pitched cry, opisthotonos, rigidity	GP, SN

Globus pallidus: GP, Subthalamic nucleus: SN, Male: M, Female: F, Term:T, Preterm:P.

T1-weighted MRI findings are summarized in Table 2. The increase in signal intensity on T1-weighted MRI scans in GP was found to be significant in the preterm cases when compared to the term babies (p= 0.017), (Table 3). At the time of hospital admittance, neurological findings were present in 22 of the term and three of the preterm cases. Neurological findings were not present in eight term and two preterm neonates. MRI findings in term and preterm neonates are summarized in Table 3. Nine cases without any increase in signal intensity on T1-weighted MRI scans were spared from neurological findings. Out of 10 cases with increased signal intensity in their GP, nine were found to have clinical neurological signs. All of the 16 cases with increased signal intensity both in GP and SN showed clinical neurological findings (Table 3).

A statistically significant correlation (a coefficient of 41.6%) was determined between peak bilirubin values and increased signal intensity on T1-weighted MRI scans (p= 0.004). In the 26 cases with increased signal intensity on T1-weighted MRI scans, the mean indirect peak bilirubin value was 41.03 ± 9.02 mg/dl, mean gestational age was 37.8 ± 3.3 weeks and mean birth weight was 2917 ± 832 gr. In the nine cases without increased signal intensity on T1-weighted MRI scans, these values were 31.75 ± 3.67 mg/dl, 37.7 ± 3.8 weeks and 2927 ± 550 gr respectively.

TABLE 2: The clinical and MRI findings in the study groups.

	MRI (+) n:26	MRI(–) n:9	OR(95 % CI)	p
Gender (M/F)	11/15	4/5	0.69 (0.02-11.60)	0.76
Gestation age(Week)	37.8 ± 3.3	37.7 ± 3.8		0.98
Preterm/Term	4/22	1/8	0.688 (0.06-7.10)	0.75
Age on admission(Day)	5.3±2.7	6±2.54		0.86
Indirect bilirubin value	41±9	31.7±3.6		0.003
Indirect bilirubin group				
24-35 mg/dl	6	8		0.0005
36-45 mg/dl	11	1		0.08
46-60 mg/dl	9	0		0.04
Weight on admission (gr)	2917 ± 832	2927 ± 550		0.49
MR scan age (Day)	11.9 ± 5.5	10.4 ± 2.9		0.67

MRI(+): Increase in MRI signal, MRI(-): No increase in MRI signal.
Term ≥ 37 weeks gestation, Preterm: <37 weeks.
M: Male, Female: F.
Fisher's exact test, Student's t-test for independent variables, Mann-Whitney U test.

TABLE 3: Signal intensity on MRI scans, term and preterm

	Term		Preterm		Total		
	No	%	No	%	No	%	p
MRI SI (-)	8	88.9	1	11.1	9	100	
MRI GP (+)	6	60	4	40 *	10	100	* 0.017
MRI GP ve SN (+)	16	100	0	0	16	100	
Total	30	85.7	5	14.3	35	100	

MRI SI (-): No increase in MRI signal.
MRI GP (+): Increase in the MRI signal in the globus pallidus.
MRI GP ve SN (+): Increase in the MRI signal in the globus pallidus and Subthalamic Nucleus.
Preterm are more inclined to have increased signal intensity in GP (* p ≤ 0.017).
Fisher's exact test.

Increased signal intensity on T1-weighted MRI scans did not correlate with postpartum age of the newborn, age at hospital admission or age at the time of MRI study. The presence of increased signal intensity on the T1-weighted MRI and the bilirubin levels did not correlate with the age at hospital admission. In 26 of 35 patients (74.3%), there was bilateral and symmetrically increased signal intensity in GP on T1-weighted MR images (Figure 1). Globus pallidus involvement together with subthalamic nucleus was present in 16 cases on T1-weighted MR images (Figure 2).

Impaired hearing was detected in six cases (17.1%) through Auto Acoustic Emission and they were referred to Ear, Nose and Throat specialist for detailed examination and follow-up.

