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Original Research Article

Association of ABO and Rh incompatibility with neonatal hyperbilirubinaemia

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ABSTRACT

Background: 60% of term new-born have clinical jaundice, in the first week of life. ABO incompatibility is the most common cause of haemolytic disease of the new-born. So early intervention, at proper time, is mandatory to prevent these sequelae.
Methods: This study was done at Dhiraj Hospital in Obstetrics and Gynecology Department. It was prospective observational study. 200 new-born with ABO incompatibility and 20 new-born with Rh incompatibility, causing clinically significant neonatal hyperbilirubinemia, were recruited for the clinical study noted.
Results: The incidence of ABO incompatibility in our study was 13.79% and of Rh incompatibility was 1.37%. In ABO incompatibility group, 90% new born developed clinical jaundice. In treated group, out of 88 new born, 82 were from O-A and O-B incompatibility group. In ABO incompatibility DCT was positive in only 9%, whereas in Rh incompatibility it was 25%. In ABO incompatibility group, majority, 56% did not require treatment, whereas in Rh incompatibility group 65% required treatment. In ABO incompatibility group only 1% required exchange transfusion whereas in Rh incompatibility, it was required in 10%. In ABO incompatibility, all new-born treated well except, 0.5% developed kernicterus. In Rh incompatibility group, 10% new-born developed kernicterus
Conclusions: In ABO incompatibility, if jaundice develops, it remains in physiological limits. In presence of some aggravating conditions may present as pathological jaundice. It results in significant morbidity but no mortality. So prevention of aggravating factors is very important, in case of ABO incompatibility.

Keywords: ABO incompatibility, Rh incompatibility Kernicterus

INTRODUCTION

Today's child is tomorrow's future. The child is the heritage of the family and children's health is India's health. Neonatal period represents the most crucial period for a child's survival.[1] wherein, the neonates are at risk of acquiring many problems. Among these, the major health problems are jaundice, infections, nutritional deficiency, trauma and regulation of body temperature. Of these, jaundice is first affliction that clinically appears, besides thermo regulation disturbances. So, we studied clinical effects of aggravated physiological jaundice. 1000 years ago, Neonatal jaundice was first described in a Chinese textbook.

Physiological jaundice normally occurs between second and fourth day of life, appears in 50% of all full-term new-borns. A bilirubin level, exceeding 12 mg/dl for the full-term infant is suggestive of more than normal physiology and should be considered pathological hyperbilirubinemia, can become a worrisome problem, as higher bilirubin levels are associated with neurological abnormalities, hearing loss, motor abnormalities.[2] Under certain circumstances, severe hyperbilirubinemia can cause complication, known as Kernicterus. Orth first

described yellow staining of the brain, in 1875, later referred to by Schmorl as kernicterus.[3] The effects of Kernicterus, range from fever, seizures and high pitched crying, leading to mental retardation, with a poor chance of survival, in some cases. Blood group incompatibilities (e.g. ABO, Rh), may increase bilirubin production through increased hemolysis, and it is the most common cause of hemolytic disease of newborn (HDN).

ABO incompatibility is the most common conflict of natural elements, and nature always tries to keep most common things in the range of minimum severity, resembling to physiological condition. Clinically significant, neonatal anemia due to ABO incompatibility occurs infrequently. The major clinical issue with HDN due to ABO incompatibility is jaundice. Rh incompatibility is very severe and in that nature, tries to keep severe things to occur rarely.

Thus, Rh incompatibility is always pathological condition. The most common cause of Rh incompatibility is, exposure of Rh-negative mother to Rh-positive foetal blood during pregnancy or delivery. Here in this study we try to focus on ABO incompatibility, being a, physiological condition, only in presence of other aggravating factors, it crosses the physiological range, to be a severe condition, while Rh incompatibility is basically a pathological condition. During this study, we made an effort to find the patients, whose babies are at higher risk, so that preventive measures can be taken ante-natally, to reduce the morbidity of neonates, post-natally.

The objectives of the study are

- To quantify the causes of increase in bilirubin level.
- To identify the cases, which need intervention.
- To assess the incidence and severity of ABO incompatibility in neonatal hyperbilirubinemia.
- To assess the incidence and severity of Rh incompatibility in neonatal hyperbilirubinemia.

METHODS

The present study is a prospective observational study. Out of all delivered patients, who were ABO incompatible and Rh incompatible were included in study, as per inclusion and exclusion criteria, between June 2015, to July 2016, at Dhiraj Hospital, a tertiary care center situated in the rural area of Vadodara.

