The Impact of Chronic Liver Diseases on the Level of Heart-Type Fatty Acid-Binding Protein (H-FABP) Concentrations

SQU Med J, August 2009, Vol. 9, Iss. 2, pp. 153-156, Epub 30th June 2009
Submitted - 3rd Nov 08
Revision Req. 21st Mar 09, Revision Recd. 29th Mar 09
Accepted - 13th May 09

CLINICAL & BASIC RESEARCH

The Impact of Chronic Liver Diseases on the Level of Heart-Type Fatty Acid-Binding Protein (H-FABP) Concentrations

*Hafidh A Al-Hadi,[1] Brent William,[2] Keith A Fox[3]

تأثير أمراض الكبد المزمنة على تركيز بروتين حمض القلب الدهني الرابط في الدم

حفيظ الهادي، برينت ويليام، كيث فوكس

الملخص: الهدف: يعرف بروتين حمض القلب الدهني الرابط كأحد المؤشرات الكيميائية-الحيوية الجديدة التي يمكن استعمالها لتشخيص الجلطة القلبية مبكرا . لا يوجد حتى الآن دليل على وجود بروتين حمض القلب الدهني الرابط في الكبد. الهدف من الدراسة هو مقارنة تأثير أمراض الكبد على مستوى بروتين حمض القلب الدهني الرابط في الدم. **الطريقة:** تم دراسة تأثير أمراض الكبد المزمنة مثل التهاب الكبد الوبائي ومرض التليف الكبدي على مستوى بروتين حمض القلب الدهني الرابط عند عشرة أشخاص يعانون من هذه الأمراض) متوسط العمر± الانحراف المعياري هو 58,33 ± 7,19 سنة(. تم دراسة تركيز الأنزيمات و البروتينات التالية)بروتين حمض القلب الدهني الرابط. ناقِلَةُ أمين الآلانين وبيليروبين(في المرضى و مقارنة تركيزها مع مجموعة ضابطة من الأصحاء مكونة من عشرين متبرعا بالدم. متوسط العمر± الانحراف المعياري هو 63.8 ± 8.0 سنة(. **النتائج:** كان تركيز هذه المواد في المجموعة الضابطة مقارنة مع المجموعة المرضية كالتالي (المتوسط ± الانحراف المعياري): بروتين حمض القلب الدهني الرابط 6,86 ± 2,21 ميكروجرام/ لتر مقابل 6,44 ± 3,06 ميكروجرام/ لتر. ناقِلَةُ أمين الآلانين 29.8 ± 14.7 وحدة / لتر مقابل 198,67 ± 122,89 وحدة / لتر(P> 0.0005) . و البيليروبين 4.0 ± 9.6 ميكرومول / لتر مقابل 100,89 ± 87,85 ميكرومول / لتر (P > 0.0001). الخلاصة: تبين هذه البيانات بوضوح انه لا يوجد هناك تأثير هام على مستوى تركيز بروتين حمض القلب الدهني الرابط نتيجة الإصابة بأمراض الكبد . على الرغم من الارتفاع الواضح في بروتينات و أنزيمات الكبد في الدم. هذه الدراسة تدعم الاستخدام النافع لبروتين حمض القلب الدهني الرابط في تشخيص إصابة عضلة القلب لدى المرضى المصابين بأمراض الكبد المزمنة.

مفتاح الكلمات: أمراض الكبد المزمنة، بروتين حمض القلب الدهني الرابط، ناقِلَةُ أمين الآلانين ، بيليروبين.

ABSTRACT: ***Objectives:*** Heart-type fatty acid binding-protein (H-FABP) has been reported to be a potential novel biochemical marker for the early diagnosis of acute myocardial infarction (AMI). The presence of H-FABP in the liver has not been reported. The aim of this study was to compare the effect of chronic liver diseases on the level of H-FABP concentrations. ***Methods:*** The effects of chronic liver diseases including infective hepatitis and cirrhosis on the concentration of H-FABP was studied in a small group of patients (n=10, mean age ±SD = 58.33 ± 7.19 years). The serum concentrations of the following markers were measured: H-FABP, alanine aminotransferase (ALT) and bilirubin and compared with a reference control group (20 healthy blood donors, mean age ±SD = 63.8 ±8.01). ***Results:*** The serum concentrations of these markers in the control group as compared to patients with chronic liver disease were as follows (mean ± SD): H-FABP = 6.86 ±2.21 µg/L versus 6.44 ±3.06 µg/L (p = NS); ALT = 29.8 ±14.7 U/L versus ALT = 198.67 ±122.89 U/L ($p < 0.0005$) and bilirubin = 9.6 ±4.0 µmol/L versus bilirubin = 100.89 ±87.85 µmol/L ($p < 0.0001$). ***Conclusion:*** These data illustrate clearly that there is no significant interference with the normal concentration of H-FABP in the presence of liver diseases, despite the significant elevation of liver enzymes and proteins. These data may support a useful role of H-FABP for the diagnosis of myocardial injury in patients with liver diseases.