DISCUSSION

Bilirubin toxicity remains a significant problem in human infants despite recent advances in the care of jaundiced neonates. The localization of sites of central nervous system dysfunction, the determinants of vulnerability and reversibility, and the pathogenesis are still only partially understood despite decades of study.[3,4]

In spite of phototherapy and exchange transfusion, abnormal increase in signal intensity on T1-weighted MRI scans of the central nervous system was found in 26 (74.3%) cases. A statistical significance was established between increased bilirubin

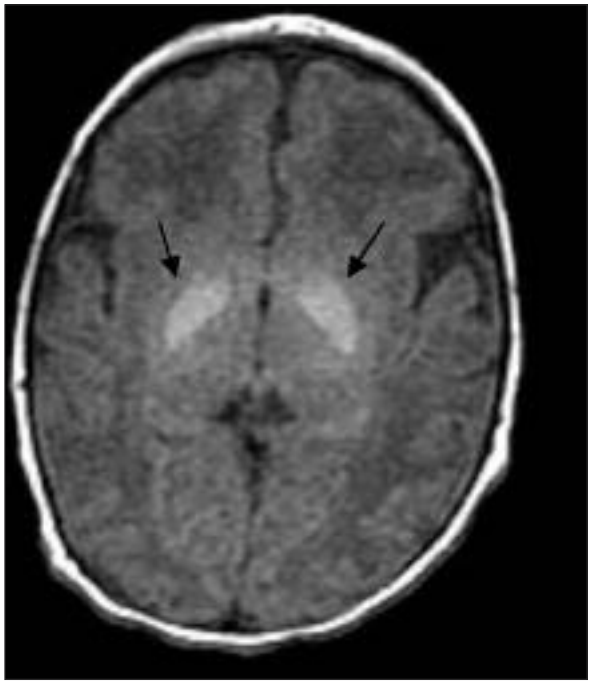

FIGURE 1: Axial T1-weighted MRI shows symmetric, hyperintense GP involvement.

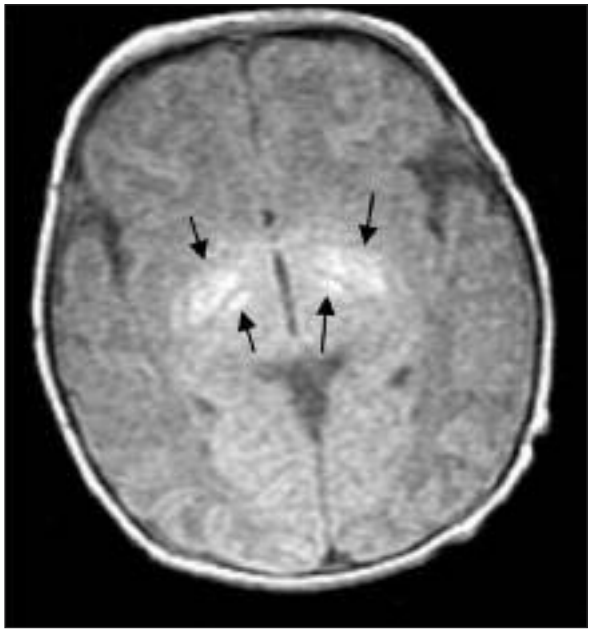

FIGURE 2: T1-weighted MRI shows symmetric, hyperintense GP involvement and subthalamic involvement.

and increased signal intensity on the T1-weighted MRI scans. All our cases with a bilirubin value of 40 mg/dl or more had some deposition of bilirubin on the T1-weighted MRI scans. In previous studies no known correlation has been mentioned between bilirubin levels and the increase in signal intensity on MRI.[12] In our study, a relationship was determined between the increased bilirubin levels and increased signal intensity on T1-weighted MRI of the central nervous system. In a series of 13 cases with a mean bilirubin level of 37 mg/dl, early T1-weighted MRI scans showed an abnormally increased bilateral, symmetrical signal intensity in GP of eight cases. These lesions were not visible on T2- weighted MRI scans. No relationship was determined between the levels of indirect bilirubin and the MRI findings.[13] In a larger series with a mean bilirubin level of 35 ± 10.8 mg/dl, no relationship was found between the level of bilirubin and the increased signal intensity in MRI scans.[14] In that study, 15 (71%) of 21 cases showed abnormally increased signal intensity in MRI when compared to 26 (74.3%) of 35 cases in our study. In the study of Coskun et al.,[13] the increase in signal intensity on T1-weighted MRI scans was confined to GP whereas our cases differed in location of the depositions on T1-weighted MRI (Deposition in GP and SN in 16 cases, and deposition only in GP in 10 cases). Coskun et al. did not observe any increase in signal intensity in SN of their 13 cases.[13] The present study reproduced the previous studies investigating the association between increased signal intensity in MRI scans coupled with higher indirect bilirubin levels.[13-15] However, our study has disclosed a new and not previously mentioned finding of an increased signal intensity in the SN on T1-weighted MRI scans of hyperbilirubinemic newborns.