Inclusion criteria

- All ABO incompatible and Rh incompatible mothers and babies.
- All full-term and preterm new-born.
- All booked and un-booked patients.
- All cases normal delivery, instrumental delivery or C.S.

Exclusion criteria

- ABO compatible mother and baby.
- Mother with AB+ve blood group, (as this does not induce any reaction to cause haemolysis.)
- Baby with O blood group. (as this does not induce any reaction to cause haemolysis)
- Data was collected, as regards to Age, Parity, Menstrual history, Obstetric history and details of baby.
- Then routine antenatal investigations of Mother were carried out as under:
- CBC,
- RBS,
- Urine Routine and microscopic examination,
- Blood Group,
- Indirect coomb's test
- HIV,
- HBsAg,
- VDRL.

In addition,Father's Blood Group, Baby Blood Group, Birth weight, Haemoglobin level, Bilirubin level, Direct coomb's test were performed.Treatment given to baby to treat hyperbilirubinemia is recorded. Perinatal morbidity/mortality was recorded. If any new born developed clinical jaundice in 1st 2 days of life, blood samples were sent for laboratory tests. (Mentioned above) On 3rd day, samples of all ABO incompatible new born were sent for laboratory tests irrespective of development of clinical jaundice. In Rh incompatibility group, cord blood was sent for laboratory test and babies' blood samples were sent every day for 1st 3 days of life for Total Serum Bilirubin test.

RESULTS

Incidence of blood group incompatibility

Out of 1450 patients, 200(13.79%) developed ABO Incompatibility and 1.37% developed Rh Incompatibility. In ABO incompatibility group, 90% baby developed hyperbilirubinemia (>5mg/dl), among them majority had physiological jaundice.

Unlike Rh, ABO disease can occur in first pregnancies, because anti-A and anti-B antibodies are found early in life from exposure to A- or B-like antigens present in many foods and bacteria (p value <0.001).

With almost equal incidence of hyperbilirubinemia in both groups, suggests that route of delivery, in absence of intra-partum sepsis does not influence the disease process (p-value=0.645).

In total serum bilirubin of >=5 mg% group, out of 180 patients, 126 patients delivered vaginally and 54 delivered by LSCS.

Table 1: Distribution of cases according to parity and mode of delivery.

Parity	Primigravida	Multigravida	VD	CS	Total
<5 mg%	2	18	13	7	20
≥5 mg%	104	76	126 (92.6%)	54(84.4%)	180
Total	106	94	139	61	200

It seems that, use of oxytocin during vaginal delivery may influence the positive relationship between the severity of jaundice and oxytocin use for labor induction or reinforcement.

Out of 54 patients, in 21 patients, oxytocin was used either for augmentation or for induction of labour, were operated for NPOL or DTA or induction failure. Out of 21, 18 new-borns required phototherapy.

Oxytocin causes osmotic swelling of erythrocytes leading to decreased deformability and hence more rapid destruction with resultant hyperbilirubinemia in the neonate.[4] 9 patients had PROM, were delivered by LSCS, 4 new-borns developed hyperbilirubinemia and required treatment. 2 of them, had sepsis as high risk factor.

New born–sex distribution

In ≥5 mg% TSB group, out of 180, females were 76 and males were more affected, they are 104 (p=0.052)

This disparity of affliction, between the sex proves an observation – that in case of any crisis, male neonates succumb more readily, than female neonates, as the fighting ability of female neonates is stronger than male neonates.

Table 2: Age at which tsb (total serum bilirubin) rise---ABO group.

	Day 1	Day 2	Day 3-5	Day >5	Total
<5 mg%	0	0	20	0	20
≥5 mg%	15	57	105	3	180

Table 3: Aggravating condition.

Aggravating condition	No.	%
Dehydration (Hypernatremia)	14	07
Pre-term	11	5.5
Sepsis	07	3.5
Birth Asphyxia	05	2.5
Caput Succedaneum	03	1.5
Weight Loss	02	01
IUGR	02	01
Fever (with dehydration)	03	1.5

Distribution of cases as per term of pregnanacy

In present study, out of 200 patients 30 patients were preterm, and out of them, 28 have TSB ≥5 mg%, and 22 patients required some type of intervention (phototherapy) (p-value=0.509).

In present study, majority of new-borns with ABO incompatibility, developed hyperbilirubinemia between 3-5 days.

