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REVIEW ARTICLE

Dandy–Walker syndrome and chromosomal abnormalities

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ABSTRACT **Dandy–Walker syndrome (DWS) is a brain malformation of unknown etiology, but several reports have been published indicating that there is a causal relationship to various types of chromosomal abnormalities and malformation syndromes. In the present article, we present a bibliographical survey of several previously issued reports on chromosomal abnormalities associated with DWS, including our case of DWS found in trisomy 18. There are various types of chromosomal abnormalities associated with DWS; most of them are reported in chromosome 3, 9, 13 and 18. We also summarize some other chromosomal abnormalities and various congenital malformation syndromes.**

Key Words: chromosomal abnormality, chromosome, Dandy–Walker syndrome, trisomy 13, trisomy 18, trisomy 3, trisomy 9, ZIC1, ZIC4

INTRODUCTION

Dandy–Walker syndrome (DWS) is designated by Benda (1954), following reports on hydrocephalus associated with cysts of the posterior cranial fossa (Dandy *et al*. 1914; Taggart & Walker 1942). Absence or hypoplasia of the vermis (Altmen *et al*. 1992) and the formation of cysts (Murray *et al*. 1985; de Souza *et al*. 1994; Teksam *et al*. 2005) that communicate with the fourth ventricle of the posterior cranial fossa are essential to the definition of this syndrome. The syndrome occurs in one of 30 000 infants (Ashwal 1999). Reports have been published on various other disorders and complications that are similar from a clinical perspective. The complications include deformation of the central nervous system, hyperdactylia, syndactyly, cleft palate, alloplasia of kidneys, liver and pancreas, and abnormal retina (Hunter *et al*. 1991). There are many reports on the complications of chromosomal abnormalities with DWS (Nyberg *et al*. 1991; Lee *et al.* 2005). We report here our case of DWS associated with trisomy 18. In addition, we present a bibliographical survey of the previous reports of association between DWS and chromosomal abnormalities with new knowledge, as well as various malformation syndromes.

CASE REPORT: DWS ASSOCIATED WITH TRISOMY 18

A 25-year-old pregnant female underwent fetal ultrasonography. She was referred to the department of gynecology and obstetrics of our hospital due to slow fetal growth and suspected ventricular enlargement at the 32nd week of gestation. She had no history of delivery or miscarriage, and no history of infection in the early pregnancy period. Her husband was 30 years old and in good health. Subsequent observation of the course of fetal growth showed intrauterine growth retardation and polyhydramnios. The baby was born by spontaneous delivery at 39 weeks gestation. Apgar score was 3 at 1 min and 4 at 5 min. Because of respiratory failure, the baby was ventilated mechanically. He was 42 cm tall (−3.2 SD) and weighed 1988 g (−3.0 SD). His head circumference was 34.4 cm (+1.1 SD), and chest circumference was 27 cm (−3.0 SD). Cardiac ultrasonography showed ventricular septal defect and patent ductus arteriosus. There were multiple anomalies including syndactyly, small auricles, undescended testis, dislocation of the hip joint, hyperrigidity of the four limbs, and rocker bottom feet. G-banding analysis revealed that the karyotype was 47, XX, +18 (Fig. 1). Fluorescent *in situ* hybridization method showed complete trisomy 18. Brain ultrasonography revealed a cyst in the posterior area (Fig. 2). Brain CT showed cerebellar cyst communicating with the fourth ventricle, suggesting DWS (Fig. 3). The baby died of acute respiratory failure without withdrawal from the respirator at the age of 414 days. No autopsy was performed.

REVIEW OF PUBLISHED REPORTS

The cause of DWS is unknown, but there have been many reports of various chromosomal abnormalities associated with DWS. Many cases have been reported with complications of trisomy and partial trisomy, including trisomy 18, as is reported here. Complications of sex chromosomal abnormalities and multiple malformation syndromes have also been reported. In the present report we first discuss the frequency of complications of chromosomal abnormalities with DWS. Second, we focus on chromosomes 3, 9, 13 and 18 as the major chromosomal abnormalities reported in many previous cases, and summarize the association with DWS. Finally, we report complications of other chromosomes and congenital malformation syndromes with DWS.