Keywords: Heart-type fatty acid-binding protein (H-FABP); Chronic liver diseases; Bilirubin; Alanine aminotransferase.

Advances in Knowledge

1. *Heart-type fatty acid-binding protein is a useful early marker for the diagnosis of acute myocardial infarction.*
2. *The effect of chronic liver diseases on the diagnostic potential of this marker is not known.*
3. *This article illustrates the lack of interferences of the various types of chronic liver diseases on the ability to use heart-type fatty acid binding-protein as an early cardiac marker for the early diagnosis of acute myocardial infarction.*

Application to Patient Care

1. *The information provided in this article will help health institutions caring for patient's with acute myocardial infarction on how best to use, interpret and apply the results obtained with heart-type fatty acid-binding protein in patients presenting with acute chest pain suggestive of evolving acute myocardial infarction who also have various co-existing types of chronic liver diseases.*

[1]Department of Medicine, Sultan Qaboos University Hospital, Muscat, Sultanate of Oman. [2]Department of Medical Sciences, Faculty of Medicine, University of Edinburgh, UK. [3]University of Edinburgh, Cardiovascular Research Unit, Royal Infirmary of Edinburgh, UK.

**To whom correspondence should be addressed. Email: halhadi@hotmail.com*

Heart-type fatty acid binding-protein (H-FABP) is a small soluble non-enzyme protein composed of 132 amino acids.[1] It is one of the most abundant proteins in the heart and comprises 5-15% of the total cytosolic protein pool. H-FABP exists in high concentrations in the heart; however, this protein is not totally cardiac specific and occurs in other tissues although in a much lesser concentrations.[2,3] H-FABP was introduced by Glatz *et al.* in 1988 as a potential novel biochemical marker for the early diagnosis of acute myocardial infarction (AMI).[4] This was soon confirmed in many other studies.[5-9] Some of the more recent studies have questioned the value of these early markers (H-FABP and myoglobin) when compared with specific markers like cardiac troponin I (cTnI).[10]

H-FABP is released into plasma within 2 hours after symptom onset and is reported to peak at about 4-6 hours and return to normal base line value in 20 hours.[7] Within the period of 30-210 minutes after symptom onset, H-FABP has > 80% sensitivity for the diagnosis of AMI.[11] Within the interval of 0-6 hours after symptom onset, the other cardiac markers such as creatine kinase (CK), CK-MB mass or activity, cTnI and T (cTnT) will only be starting to accumulate in the plasma, and their sensitivity has been reported to be around 64%.[12]

The exact route(s) of excretion of H-FABP from the circulation is not fully understood. As suggested by previous studies, the kidney may be the major route of excretion of H-FABP from circulation. A rise in serum and urine H-FABP concentration above normal values is seen in patients who present with AMI as early as 1.5 hours after symptom onset.[13] Studies in animals have also shown decreased myocardial tissue content and rising plasma and urine concentrations of H-FABP very early after coronary artery ligation.[14-15] H-FABP circulates for a longer time (> 25 hours) after AMI in the presence of renal failure.[11]

The presence of H-FABP in the liver has not been reported. However, an isoform specific to the liver called liver-type FABP exists.[16] The interferences of this protein and chronic liver diseases on the concentration of H-FABP has not been studied before. Also, the effect of chronic liver diseases on the release of H-FABP from other tissues has not yet been fully evaluated.[17] Therefore, the aim of the study was to compare the effect of chronic liver diseases on the serum levels of H-FABP.

Methods

The effects of disease states in particular chronic liver diseases on the normal concentration of H-FABP was studied in 2003-2004 a small group of patients with a mixture of chronic liver disorders (n=10, mean age ±SD = 58.33 ±7.19 years, range 45-70 years, median = 59 years) These patients had a range of conditions including infective hepatitis and cirrhosis (chronic hepatitis B = 2, chronic hepatitis C = 2, chronic alcoholic hepatitis = 3, other cirrhosis = 3). They were recruited from the Liver Unit at the Edinburgh Royal Infirmary, UK. Ethical approval was obtained from the local ethical committee (Lothian Research Ethics Committee, Edinburgh) and informed consent was obtained from each patient before beginning the study. The study complies with the Declaration of Helsinki. The serum concentrations of the following markers H-FABP, ALT and bilirubin were measured in the study group and compared with the concentrations of these markers in a normal reference control group of healthy blood donor controls (n=20, mean age ±SD = 63.8 ±8.01, range 53-75 years, median = 65 years). Peripheral blood samples for serum analysis were collected in white Starstedt Monovette vacutainer tubes by venepuncture. The blood samples (5mls) were taken through a peripheral line (intravascular access). The extracted samples were allowed to clot at room temperature for 1 hour and then centrifuged at 4°C, and the resulting serum was divided into small aliquots and frozen at -70°C until analysis. H-FABP was analysed by an enzyme linked immunosorbent assay method using commercially available assays (Hycult, Cambridge).[17] Bilirubin and ALT were measured in the Biochemistry Department of the Edinburgh Royal Infirmary on an automated analyser machine using commercial assays.