It shows, hemolytic disease due to ABO incompatibility, becomes severe in presence of aggravating conditions or with risk factor. Otherwise, hyperbilirubinemia due to ABO incompatibility is usually very mild and resolve by simple management.

Direct coombs test

Direct Coombs test is weakly to moderately positive, in ABO incompatibility. In our study,only 9% newborns had positive DCT. Indirect Coombs test was negative in all the mothers of the patients, and this means, that this test is a weak marker for haemolysis.

Reticulocyte count

Presence of Reticulocytes is, a sign of erythropoiesis, which increase in case of hemolysis, as a compensatory mechanism.

In present study, only 5(2.5%) new-born had >6% reticulocyte count, remaining all new-born had normal range of reticulocyte count. This shows that ABO incompatibility does not cause severe haemolysis.

Hemoglobin level

Mean value of hemoglobin was 16.941± 2.01. This indicates that anaemia due to hemolysis, in ABO incompatibility is not commonly found in affected babies as well.

Treatment

Hyperbilirubinemia due to ABO incompatibility, resolves naturally in most cases (56%), as there is very mild hemolysis. In cases, who required treatment, most of them were cured only by phototherapy (43%). Extensive

and exhaustive management was required in only 2 cases (1%), as exchange transfusion.

Table 4: Total duration of phototherapy.

Total duration of phototherapy	No	% (n=86)
1 day	23	26.7
2-3 days	58	67.5
>3 days	5	5.8

Total duration of phototherapy

In present study, 86 patients treated with phototherapy, majority patients 58 (67.5%) required it, for a short duration of only 2 to 3 days.

Total surface, double surface and single surface phototherapy required in 24.41%, 31.39%, 44.18% newborns, respectively. This proves that, hyperbilirubinemia due to ABO incompatibility, resolves with simple treatment.

In present study, pharmacological treatment like phenobarbital was not given to a single child.2 new-born required exchange transfusion.

One baby was discharged on 3rd day, after delivery, and was re-admitted to NICU with hypernatremic dehydration and kernicterus, on day 5. Exchange transfusion was done.

In 2nd one, there was aggravating condition-had hypernatremic dehydration and was treated by TSPT for one day but, as there was no significant fall in total serum bilirubin so exchange transfusion was done.

99.5% newborn fully recovered, only one (0.5%) had kernicterus.No neonatal mortality occurred in present study.

Rh Incompatibility as a cause of Hyperbilirubinemia

Distribution as per appearance of hyper-bilirunemia

In present study, on day 0, the level of cord blood bilirubin, was estimated, all 20 patients had <5 mg% bilirubin and none of them required any intervention.

On day 1, out of 20 patients, 7 had ≥5 mg% TSB, and 4 required phototherapy. Mean serum total bilirubin 5.455 mg%.

On day 2, out of 20 patients, 16 had ≥5 mg% TSB, and 12 required phototherapies, and 1 required exchange transfusion. Mean TSB -11.82 mg%. On day 3, out of 20 patients, 17 had ≥5 mg% TSB, and 7 required phototherapies and 1 required exchange transfusion. Mean TSB-10.49 mg%.

In Rh Incmpatibility group 13 (65%) newborn required treatment for hyperbilirubinemia

Table 5: Distribution of cases according to parity, sex and terms of gestation.

Intervention	primi gravida	multi gravida	female	male	ft	pt
Treatment not required	5	2	6	1	7	0
Treatment required	0	13	5	8	11	2
Total	5	15	11	9	18	2

It is due to a fact, that in a primigravida, sensitization does not occur, except in a rare case, with H/O previous blood transfusion of Rh positive blood, which, in present day does not happen.

Rh incompatibility was significantly related to male sex of new-born (p=0.043).

In present study, out of 20 Rh incompatible new-borns, 18 were full term and 2 were pre-term. In present study, the term pregnancy, was fortunately, not a crucial factor to worsen the clinical condition of new born, comparing it on bilirubin level modality. (p value=0.274) Even full term neonates required some help to be relieved of hyperbilirubinemia.

Out of 2 pre-terms, both pre-term new-born required interventions. It proves that, if pre term baby has Rh incompatibility, then severity of neonatal hyperbilirubinaemia can increase in equal clinical condition.

Table 6: Severity of haemolysis in Rh incompatibility.