General view of DWS associated chromosomal abnormalities

DWS is rare. It has a frequency of occurrence in one in 30 000 infants (Ashwal 1999). Three papers have been published (Nyberg *et al*. 1991; Estroff *et al*. 1992; Ulm *et al*. 1997) containing a statistical analysis of chromosomal abnormalities with DWS (Table 1). According to Table 1, 34 cases of chromosomal abnormalities were observed with 78 cases of DWS. The karyotype of each chromosomal abnormality is unknown, but it is important to conduct a chromosomal test of cases diagnosed as DWS by diagnostic imaging, keeping in mind chromosomal abnormalities.

Chromosome 3 and DWS

In 2004 Girnberg *et al*. conducted a genetic analysis of six cases of DWS with interstitial deletion observed in 3q, and defined the first critical region associated with DWS in 3q24, encompassing two adjacent zinc fingers in cerebellum genes ZIC1 and ZIC4 (Girnberg *et al*. 2004; Grinberg & Millen 2005; Titomanlino *et al*. 2005).

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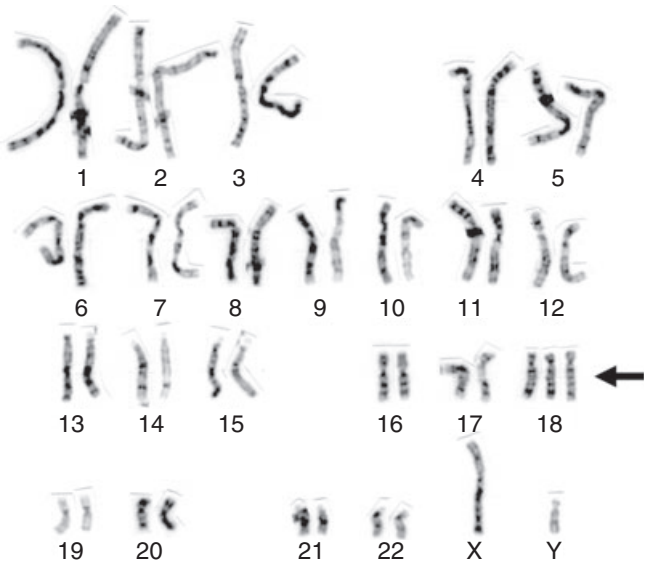

Fig. 1 Karyotype analysis G-banding method. There was an extra chromosome with the 18th pair in Group E, suggesting trisomy 18.

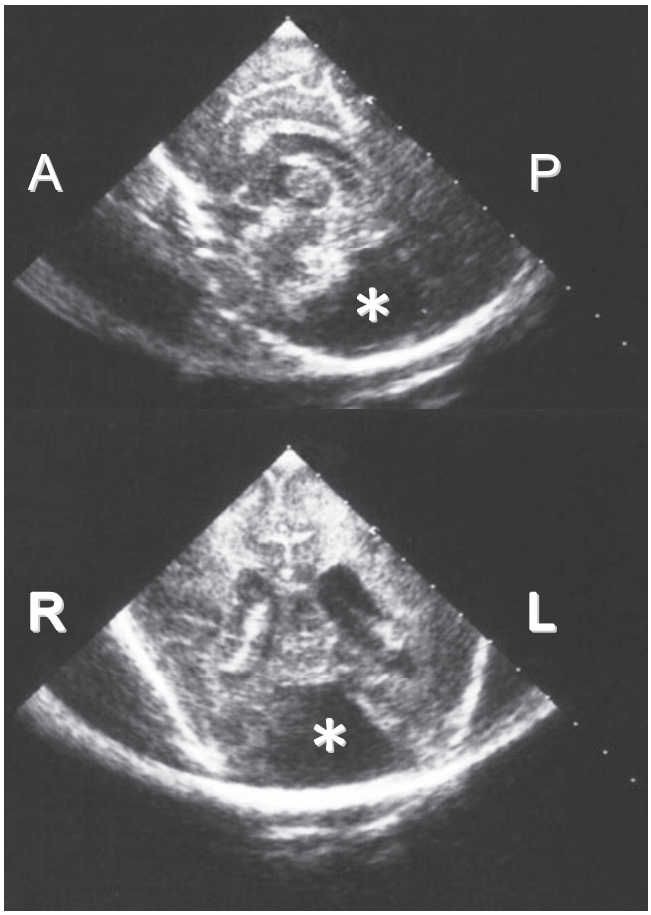

Fig. 2 Brain ultrasonography. Brain ultrasonography (upper; sagittal image/lower; axial image) showed enlarged lateral ventricles associated with hypoplasia of the cerebellar vermis (*). A, anterior; P, posterior.