Statistical analyses were performed using the Statistical Package for Social Sciences (SPSS™, Pittsburgh, Version 15). Continuous variables were presented as mean ± standard deviation. Comparisons between the study group and control group variables were conducted by the Mann-Whitney U test for continuous variables. Significant results were indicated by probability values less than or equal to 0.05.

Table 1: Age and concentrations of marker proteins in the control and study groups

	Control Group (Blood donors)	Study Group (Liver disease patients)	*p* value
Numbers	n=20	n=10	-
Age	63.8 ±8.0	58.33 ±7.2	(NS)
ALT	29.8 ±14.7	198.67 ±122.9	< 0.0005
Bilirubin	9.6 ±4.0	100.89 ±87.9	< 0.0001
H-FABP	6.86 ±2.2	6.44 ±3.1	(NS)

Legend: NS = not significant; ALT = alanine aminotransferase; H-FABP = Heart-type fatty acid binding-protein

Results

The analytical sensitivity of H-FABP assay (mean ± 2SD) was 0.206 ±0.047 g/L.[17] The normal concentrations of these markers in the normal reference control group of healthy blood donor controls were as follows: H-FABP = 6.86 ±2.21 µg/L; ALT = 29.8 ±14.7 U/L and bilirubin = 9.6 ±4.0 µmol/L. The study group consisted of 10 patients. The concentration of these markers in patients with chronic liver diseases were as follows: H-FABP = 6.44 ±3.06 µg/L, (range 2-11 µg/L, median = 7 µg/L); ALT = 198.67 ±122.89 U/L, (range 73-500 U/L, median = 114 U/L) and bilirubin = 100.89 ±87.85 µmol/L, (range 17 - 337 µmol/L, median = 66 µmol/L). There was no significant difference between the concentration of H-FABP in the study group and controls; however, the concentrations of liver enzymes and protein (ALT and Bilirubin) were significantly elevated in the study group [Table 1].

Discussion

Under normal conditions H-FABP is present in plasma in very low concentrations (< 5 µg/L), but it is significantly elevated upon cellular injury.[18] This makes the plasma estimation of H-FABP suitable for the early detection and quantification of myocardial tissue injury. However, this protein is not totally cardiac specific as it occurs in skeletal muscle in concentrations varying between 0.05-0.2 mg/g wet weight of tissue, depending on muscle fibre type studied.[5] It has also been reported in very low concentrations in tissues like the kidney, aorta, testes, mammary glands, placenta, brain, adrenal glands, adipose tissue, and stomach.[2,3] The concentration of H-FABP in the study group was not statistically different from the control group. This finding leads to several assumptions. First, the Liver-FABP (L-FABP) is a separate factor with no or negligible cross-reactivity with H-FABP assays. Indeed, the cross-reactivity between these two proteins has been reported to be < 0.005.[17] Second, the release of H-FABP from other tissues containing this protein (see above) is at best minimal in patients who have chronic liver diseases. Our study was the first of its kind to address the interference of chronic liver diseases on the normal concentrations of H-FABP. There are no data on this issue in the literature hence it is difficult to correlate our findings.

In a previous study, we have shown major limitations for the use of H-FABP concentration for the diagnosis of myocardial injury in the presence of renal failure.[19] The liver contains only L-FABP, but co-expression of H-FABP and L-FABP occurs in the kidney. Similarly, intestinal-type FABP (I-FABP) and L-FABP are found in intestines, and brain-type FABP (B-FABP) and H-FABP occur in the brain. Preliminary but promising applications of these proteins have been demonstrated for liver rejection, viability selection of kidneys from non-heart-beating donors (NHBD), inflammatory and ischaemic bowel disease, traumatic brain injury and in the prevention of muscle injury in trained athletes.[20] Measurement of H-FABP in the first 24 hours after onset of symptoms may be potentially useful for the diagnosis of AMI; identification of patients who need reperfusion treatment early; identification of patients who reperfuse their infarct related artery; detection of re-infarction if it occurs early, and estimation of infarct size.[21]

Conclusion

These data illustrate clearly that there is no significant interference with the normal concentration of H-FABP in the presence of chronic liver diseases, despite the significant elevation of liver enzymes and proteins. This is consistent with the reduced cross-reactivity between H-FABP and other FABP

including L-FABP. These findings may support a useful role of H-FABP for the diagnosis of myocardial injury in patients with chronic liver diseases.

Source of Funding:

The research was funded by a grant from the Cardiovascular Research Unit at the University of Edinburgh.

Conflict of Interest:

The authors report no conflit of interest.