DCT	No. of cases	%
DCT (+VE)	5	25
DCT (-VE)	15	75
Total	20	
Reticulocyte count	No. of cases	% (n=20)
0-6	16	80
>6	4	20
Total	20	
Hb LEVEL	No. of cases	
<14 gm%	4	20
14-20 gm%	16	80
Total	20	

Treatment

In present study, 7 (35%)new born did not require any treatment, born of primigravida. That proves, iso-immunization is pre-requisite for Hemolytic disease of new born due to Rh incompatibility.

11(55%) newborn required phototherapy and 2(10%) newborn required exchange transfusion.

Total surface, double surface and single surface phototherapy required in 36.36%, 45.45%, 18.18% newborns respectively.

Table 7: Total duration of phototherapy.

Total duration of phototherapy	No. of cases	% (n=20)
1 day	3	15
2-3 days	6	30
>3 days	2	10

Neonatal outcome

90% new-born fully recovered, 2(10%) had kernicterus. No neonatal mortality occurred in present study.

DISCUSSION

Most newborns have physiological jaundice. It is most noticeable when the baby is 2 to 4 days old. Most of the time, it does not cause problems, and fades away within 2 weeks.

Neonatal physiologic jaundice results from, simultaneous occurrence of the following two phenomena[5]

- Bilirubin production is elevated, because of shortened lifespan of fetal erythrocytes, and the higher erythrocyte mass in neonates.[6,7] Life span of circulating RBCs in neonates is significantly shorter (80 to 90 days), than adult RBCs (120 days).[8] Fetus has more RBCs than adult (7 million/mm^3 compared to adult value of 5 million/mm^3).
- Low hepatic excretory capacity, because of low concentrations of ligandin, and, low activity of glucuronyl transferase, the enzyme responsible for binding of bilirubin to glucuronic acid (conjugation).

Pathologic neonatal jaundice occurs, when additional factors accompany the basic mechanisms. e.g., immune or non-immune hemolytic anemia, polycythemia, and the presence of bruising or extravasation of blood.

ABO incompatibility is more common than Rh incompatibility. Rh negative blood group is present in only 15% of population. Iso-immunisation will not result in all cases of Rh incompatibility. Hemolytic disease will occur only in iso-immunised group. In ABO incompatibility, severity of hemolytic disease is very less, and neonatal hyperbilirubinemia remains within physiological limit. It is easily reversible, with minimal morbidity, and without any mortality.

If ABO incompatibility is present with aggravating conditions, which affect bilirubin level, bilirubin level will rise more than clinically accepted range. It becomes clinically significantly morbid, and results in higher degree of morbidity. e.g. dehydration, infection, cephalhematoma, pre-term babies etc.

Incidence of abo incompatibility

According to the population and race, distribution of the blood groups A, B, O and AB varies across the world.

One study showed almost a double-fold (38%) ABO incompatibility frequency when compared with Caucasian populations, which showed about one fifth of all pregnancies (20%) having ABO incompatibility between fetus and mother.[9]

Incidence of Rh incompatibility

The frequency of Rh D-negative status is much lower, in people of Asian descent (including people from China, India, and Japan), averaging about 2%.[10]

Incidence of jaundice due to abo incompatibility

The spectrum of HDN has changed over the last few decades. Following the introduction of Rh Ig, the incidence of Rh D allo-immunization in pregnancy, has decreased. Consequently, hemolytic disease due to ABO incompatibility, and other allo-antibodies have now emerged as the major causes of HDN.

Table 8: Combination of blood group in abo system, causing significant hyperbilirubinemia.

Mother BG	Baby BG	%	<5 mg%	No. of cases with hyperbilirubinemia	No Rx	Rx
O	AB	1.5	0	3	3	0
A	B	8.5	4	13	11	2
A	AB	3	1	5	3	2
B	A	18	8	28	26	2
B	AB	3.5	0	7	7	0

Rh hemolytic disease is still commonly seen in many developing countries, including India, and it is likely that inadequate prenatal care or failure to administer Rh Ig is responsible for this.

It is more common in 'O' blood group mothers, because 'O' blood group mothers have high titers of IgG, than 'A' or 'B' group mothers.

In my study, I analyzed other ABO group incompatibility, and found that, in them, hyperbilirubinemia was present, but majority did not require any treatment. They had no any significant clinical morbidity.

In type A and B individuals, naturally occurring anti-B and anti-A iso-antibodies, which are largely IgM molecules; do not cross placenta. In comparison, the allo-antibodies, present in type O patients, are mainly of IgG antibodies. For this reason, ABO incompatibility is largely limited, to type O mothers, having fetal blood group A or B. The occurrence of IgG anti-A or anti-B antibodies, in type O mothers, also explains why hemolysis caused by ABO incompatibility, frequently occurs during the first pregnancy, without prior sensitization.