Furthermore, the authors pathologically proved that mice with heterozygous deletion of these two linked genes had a phenotype that closely resembled DWS and provided a mouse model of this malformation. There have also been four case reports of DWS complicated by chromosome 3 abnormalities including: partial trisomy3p and partial monosomy 11q (Chen *et al*. 2002b); partial trisomy 3q (de Azevedo *et al*. 2005); dup(3q) syndrome (Ounap *et al*. 2005); and an interstitial deletion of chromosome 3q [3q25.1–3q25.33] (Sudha *et al*. 2001).

Chromosome 9 and DWS

There is a major participation of chromosome 9 in the chromosome abnormalities where Dandy–Walker syndrome is concerned. Sepulveda *et al*. (2003) conducted diagnostic imaging of nine cases of trisomy 9 and reported that four cases were diagnosed as DWS. There have been at least 20 case reports on DWS cases complicated by trisomy 9 (Golden & Schoene 1993). These reports include cases complicated by DWS such as trisomy 9 mosaic syndrome (Bureau *et al*. 1993; Tarani *et al*. 1994; Murru *et al*. 2002), partial trisomy 9 (Zacharias *et al*. 1983; Hannam *et al*. 1999; von Kaisenberg *et al*. 2000; Chen *et al*. 2002a, 2005; Metzke-Heidemann *et al*. 2004), tetrasomy 9p (Melaragno *et al*. 1992; Cazorla *et al*. 2003; Hengstschlager *et al*. 2004), and complete trisomy 9 (McDuffie 1994). The number of these reports shows that DWS can be commonly encountered in chromosome 9.

Chromosome 13 and DWS

In an analysis of 33 cases of chromosomes of DWS by Nyberg *et al*. (1991), three cases were diagnosed as trisomy 13. One case was diagnosed as trisomy 13 in a chromosomal analysis of 17 cases of DWS by Estroff *et al*. (1992). According to these two articles, complication of trisomy 13 was observed in four of 50 cases of DWS. Four case reports of DWS associated with deletion of the 13q arm have been reported (Patacchiola *et al*. 1999; Alanay *et al*. 2005; Gul *et al*. 2005; Kolomietz *et al*. 2005). Holoprosencephaly is a malformation of the brain known to occur in association with chromosome 13. One of the three cases mentioned above was a case complicated by DWS and holoprosencephaly with deletion of the 13q arm (McCormack *et al*. 2003). It is anticipated that the accumulation of further case reports will result in the prediction of the gene loci that will identify candidate genes for DWS from chromosome 13.

Chromosome 18 and DWS

Three summarized reports have been published regarding chromosome 18 and DWS (Table 2). Nyberg *et al*. (1991) analyzed the karyotypes of chromosomes in 33 cases of DWS, and reported 15 cases of trisomy 18. Estroff *et al*. (1992) reported chromosome analysis in 17 cases of DWS, and trisomy 18 was observed in two cases. Ulm *et al*. (1997) reported chromosome analysis 28 cases of DWS, and trisomy 18 was included in three cases. These three reports show that trisomy 18 occurred in 20 of 78 cases of DWS. Nyberg *et al*. stated in the discussion of the article that DWS had a high frequency of complication by trisomy 18, and thus ultrasound or imaging tests should be conducted at an early stage, keeping in mind trisomy 18 complicated by DWS (Nyberg *et al*. 1991). Moreover, regarding the early diagnosis of DWS, Chen CP *et al*. reported that a prenatal diagnosis could be made for DWS complicated by trisomy 18 in cases with intrauterine growth retardation, hydrops amnii, and small placenta observed by fetal ultrasound (Reece *et al*.