References

1. Offner GD, Brecher P, Sawlivich WB, Costello CE, Troxler RF. Characterization and amino acid sequence of a fatty acid-binding protein from human heart. Biochem J 1988; 252:191-8.
2. Crisman TS, Claffey KP, Saouaf R, Hanspal J, Brecher P. Measurement of rat heart fatty acid-binding protein by ELISA. Tissue distribution, developmental changes and subcellular distribution. J Mol Cell Cardiol 1987; 19:423-31.
3. Glatz GF, Van der Busse GL. Cellular fatty acid-binding protein: their function and physiological significance. Prog Lipid Res 1996; 35:243-82.
4. Glatz JF, Van Bilsen M, Paulussen RJ, Veerkamp JH, Van der Vusse GJ, Reneman RS, *et al.* Release of fatty acid- binding protein from isolated rat heart subjected to ischemia and reperfusion or to the calcium paradox. Biochim Biophys Acta 1988; 961:148-52.
5. Yoshimoto K, Tanaka T, Somiya K, Tsuji R, Okamoto F, Kawamura K, et al. Human heart-type cytoplasmic fatty acid-binding protein as an indicator of acute myocardial infarction. Heart Vessels 1995; 10:304-9.
6. Abe S, Okino H, Lee S, Toda H, Miyata M, Nomoto K et al. Human heart fatty acid-binding protein. A sensitive and specific marker of coronary reperfusion. Circulation 1991; 84:II-291.
7. Glatz JF, Van der Vusse GJ, Maessen JG, Van Dieijen-Visser MP, Hermens WT. Fatty acid-binding protein as marker of muscle injury: experimental finding and clinical application. Acta Anaesthesiol Scand Suppl 1997; 111:292-4.
8. Ishii J, Wang JH, Naruse H, Taga S, Kinoshita M, Kurokawa H, et al. Serum concentrations of myoglobin vs human heart-type cytoplasmic fatty acid-binding protein in early detection of acute myocardial infarction. Clin Chem 1997; 43:1372-8.
9. Alhadi HA, Fox KA. Do we need additional markers of myocyte necrosis: the potential value of heart fatty acid-binding protein. QJM 2004; 97:187-98.
10. AlAnsari SE, Croal BL. Diagnostic value of heart fatty acid binding protein and myoglobin in patients admitted with chest pain. Ann Clin Biochem 2004; 41:391-6.
11. Kleine AH, Glatz JF, Van Nieuwenhoven FA, Van der Vusse GJ. Release of heart fatty acid-binding protein into plasma after acute myocardial infarction in man. Mol Cell Biochem 1992; 116:155-62.
12. BakkerAJ, Koelemay MJ, Gorgels JP, van Vlies B, Smits R, Tijssen JG, et al. Failure of new biochemical markers to exclude acute myocardial infarction at admission. Lancet 1993; 342:1220-2.
13. Tanaka T, Hirota Y, Sohmiya K, Nishimura S, Kawamura K. Serum and urinary human heart fatty acid-binding protein in acute myocardial infarction. Clin Biochem 1991; 24:195-201.
14. Knowlton AA, Apstein CS, Saouf R, Brecher P. Leakage of heart fatty acid-binding protein with ischemia and reperfusion in the rat. J Mol Cell Cardiol 1989; 21:577-83.
15. Volders PG, Vork MM, Glatz JF, Smits JF. Fatty acid-binding proteinuria diagnoses myocardial infarction in the rat. Mol Cell Biochem 1993; 123:185-90.
16. Pelsers MM, Morrovat A, Alexandr GJ, Hermens WT, Trull AK, Glatz JF, *et al.* Liver fatty acid-binding protein as a sensitive serum marker of acute hepatocellular damage in liver transplants. Clin Chem 2002; 48:2055-7.
17. HyCult biotechnology b.v. Hbt human H-FABP ELISA Test Kit Product Information Manual, 1999. Insert sheet.
18. Pelsers MM, Chapelle JP, Knapen M, Vermeer C, Glatz JF. Influence of age, sex and day-today and within-day biological variation on plasma concentrations of fatty acid-binding protein and myoglobin in healthy subjects. Clin Chem 1999; 45:441-4.
19. Alhadi HA, William B, Kox KA. Serum level of heart fatty acid binding protein in patients with chronic renal failure. SQU Med J (Accepted for publication 10 May 2009).
20. Pelsers MM, Hermens WT, Glatz JF. Fatty acid-binding proteins as plasma markers of tissue injury. Clin Chim Acta 2005; 352:15-35.
21. Colli A, Jossa M, Pomar JL, Mestres CA, Gharli T. Heart fatty acid binding proteins in diagnosis of myocardial infarction: where do we stand now? Cardiology 2007; 108:4-10.

SQU Med J, August 2009, Vol. 9, Iss. 2, pp. 157-161, Epub 30th June 2009
Submitted - 10th Feb 2008
Revision Req. 30th Nov 08, Revisions Recd. 21st Jan 09 & 22nd Feb 09
Accepted - 1st April 09

CASE REPORT

A Female Child with Skin Lesions and Seizures

Case report of *Incontinentia Pigmenti*

Sana Al-Zuhaibi,[1] Anuradha Ganesh,[1] Ahmed Al-Waili,[3] Faisal Al-Azri,[4] Hashim Javad,[2]
*Amna Al-Futaisi [2]

طفلة مع آفات جلدية وحالة صرع

تقرير عن حالة سَلَسُ الصِّباغ

سناء الزهيبي، أنورادها غانيش، أحمد الوائلي ، فيصل العزري، هاشم جواد، آمنة الفطيسي