Rh hemolytic disease, rarely occurs during the first pregnancy. However, once sensitization occurs, re exposure to Rh(D) RBCs in subsequent pregnancies leads to an anamnestic response and there is a rise in the maternal anti-D titre, and an increased incidence of affected infants." We also deduced, that for HDN of the new-born, due to ABO incompatibility, gravidity does not appear to be a major criterion.

New-born sex distribution

Male new-born was more affected. In present study also, males were more affected. This disparity of affliction between the sex proves an observation-that in case of any crisis, male neonates succumb more readily, than female neonates, as the fighting ability of female neonates is stronger than male neonates.

Term of gestation

Infants who are premature, small for gestational age, and/or ill (e.g. with sepsis, hypothermia, or hypoxia) are at much greater risk. In such infants, risk increases with increasing hyperbilirubinemia, treatment is given based on age and clinical factors.

With ABO incompatibility, anaemia is usually absent or moderate at birth, and late anaemia is rare. In present study, mean hemoglobin level in ABO incompatible new-born was 16.94±2.01. Only 5 (2.5%) new-born had anaemia, hemoglobin level was <14 mg%. It was supported by other studies as well.[11,12]

In present study, all new born who had sepsis, and high CRP level, had developed hyperbilirubinemia.

Previous studies, by authors mentioned below, also show, sepsis is a risk factor, for neurotoxicity in new-born with severe neonatal hyperbilirubinemia. Rh incompatibility and sepsis greatly increased the risk for bilirubin encephalopathy.[13]

O***utcome***

In present study, out of 200 new-borns, 199 new-borns treated well and only 1 new-born developed kernicterus and all were discharged well from the hospital. There was no mortality.

ABO Incompatibility and Rh incompatibility

- Comparison of severity in ABO incompatibility group only 44% required treatment while in Rh incompatibility group 65% required treatment.
  Severity of Rh incompatibility is more than ABO incompatibility.
- In ABO incompatibility group, development of jaundice was higher in new-born of primigravida patients, in 104 patients.
- In Rh incompatibility group, 11 new-borns required treatment, and they were of multigravida mothers. Unlike Rh, ABO disease can occur in first pregnancies. There is no need for sensitization.
- In both, ABO and Rh incompatibility group, incidences of jaundice were high in males.
- In both, ABO and Rh incompatibility group, incidences of jaundice in preterm babies were high.

Incidence of anaemia

In present study, anaemia in new born was higher in Rh incompatibility group than in ABO incompatibility group. Anaemia is usually not a feature of ABO incompatibility, and if it is present, severity of anaemia is very less.

Direct coombs test (dct)

In present study, in ABO incompatibility, DCT was positive in only 9% cases and in Rh incompatibility group it was positive in 25%. It proves that in Rh incompatibility, there is severe iso-immunization.

Table 9 Type of phototherapy

Type of incompatibility	SSPT	DSPT	TSPT
Abo incompatibility (n=86)	44.18%	31.39%	24.41%
Rh incompatibility (n=11)	36.36%	45.45%	18.18%

Treatment modality

In ABO incompatibility group majority of new borns with hyperbilirubinaemia were treated with phototherapy and only 1% required exchange transfusion while in Rh incompatibility group 10% required exchange

transfusion, which shows the severity of ABO incompatibility is less compared to RH incompatibility.

Table 10 Outcome

Type of incompatibility	Well, fully recovered	Kernicterus	Death
ABO incompatibility	99.5%	0.5%	0 %
Rh incompatibility	90%	10%	0%

Treatment modality, type of treatment and outcome shows that Rh incompatibility is more severe and morbid than ABO incompatibility.

CONCLUSION

Most common cause of hyperbilirubinemia is ABO incompatibility. Most cases of ABO incompatibility develop jaundice, which remains in physiological limits. In presence of some aggravating conditions, this physiological jaundice may present as pathological jaundice. It results in significant morbidity but no mortality.

Due to development of immunological prophylaxis, hemolytic disease due to Rh incompatibility have decreased drastically. The cases which develop hyperbilirubinemia, due to Rh incompatibility, are associated with increased morbidity and mortality. Incidence of kernicterus, in cases of Rh incompatibility, is quite high as compared to that in ABO incompatibility

Even with most vigilant and effective antenatal screening protocols, it is not possible, either to predict or forecast which patients couple will deliver a fetus that will develop ABO incompatibility hyperbilirubinemia. The incompatibility reaction, as well, cannot be averted. As a result, this type of hyperbilirubinemia becomes a routine post-natal neonatal affliction, which, whenever indicated, or required, needs to be actively treated, and managed.