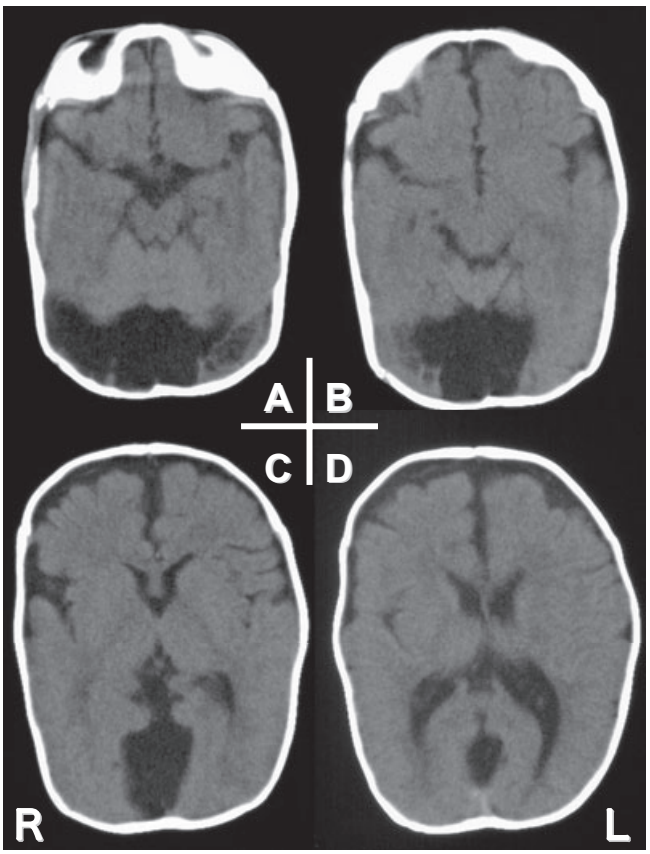

Fig. 3 Brain computed tomography showed hypoplasia of the cerebellar vermis (A,B) and a cyst communicating with the 4th ventricle (B,C,D), suggesting DWS.

Table 1 Chromosomal abnormalities and Dandy–Walker syndrome (DWS)

	No. cases with DWS	Chromosomal abnormalities
Nyberg *et al*. (1991)	33	21
Estroff *et al*. (1992)	17	5
Ulm *et al*. (1997)	28	8
Total	78	34

Table 2 Trisomy 18 and Dandy–Walker syndrome (DWS)

	No. cases with DWS	Trisomy 18
Nyberg *et al*. (1991)	33	15
Estroff *et al*. (1992)	17	2
Ulm *et al*. (1997)	28	3
Total	78	20

1987; Thurmond *et al*. 1989; Chen *et al*. 1996, 2002). However, because the timing of operation for congenital hydrocephalus is the biggest problem in the early diagnosis of DWS (Aletebi & Fung 1999; Zhang *et al*. 2004), it is necessary to consider the ethical aspect (Imataka *et al*. 2004, 2006). In our case, the hydrocephalus associated with DWS was not a candidate for surgery and was not the direct cause of death. The cause of death in this case was congenital cardiac disorder associated with trisomy 18. It is generally known that because severe congenital cardiac disorders simultaneously occur with trisomy 18 in many cases, the long-term survival rate is very low (Rasmussen *et al*. 2003; Kuroki & Kurosawa 2004; Imataka *et al*. 2007). Since the statistics show that death within 24 h after birth is observed in approximately 9–15% of cases (Imataka *et al*. 2007), many cases of deaths that may be reported as being due to congenital cardiac disorder in trisomy 18, with no diagnosis of DWS. However, there have been many cases of trisomy 18 with long-term survival in recent years, and it has been reported that approximately 10% of cases survived for over 1 year, depending on the medical situation of the country (Rasmussen *et al*. 2003; Kuroki & Kurosawa 2004; Imataka *et al*. 2007). The case of trisomy 18 that we presented here was a case of long-term survival of 414 days. No reports on complications of DWS in other karyotypic abnormalities of chromosome 18 have been found.