الملخص: سَلَسُ الصِّباغ مرض وراثي نادر مرتبط بالجنس وذو وراثة سائدة. المرض يصيب أجهزة متعددة متعلقة بالأديم الظَّاهِر العَصَبيّ تشمل الجلد والعين والشعر والأظافر والأسنان والجهاز العصبي المركزي. عادة ما يكون المرض قاتلا عند الذكور . بينما يكون ذا أشكال متغيرة سريريا عند الإناث. ننشر هنا تقريرا عن حالة طفلة عمرها ستة أشهر أدخلت إلى مستشفى جامعة السلطان قابوس (سلطنة عمان) بحالة صرع حديثي الولادة مصحوبة بآفات جلدية ناقصة الصباغ أو مفرطته و لديها مظاهر عينية وعصبية متعددة غير طبيعية نوقشت في هذا التقرير.

مفتاح الكلمات: سلس الصباغ، صرع، عينية، نقص الميلانين لايتو، مرض عصبي، تقرير حالة،عمان

ABSTRACT: *Incontinentia Pigmenti* (*IP*), (OMIM # 308300), is a rare X-linked dominant condition. It is a multisystemic disease with neuroectodermal findings involving the skin, eyes, hair, nails, teeth, and central nervous system. It is usually lethal in males; the disease has variable expression in an affected female. We report the case of a 6 month old girl who presented at Sultan Qaboos University Hospital, Oman, with neonatal seizures and hypopigemented/hyperpigmented skin lesions. She had multiple ophthalmic abnormalities and neurological manifestations which are discussed in this report.

Keywords: *Incontinentia Pigmenti (IP)*; Seizures; Ophthalmic; Hypomelanosis of Ito; Neurologic diseases; Case report; Oman.

Incontinentia pigmenti (*IP*) type 2, also known as Bloch-Sulzberger syndrome, is an inherited multisystem neurocutaneous disorder with a low incidence (1% of all neurocutaneous disorders).[1] It is an X-linked dominant condition dominant inheritance. The disease is lethal in males, except in rare cases of somatic mosaicism, or mutations in *IKBKG,* and when the condition occurs in patients with Klinefelter syndrome.[2,3] Typical skin lesions are seen in 100% of (*IP*) patients.[2] Other manifestations include dental (90%), skeletal (40%), central nervous system (CNS) (40-50%) and ocular (35%) conditions.[4,5]

Patients with *IP* frequently have systemic involvement, similar to the involvement in patients with hypomelanosis of Ito, including CNS manifestations. In patients with *IP*, cutaneous lesions undergo three stages, which may overlap.[6]

In this report, we discuss the dermatologic, neurological and ophthalmologic findings of a 6 month old female who presented with early onset neonatal seizures and displayed hypopigmented/hyperpigmented skin lesions. In addition, this child had characteristic ophthalmologic findings.

Case Report

This 6 month old girl was born by spontaneous vaginal delivery to healthy non-consanguineous parents with two normal sons. She was referred to Sultan Qaboos University Hospital (SQUH), Oman, from a peripheral hospital for evaluation of abnormal skin lesions and seizures.

She was reported to have had hyper/hypopigmented skin lesions all over her body except the face since she was 6 days old. The skin lesions were noted to be of linear pattern over the upper and lower limbs and of a whorled pattern over the anterior and posterior chest wall. The mother denied the presence of any skin lesion at birth. Her examination showed evidence of hypotonia and

Departments of [1]Ophthalmology, [2]Child Health, [3]Family and Community Health, and [4]Radiology & Molecular Imaging, Sultan Qaboos University Hospital, Muscat, Sultanate of Oman

**To whom correspondence should be addressed. Email: amnaf@squ.edu.om*

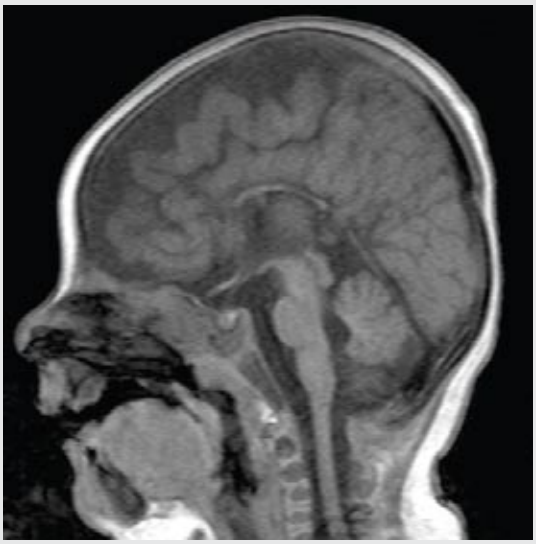

Figure 1a: Magnetic resonance imaging scan: Sag T1W SE, midline. There is hypoplasia of the corpus callosum. Optic chiasm, pituitary gland and midbrain are grossly normal.

