Diagnostic criteria and tumor screening for individuals with isolated hemihyperplasia

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Abstract: Isolated hemihyperplasia, formerly termed isolated hemihypertrophy, is a congenital overgrowth disorder associated with an increased risk for embryonal tumors, mainly Wilms tumor and hepatoblastoma. This practice guideline will set forth the diagnostic criteria and tumor screening recommendations for children with isolated hemihyperplasia, based on the best information available. There is clinical overlap between isolated hemihyperplasia with Beckwith-Wiedemann syndrome. The majority of Beckwith-Wiedemann syndrome patients have a molecular abnormality involving the imprinted cluster of genes at 11p15.5. In contrast, the preponderance of isolated hemihyperplasia patients studied have no identified etiology. Tumors have developed in isolated hemihyperplasia patients with and without molecular abnormalities. For this reason, molecular diagnostics are not helpful in identifying the subset of isolated hemihyperplasia patients with tumor risk and all isolated hemihyperplasia patients should undergo tumor screening. ***Genet Med*** **2009:11(3):220–222.**

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DIAGNOSTIC CRITERIA FOR ISOLATED HEMIHYPERPLASIA

Isolated hemihyperplasia (IH, OMIM 23500) is most succinctly defined as asymmetric regional body overgrowth because of an underlying abnormality of cell proliferation in individuals without any other underlying diagnosis. There are no widely accepted criteria for defining IH as distinct from normal growth variation in children, and therefore the pragmatic case definition is that IH should be apparent "from the end of the bed." The asymmetry can be due to differences in the growth of bone, soft tissue, or both.

The diagnosis of IH should be made by a clinical geneticist experienced in the differentiation of IH from other causes of body asymmetry, including regional body undergrowth, seen for example with mild fibular hemimelia and hemiatrophy. Known overgrowth syndromes, including Beckwith-Wiedemann syndrome (BWS), proteus syndrome, neurofibromatosis Type 1, mosaic trisomy 8, and disorders associated with vascular malformations including Klippel-Trenaunay syndrome and megalencephaly-cutis marmorata telangiectatica congenital, must be ruled out.

TUMOR OCCURRENCE IN INDIVIDUALS WITH IH

The increased risk of embryonal tumors in individuals with IH is well documented in case reports and clearly substantiated by the only prospective study, which was reported by Hoyme et al.[1] in 1998. They followed 168 children with IH for 10 years and reported 10 tumors in 9 individuals. There were six Wilms tumors (WTs), one hepatoblastoma (HBL), two adrenal cell carcinomas, and one small bowel leiomyosarcoma, giving a tumor incidence of 5.9%. In a review of 134 tumors in IH patients, Lapunzina[2] noted that the types of tumors in IH patients are similar but not identical to those seen in BWS. As in BWS, the IH tumors were mostly embryonal, 94% occurred in the abdomen, and usually diagnosed before 10 years of age. The six extraabdominal tumors involved the brain, testes, lung, uterine cavity, and bone marrow.

ASSOCIATION BETWEEN OCCURRENCE AND TYPES OF TUMORS WITH EPIGENETIC CAUSES OF IH

Recognition that IH and BWS have clinical overlap and similar tumor associations has led to the search for the same constitutional epigenotypes involving the gene cluster at 11p15.5 in IH patients, that are known to underlie BWS. As of early 2008, a minority of IH patients have indeed been found to have one of the three most common epigenotypes found in

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BWS, namely uniparental paternal disomy of 11p15 (UPD), loss of maternal methylation of *KCNQ1OT1*, and hypermethylation of maternal *H19*.[3–8]

Shuman et al.[8], in 2006, reported the largest single cohort of IH patients (51) studied for these molecular defects. They found that 40 (78%) had no identified abnormality but had six tumors, i.e., a tumor incidence of 15%. Eight (16%) patients had UPD of whom four developed tumors for a tumor incidence of 50%. Three (6%) had loss of maternal methylation of *KCNQ1OT1* and none had tumors. No patients had hypermethylation of maternal *H19* alone. The authors point out that because UPD is always mosaic, it can be missed and therefore it is likely that a subset of patients without identified molecular defects may actually have UPD. The authors also noted that of the four UPD patients with tumors, two were conceived by assisted reproductive technologies, raising the question of whether assisted reproductive technology is a risk factor for IH because of UPD and associated high tumor risk.