In a study of 21 cases,[16] neurological findings were present in 76% of the patients upon admission whereas 71.4% of our cases presented with neurological findings upon admission. Two infants with increased signal intensity in globus pallidus, poor feeding, jaundice, lethargy, opisthotonos and rigidity had died. The MRI findings reflect the pathological findings in kernicterus. Bilateral higher signal intensity in GP corresponds with the areas of preferential deposition of unconjugated bilirubin. The posteromedial border of GP has been speculated to be the most sensitive area to kernicterus lesions based on MRI findings.[17] Yilmaz et al. re-

ported a patient with normal cranial MRI, despite its severe neurological findings.[15] In this study, 3 cases (14%) had normal cranial MRI despite the clinical diagnosis of kernicterus.[15] It has been reported that cranial MRI findings may improve with growth.[18] In our study, all cases with neurological findings showed an abnormal increase in signal intensity on T1-weighted MRI scans whereas only one case showed increased signal intensity on T1-weighted MRI scans without any neurological findings.

No statistical significance was found between gestational age, neonatal age, duration of the disease at the presentation to hospital and the day of MRI scanning. No statistical significance was observed between the day of presentation and the level of bilirubin. Although no statistical significance was found between the day of presentation to hospital and the bilirubin levels and increased signal intensity in MRI, there was a statistically significant relationship between the bilirubin levels and the increased signal intensity on MRI. Therefore we thought that the bilirubin level was more important than the duration of hyperbilirubinemia for the involvement of the central nervous system. A prospective study is required to show the impact of the level of bilirubin and the duration of hyperbilirubinemia on the central nervous system. There was a negative correlation between the time of presentation of jaundiced infants to the hospital and their weight at presentation. The higher birth weight infants presented to hospital earlier than those counterparts with lower birth weight. In our view, this negative correlation arises from the families' greater expectations of survival for a higher birth weight infant.

Despite the intensive care and interventional therapies, a deposition of indirect bilirubin has developed on the MRI of a two day old term infant with Rh incompatibility and a bilirubin value of 25 mg/dl. Although a positive correlation was established between high values of bilirubin and increased signal intensity on MRI, this increased signal intensity was also seen in a case having a lower bilirubin level. This case emphasizes the role of the risk factors for the potential development of kernicterus even in neonates with lower bilirubin levels. There are numerous published case reports regarding MRI findings and diagnosis of kernicterus. The first report about the acute phase MRI findings of a eight days old infant with hyperbilirubinemia was published by Penn et al.[19] This report was also the first MRI study showing brain injury secondary to kernicterus. T1-weighted images revealed hyperintensity in GP, internal capsule and thalamus. Harris et al. reported MRI findings of four neonates with acute kernicterus aged between five and 21 days, one whom had T1-weighted hyperintensity in GP.[20]

The MRI findings of an 8-day old term infant with a total bilrubin level of 50 mg/dl were reported by Shah et al.[21] They showed a bilateral and abnormally high signal intensity in GP on T2- weighted images. There was a bilateral and decreased signal intensity in T1-weighted images of GP corresponding to the same region in T2-weighted images. Yilmaz et al. described a case of kernicterus where MRI demonstrated bilateral symmetric hyperintensity in GP on T2-weighted images.[12] No change in the signal intensity was observed in our cases on T2-weighted images.

In conclusion, Kernicterus can be suspected in the neonatal period on specific clinical, imaging and laboratory grounds. MRI has crucial value, but as stated by others, the signal changes on both T1 and T2-weighted images are subtle and easily overlooked. Our study confirms the finding of signal abnormalities encountered previously on T1-weighted early stage MR scans. Our results indicate that there may be a strong relationship between the peak level of indirect hyperbilirubinemia and the abnormally high signal intensity on T1-weighted MRI of the central nervous system. There was no connection between the level and the location of the deposition of bilirubin and abnormally increased signal intensity in the central nervous system.

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