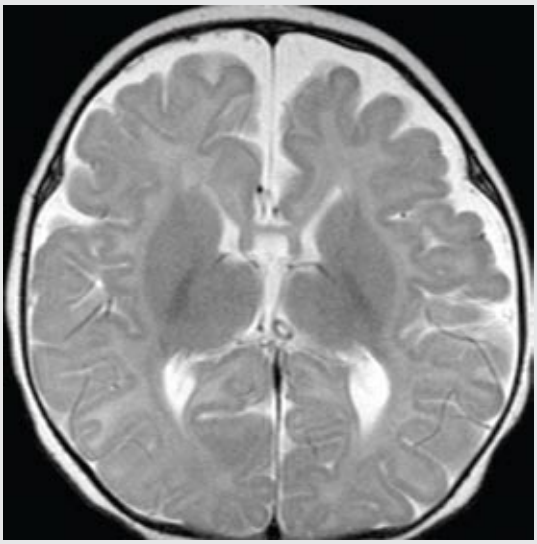

Figure 1b: Magnetic resonance imaging scan: axial T2W SE at level of basal ganglia. There is bilateral hyperintense signal abnormality in the periventricular white matter associated with brain atrophy. No imaging findings of acute ischemia or cortical necrosis

mild developmental delay with microcephaly where her head circumference was significantly below the third percentile for age. Her weight was below the third percentile, but her height was normal for age. Her tone was mildly decreased with normal reflexes and positive Babinski reflex. She had a normal visual following, but was not able to respond to sound clinically. Other systemic examinations were normal.

The child developed clonic seizures at the age of 3.5 months and was commenced on oral phenobarbitone with good seizure control. The computed tomography (CT) scan of the brain (performed at a peripheral hospital) showed atrophy of the frontal horns with corpus callosum agenesis. A chromosomal study showed a normal female karyotype.

At SQUH, a magnetic resonance imaging (MRI) of the brain showed hypoplasia of the corpus callosum and hypomyelination with perivetricular white matter hyperintense signal abnormalities [Figures 1a and 1b]. Electrophysiological testing showed positive visual evoked potential (VEP) responses using a flash stimulation, but negative responses for brain stem auditory evoked potentials (BAEP).

An ophthalmologic evaluation was performed at the age of 5 months. The child was able to follow and fixate with both eyes. There was no obvious nystagmus, ocular deviation or ptosis. Further examination under anaesthesia revealed bilateral inferior superficial epithelial corneal erosions; there were no stromal infiltrates or any increase in corneal thickness. The corneal size was normal for age in both eyes. She had a bilateral mild form of persistent pupillary membrane. She had a normal red reflex and normal reacting pupils with no evidence of any relative afferent defect. The intraocular pressure was 24mmHg in both eyes. No major refractive error was noted. A dilated fundus examination showed a large optic disc cup (disc cup ratio of 0.8 in both eyes). There were diffuse non-specific retinal pigment epithelial changes. The peripheral retinal examination revealed areas of fibrovascular proliferation with no evidence of retinal traction or detachment [Figures 2a and 2b]. The child was started on latanoprost 0.05% eye drops q.h.s. in both eyes with regular follow-ups at the eye clinic. Histological studies of the skin lesions and genetic studies were scheduled; unfortunately, the child died from *status epilepticus* at a peripheral hospital before these studies could be undertaken.

Discussion

IP is characterized by abnormalities of the tissues and organs embryologically derived from ectoderm and neuroectoderm.[4] The diagnosis of *IP* is made on

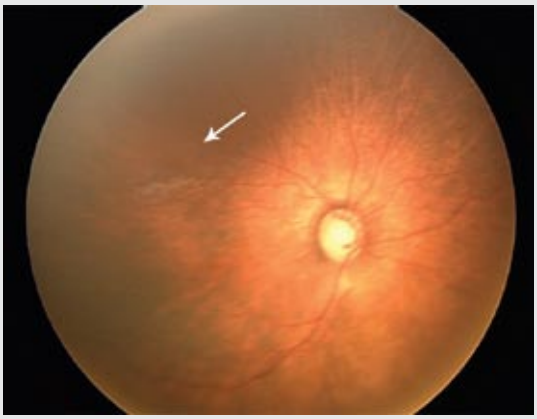

Figure 2a: RetCam fundus photo of the right eye showing large disc cupping and epiretinal pseudoglial tissue superior to the fovea (arrow)