Niemitz et al.[9], in 2005, reported the results of similar molecular studies on 15 IH children with WT, and noted that 12/15 (80%) had no identified abnormality, and all three of those with abnormalities had hypermethylation of maternal *H19*, two because of UPD and one an isolated methylation defect only. These authors suggested that the methylation defect of *H19* per se, with or without UPD, confers a high tumor risk.

Overall, the preponderance of IH patients with or without tumors who have undergone epigenetic studies have no identified etiology. This is in contrast to BWS, 70% of whom have an identified epigenetic or genetic etiology. Tumors have developed in IH patients with and without molecular abnormalities. Therefore, current molecular techniques are not helpful in identifying the subset of IH patients with tumor risk and so all IH patients should be screened for tumors. Similarly, data on tumor risk for specific molecular defects is too limited to be clinically useful at this time, although the studies noted above have reported high tumor risk with methylation of *H19* with or without UPD.

EVIDENCE FOR EFFECTIVENESS OF EXISTING TUMOR SURVEILLANCE PROTOCOLS

The purpose of tumor surveillance in high-risk individuals is to facilitate identification of tumors at an early stage when treatment is most effective and least invasive. The most frequent tumors in children with IH are WT and HBL, but other tumors including neuroblastoma, adrenocortical tumors, and sarcomas occur. The vast majority of tumors occur in the abdomen and, given the ready availability and noninvasiveness of diagnostic ultrasound, abdominal ultrasound is the screening modality of choice for most tumors.

Beckwith in 1998 recommended abdominal ultrasound every 3 months until age 7 or 8 years for children with BWS. These are the ages that 90% and 93%, respectively, of WT are diagnosed.[10] He based his recommendation on the epidemiology and biology of WT (including rapid WT growth), benefits, risks, and cost of monitoring for WT in BWS patients. Data on the effectiveness of this protocol are somewhat limited for IH, as studies have been retrospective and most studied patients have had BWS. One such study is that by Choyke et al.[11], who looked at whether screened patients with BWS or IH who developed WT had less late-stage disease than those not screened. Their results suggested strongly that ultrasound screening at intervals of 4 months or less reduced the proportion of late-stage WT. Beckwith's original protocol has also been recommended by Tan et al.[12], in 2006, after a comprehensive review of the literature. All of the above authors have recognized the potential adverse effects of ultrasound screening, primarily false positive findings, some of which have led to invasive surgeries.[11]

Tan et al. have also recommended that serum alpha-fetoprotein (AFP) be measured every 3 months until age 4, by which time 90% of HBL will have developed. They cite a case report with this recommendation by Clericuzio et al.[13], of five children (three with BWS and two with IH) with normal hepatic ultrasounds for whom rising serial AFP measurements prompted additional imaging and ultimate diagnosis of early stage HBL. Caution in interpretation of infant AFP levels is necessary, given the high levels of AFP at birth which fall rapidly to the normal adult level by 10–12 months of age.[14,15]

Lastly, one of the authors (C.L.C.) is an advocate of teaching parents the "daily caretaker abdominal examination" for young children with IH.[16] On the basis of this author's personal experience, most parents are eager to take an active role in their child's care. Those that are too anxious to do the exam are fully supported in not doing so. The benefits of this practice are anecdotal: one parent found a WT half-way through the 3 month screening interval (personal observation). As there is no evidence of an adverse effect of teaching parents the abdominal examination, it seems reasonable to offer this education as an option.