Prenatal counseling is not a practical solution, as ABO incompatibility, never results in a mortality, nor does it result in a lifelong morbidity. One cannot prevent an “O” group woman, marrying to A or B group male, just because this may result in hyperbilirubinemia, which is not life threatening.

Nonetheless, good, vigilant antenatal and intra-natal care, can go a long way to reduce the incidence and severity of the situation, when this reduce the factors that increase the severity and morbidity of neonatal hyperbilirubinemia.

- Good antenatal care, that results in development of a healthy foetus in utero, weighing >3 kg, after birth,
- helps a pregnant woman to successfully reach the full-term duration of pregnancy, as a full term born, neonate does not suffer, as a preterm newborn does.
- During labour, take antiseptic, as well as aseptic measures, to reduce intra-natal intra-amniotic infection, Chorio-amnionitis , that infects the foetus, and increase the severity of hyperbilirubinemia. This can be done by administration of antibiotic to the woman prophylactically, as well as reducing the frequency of vaginal examination, to bare minimum.
- Care should be taken during delivery, to prevent any injury to the foetus, in case of operative deliveries.
- Similarly, after the delivery, care should be taken to prevent infection of the newborn, by any route. Antibiotic prophylaxis in high risk group babies, can play it’s helpful role.
- Maintaining hydration of the newborn, by adequate and frequent breastfeeding, should be practiced, and explained to the mother.
- Expose the new born to early morning sunlight, without any cover, helps to reduce the intensity of hyperbilirubinemia, working as a natural phototherapy.

All these steps, will not prevent hyperbilirubinemia, but very certainly help to reduce the severity, thereby minimizing the morbidity, and improve the perinatal outcome of labour, and prove that good antenatal as well intra-natal care can certainly reduce the morbidity, in all conditions, physiological, as well pathological conditions.

The net result of all these exercises a healthy new born goes home with a healthy mother, a successful outcome of that pregnancy, for both, parents and obstetrician, as well.

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REFERENCES

1. Global Health Observatory (GHO) data. Neonatal mortality. Available at: http://www.who.int/gho/child_health/mortality/neonatal_text/en.
2. Pathologic hyperbilirubinemia. Available at: https://www.utmb.edu/pedi_ed/core/neonatology/page_30.htm
3. Thor WR Hansen. Chief Editor: Ted Rosenkrantz, MD; Neonatal Jaundice, 2016. Available at http://emedicine.medscape.com/article/974786-overview.
4. Buchan PC. Pathogenesis of neonatal hyperbilirubinaemia after induction of labour with oxytocin. Br Med J. 1979;2(6200):1255-7.
5. Huang MJ, Kua KE, Teng HC, Tang KS, Weng HW, Huang CS. Risk factors for severe

hyperbilirubinemia in neonates. Pediatr Res. 2004;56(5):682-9.
6. Christensen RD, Yaish HM. Hemolytic disorders causing severe neonatal hyperbilirubinemia. Clin Perinatol. 2015;42(3):515-27.
7. Woodgate P, Jardine LA. Neonatal jaundice: phototherapy. BMJ Clin Evid. 2015.
8. Harrison, KL. Fetal Erythrocyte Lifespan. J Paedia Child Health. 1979;15(2):96-7.
9. Available at http//www.obgyn.net/English /pubs/features/presentations/panda/3/ABO-Rh.ppt. Assessed on 20 November 2009.
10. Garratty G, Glynn SA, McEntire R. ABO and Rh(D) phenotype frequencies of different racial/ethnic groups in the United States. Transfusion. 2004;44:703-6.
11. Murray NA, Roberts IAG. Haemolytic disease of the newborn: Arch Dis Child Fetal Neonatal Ed. 2007; 92(2):F83-F88.
12. Julia A. Oski's Solution: Oski's Pediatrics: Principles and Practice, Plus Integrated Content Website. 4th ed. 443.
13. Gamaleldin R, Iskander I, Seoud I, Aboraya H, drAravkin A, Sampson PD et al. Risk factors for neurotoxicity in newborns with severe neonatal hyperbilirubinemia. Pediatrics. 2011;128(4).

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