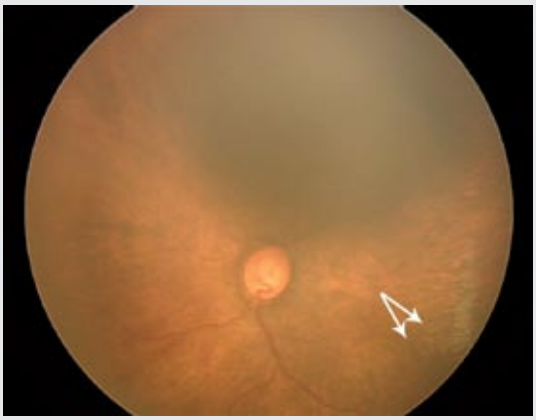

Figure 2b: RetCam fundus photo of the right eye showing large disc cupping and epiretinal pseudoglial tissue superior to the fovea (arrow)

clinical grounds aided by histological confirmation. The skin lesions may follow the Blaschko lines and the initial appearance of skin lesions can be seen immediately after birth or early during the neonatal period. Timely recognition of *IP* by pediatricians and dermatologists is therefore crucial. *IP* overlaps with hypomelanosis of Ito, which is a syndrome with hypopigmented whorls of the skin along the Blaschko lines, especially when it presents at the stage of skin hypopigmentaion. Chromosomal mosaicism is believed to be the reason that hypomelanosis of Ito is so varied in phenotype. Certain genes, namely, those on 9q33-qter, 15q11-q13, and Xp11, have been implicated in hypomelanosis of Ito; however, no consensus exists about the identity of the hypomelanosis of Ito gene.[5, 6]

In around 40-50% of *IP* cases, there may be neurological problems such as seizures, spasticity, or mental retardation.[1] Seizure can be the first manifestation of the disease.[2] Abnormal tooth eruption, malformed tooth crowns, and patchy alopecia are commonly seen. Retinal dysplasia can sometimes lead to visual problems.

The diagnosis of *IP* is also aided by family history and a history of miscarriages of the male gender as the disease is prenatally lethal in males. The disease is caused by a genomic rearrangement of the gene for NEMO, or nuclear factor kappa B essential modulator (IKBKG-IKK gamma). The defect in the X chromosome is proximal to the gene for factor VIII at Xq28. [7, 8] Although this child was the first affected in her family with two normal male siblings and no previous miscarriages in the family, she had hypopigmented/hyperpigmented lesions suggestive of the disease. Initially, the diagnosis was not entertained, despite the skin manifestations, until her presentation with partial seizures. The possibility of hypomelanosis of Ito diagnosis was also kept in mind though further evidence of neurological involvement and the eye manifestations were suggestive of *IP*.

The skin lesions in *IP* manifest in stages that evolve sequentially.[7] The onset and duration of each stage vary among individuals; not all individuals experience all four stages.[1] Typically four dermatological stages are seen: 1) the bullous stage; early blistering with eosinophilia; 2) the verrucous stage: eruption of hyperkeratotic lesions; 3) the hyperpigmentation stage: hyperpigmentation along the lines of Blaschko and, finally, 4) the atretic stage: dermal scarring. In the vast majority of cases, the onset of skin changes is before 6 weeks of age.[1] Our patient had the third stage which was not preceded by the first or second stages. The differential diagnosis of patients presenting with stage 3 and 4 skin lesions includes: hypomelanosis of Ito; *IP achromians*; focal dermal hypoplasia syndrome (Goltz syndrome) and X-linked dominant *chondrodysplasia punctata*.

In *IP,* variable clinical expressions of CNS involvement are seen. They include epilepsy, mental retardation, hemiparesis, spasticity, microcephaly, and cerebellar ataxia.[5] The pathogenesis of the CNS lesion in *IP* remains unclear.[9,10,11] Recent brain-imaging techniques, such as MRI and magnetic resonance angiogram (MRA), have provided a better understanding of the nature of the CNS pathology. These imaging studies have demonstrated scattered cortical neuronal and white-matter necrosis,

hypoplasia of the corpus callosum, periventricular white-matter cystic lesions, neuronal heterotopia, and cerebral atrophy.[12, 13]

Our patient had evidence of hypoplasia of the corpus callosum and decreased myelination of the white matter and, clinically, both seizures and developmental delay. The presence of CNS involvement, such as seizures, in the neonatal period is a poor prognostic sign.[4, 6, 7]

Ocular abnormalities occur in 35% or more of patients and 19% are at risk of severe visual loss in one or both eyes.[14,15] A wide range of ophthalmologic findings are seen in patients with *IP*.[7] The commonest reported are strabismus in 18.2% and a retrolental mass or retinal pseudoglioma in 15.4%.

There are previous reported cases in literature of multiple corneal abnormalities including megalocornea, corneal oedema, band keratopathy, bullus keratopathy, variable corneal epithelial and stromal changes and iridocorneal attachments.[10] The corneal findings in this child were superficial punctuate epithelial erosion and features suggestive of an inflammatory noninfectious process.

The posterior segment findings may include multiple retinovascular abnormalities (such as retinal vascular tortuosity, macular capillary dropout, peripheral arteriovenous shunts, retinal neovascularisation, and vitreous haemorrhage). Subsequently, preretinal fibrosis, pseudoglioma and traction retinal detachment can result.[14] This child had findings suggestive of what looked like pseudogliomas in both eyes [Figures 2a and 2b] and peripheral fibrovascular lesions OU with no evidence of retinal traction.