Recommendations

1. Any child with suspected IH should be referred to a clinical geneticist for evaluation.
2. Abdominal ultrasound every 3 months until 7 years.
3. Serum alpha-fetoprotein measurement every 3 months until 4 years.
4. Daily caretaker abdominal examination at the discretion of the provider/parent.

REFERENCES

1. Hoyme HE, Seaver LH, Jones KL, Procopio F, Crooks W, Feingold M. Isolated hemihyperplasia (hemihypertrophy): report of a prospective multicenter study of the incidence of neoplasia and review. *Am J Med Genet* 1998;79:274–278.
2. Lapunzina P. Risk of tumorigenesis in overgrowth syndromes: a comprehensive review. *Am J Med Genet C Semin Med Genet* 2005;137:53–71.
3. Grundy P, Telzerow P, Paterson MC, et al. Chromosome 11 uniparental isodisomy predisposing to embryonal neoplasms. *Lancet* 1991;338:1079–1080.
4. Hertel NT, Carlsen N, Kerndrup G, et al. Late relapse of adrenocortical carcinoma in Beckwith-Wiedemann syndrome. Clinical, endocrinological and genetic aspects. *Acta Paediatr* 2003;92:439–443.
5. West PM, Love DR, Stapleton PM, Winship IM. Paternal uniparental disomy in monozygotic twins discordant for hemihypertrophy. *J Med Genet* 2003;40:223–226.
6. Martin RA, Grange DK, Zehnbauer B, Debaun MR. LIT1 and H19 methylation defects in isolated hemihyperplasia. *Am J Med Genet A* 2005;134:129–131.
7. Cooper WN, Luharia A, Evans GA, et al. Molecular subtypes and phenotypic expression of Beckwith-Wiedemann syndrome. *Eur J Hum Genet* 2005;13:1025–1032.
8. Shuman C, Smith AC, Steele L, et al. Constitutional UPD for chromosome 11p15 in individuals with isolated hemihyperplasia is associated with high tumor risk and occurs following assisted reproductive technologies. *Am J Med Genet A* 2006;140:1497–1503.
9. Niemitz EL, Feinberg AP, Brandenburg SA, Grundy PE, DeBaun MR. Children with idiopathic hemihypertrophy and beckwith-wiedemann syndrome have different constitutional epigenotypes associated with wilms tumor. *Am J Hum Genet* 2005;77:887–891.
10. Nichols KE, Li FP, Haber DA, Diller L. Childhood cancer predisposition: applications of molecular testing and future implications. *J Pediatr* 1998;132:389–397.
11. Choyke PL, Siegel MJ, Craft AW, Green DM, DeBaun MR. Screening for Wilms tumor in children with Beckwith-Wiedemann syndrome or idiopathic hemihypertrophy. *Med Pediatr Oncol* 1999;32:196–200.
12. Tan TY, Amor DJ. Tumour surveillance in Beckwith-Wiedemann syn-

drome and hemihyperplasia: a critical review of the evidence and suggested guidelines for local practice. *J Paediatr Child Health* 2006;42: 486–490.
13. Clericuzio CL, Chen E, McNeil DE, et al. Serum alpha-fetoprotein screening for hepatoblastoma in children with Beckwith-Wiedemann syndrome or isolated hemihyperplasia. *J Pediatr* 2003;143:270–272.
14. Tsuchida Y, Endo Y, Saito S, Kaneko M, Shiraki K, Ohmi K. Evaluation of alpha-fetoprotein in early infancy. *J Pediatr Surg* 1978;13:155–162.
15. Ohama K, Nagase H, Ogino K, et al. Alpha-fetoprotein (AFP) levels in normal children. *Eur J Pediatr Surg* 1997;7:267–269.
16. Clericuzio CL. Recognition and management of childhood cancer syndromes: a systems approach. *Am J Med Genet* 1999;89:81–90.