Holstrom proposed a scheme for following patients with *IP* and eye manifestations. They recommended that eyes should be examined soon after birth, and then at least monthly for three to four months, at three-month intervals for one year, and twice yearly up to three years. They also recommended that the frequency of examinations should be increased in children with retinal disease. If, at three years of age, no abnormalities, refractive errors or strabismus are found, they state that the follow-up can cease.[16]

During the ophthalmic follow-up, visual functions should be assessed by both clinical and electrophysiological measures including VEP and electroretinography (ERG).[16,17] Any significant refractive errors should be corrected and amblyopia therapy as well as strabismus treatment should be provided.[18,19] Cryotherapy or laser photocoagulation should be applied for active peripheral retinal abnormalities and tractional retinal detachment should be treated surgically.

Conclusion

In summary, IP or Bloch-Sulzberger syndrome is a rare X-linked dominant syndrome. It has multisystemic involvement that includes the skin, central nervous system and eyes. In neurocutaneous syndromes, multidisciplinary care with periodic consultations with a paediatric ophthalmologist, neurologist and other specialists depending on the associated anomalies are essential. The differentiation between hypomelanosis of Ito and IP can be difficult as the two disorders overlap considerably. Clinicians need to be aware of the variable manifestations of this disease for a timely and multidisciplinary management of such patients.

Acknowledgments

Thanks are due to the parents of this child who consented to publication of this report and the photos in a medical journal.

References

1. Landy SJ, Donnai D. Incontinentia Pigmenti (Bloch-Sulzberger syndrome). J Med Genet 1993; 30:53-9.
2. Traupe H. Functional X-chromosomal mosaicism of the skin: Rudolf Happle and the lines of Alfred Blaschko. Am J Med Genet 1999; 85324-9.
3. Scheuerle AE. Male cases of Incontinentia Pigmenti: case report and review. Am J Med Genet 1998; 77:201-18.
4. Türkmen M, Eliaçik K, Temoçin K, Savk E, Tosun A, Dikicioğlu E. A rare cause of neonatal seizure: Incontinentia Pigmenti. Turk J Pediatr 2007; 49:327-30.
5. Fritz B, Kuster W, Orstavik KH, Naumova A, Spranger J, Rehder H. Pigmentary mosaicism in hypomelanosis of Ito. Further evidence for functional disomy of Xp. Hum Genet 1998; 103:441-9.
6. Glover MT, Brett EM, Atherton DJ. Hypomelanosis of Ito: spectrum of the disease. J Pediatr 1989; 115:75-80.
7. Berlin AL, Paller AS, Chan LS. Incontinentia pigmenti: a review and update on the molecular basis of pathophysiology. J Am Acad Dermatol 2002;

47:169-87.

8. Fusco F, Bardaro T, Fimiani G. Molecular analysis of the genetic defect in a large cohort of IP patients and identification of novel NEMO mutations interfering with NF-kappaB activation. Hum Mol Genet 2004; 13:1763-73.
9. Nenci A, Huth M, Funteh A, Schmidt-Supprian W, Bloch D, Metzger P, *et al.* Skin lesion development in a mouse model of incontinentia pigmenti is triggered by NEMO deficiency in epidermal keratinocytes and requires TNF signaling. Hum Mol Gene 2006; 15:531-42.
10. Nehal KS, PeBenito R, Orlow SJ. Analysis of 54 cases of hypopigmentation and hyperpigmentation along the lines of Blaschko. Arch Dermatol 1996; 132:1167-70.
11. Cohen BA. Incontinentia pigmenti. Neurol Clin 1987; 5:361-77.
12. Pascual-Castroviejo I, Roche MC, Martinez Fernández V, Perez-Romero M, Escudero RM, Garcia-Peñas JJ, *et al.* Incontinentia pigmenti: MR demonstration of brain changes. AJNR Am J Neuroradiol 1994; 15:1521-7.
13. Lee AG, Goldberg MF, Gillard JH, Barker PB, Bryan RN. Intracranial assessment of incontinentia pigmenti using magnetic resonance imaging, angiography, and spectroscopic imaging. Arch Pediatr Adolesc Med 1995; 149:573-80.
14. Carney RG. Incontinentia pigmenti: A world statistical analysis. Arch Dermatol 1976; 112:535-42.
15. Kasmann-Kellner B, Jurin-Bunte B, Ruprecht KW. Incontinentia pigmenti (Bloch-Sulzberger-syndrome): case report and differential diagnosis to related dermato-ocular syndromes. Ophthalmologica 1999; 213:63-9.
16. Holmstrom, G, Thoren K .Ocular manifestations of incontinentia pigmenti. Acta Ophthalmol Scand 2000; 78:348-53.
17. O'Brien JE, Feingold M. Incontinentia pigmenti a longitudinal study. Am J Child 1985; 139:711-2.
18. Mayer EJ, Shuttleworth GN, Greenhalgh KL. Novel corneal features in two males with incontinentia pigmenti. Br J Ophthalmol 2003; 87:554-6.
19. Taylor D, Hoyt CS, Eds. Pediatric Ophthalmology and Strabismus, 3rd Ed. Philadelphia: WB Saunders, 2004.