Other chromosomes and concurrent cases of malformation syndrome and DWS

Reports have been published on DWS and chromosome 1 (Wells *et al*. 1996; Poot *et al*. 2007), and two cases of chromosome 2q (Davis *et al*. 1991; Waters *et al*. 1993). There are cases of DWS with complications of trisomy 5p (Kleczkowska *et al*. 1987) and 5p deletion syndrome (Vialard *et al*. 2005) in chromosome 5. There are reports on partial monosomy 6q26 (Weimer *et al*. 2006) and subtelomeric deletions of chromosome 6p (Descipio *et al*. 2005) in chromosome 6, and partial trisomy 7q (Chen *et al*. 1996, 2006; Metzke-Heidemann *et al*. 2004) in chromosome 7. There are reports on DWS and partial trisomy 8q (Fan & Siu 2001), and trisomy 8 mosaicism (Nakamura *et al*. 1985) in chromosome 8. There are reports on partial trisomy 3 and partial monosomy 11q (Chen *et al*. 2002), and partial trisomy 11/22 (Katafuchi *et al*. 1990; Dean *et al*. 1991; Chen *et al*. 1996) in chromosome 11. There are cases of DWS with complications of partial monosomy 12q (Chen *et al*. 2006) in chromosome 12, distal trisomy 15q (Ieshima *et al*. 1985) in chromosome 15, chromosome 16 (Aviv *et al*. 2005), chromosome 17 (Kingston *et al*. 1993), and non-mosaic trisomy 20 (Hsieh *et al*. 1992) in chromosome 20. There are cases of DWS associated with trisomy 21 (Constantini *et al*. 1989; Estroff *et al*. 1992). There are cases of DWS associated with partial trisomy 11/22 (Katafuchi *et al*. 1990; Chen *et al*. 1996), and Fryns' syndrome and partial trisomy 11/22 (Dean *et al*. 1991) in chromosome 22. Regarding sex chromosome abnormalities, there are reports of DWS with X monosomy/Turner syndrome (Nyberg *et al*. 1991), X pentasomy, or X-linked inheritance (Cowles *et al*. 1993), autosomal X-linked recessive (Ulm *et al*. 1999), and fragile X syndrome (Klein *et al*. 2003). Regarding chromosome abnormalities with polyploidy, there are triploids (Ulm *et al*. 1997; Blaicher *et al*. 2002) and tetraploids (Nakamura *et al*. 2003). There are three reports of regarding premature chromatid separation with division and DWS (Kajii *et al*. 1998; Kawame *et al*. 1999; Furukawa *et al*. 2003). In addition, there are case reports of DWS complicated by oro–facial–digital syndrome, Ritscher Schinzel (3C: cranio-cerebello–cardiac) syndrome (Descipio *et al*. 2005), Rubinstein–Taybi syndrome (Agarwal *et al*. 2002), Meckel syndrome (Al-Gazali *et al*. 1996), Meckel–Gruber syndrome (Balci *et al*. 2004), Marden–Walker syndrome (Ozkunay *et al*. 1995), distal arthrogryposis type 2B (Pallotta *et al*. 2000), Shah–Waardenberg syndrome (Yoder & Prayson 2002), Fryns' syndrome (Dean *et al*.

1991), neurocutaneous melanosis (Arai *et al*. 2004), callosal agenesis (Klein *et al*. 2003) and neural tube defects (Murray *et al*. 1985; Nyberg *et al*. 1988; Grinberg & Millen 2005).

CONCLUSION

Complications of chromosomal abnormalities in various cases of brain malformation have been reported, and new causative genes have been identified one after another in recent years. As summarized in the present article, many case reports of DWS with complications of chromosomal abnormalities have been published in the past. However, only ZIC1 and ZIC4 genes of chromosome 3q24 have been identified as candidate genes in recent years. It is important to accumulate cases regarding DWS and chromosomal abnormalities because DWS involves cases with complications of various chromosomal abnormalities and malformation syndromes and there is a high possibility that further candidate genes may be identified in other regions in the near future.

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REFERENCES

Agarwal R, Aggarwal R, Kabra M, Deorari AK (2002) Dandy-Walker malformation in Rubinstein–Taybi syndrome: A rare association. *Clin Dysmorphol* **11**: 223–224.

Alanay Y, Aktas D, Utine E *et al.* (2005) Is Dandy-Walker malformation associated with 'distal 13q deletion syndrome'? Findings in a fetus supporting previous observations. *Am J Med Genet A* **136**: 265–268.

Aletebi FA, Fung KF (1999) Neurodevelopmental outcome after antenatal diagnosis of posterior fossa abnormalities. *J Ultrasound Med* **18**: 683–689.

Al-Gazali LI, Abdel Raziq A, Al-Shather W, Shahzadi R, Azhar N (1996) Meckel syndrome and Dandy-Walker malformation. *Clin Dysmorphol* **5**: 73–76.

Altmen NR, Naidichi TP, Braffman BH (1992) Posterior fossa malformations. *AJNR* **13**: 691–724.

Arai M, Nosaka K, Kashihara K, Kaizaki Y (2004) Neurocutaneous melanosis associated with Dandy-Walker malformation and a meningohydroencephalocele. Case report. *J Neurosurg* **100**: 501–505.

Ashwal S (1999) Cerebellar malformations. In: Swaiman KF, Ashwal S (eds). *Pediatric Neurology. Principles and Practice*. Mosby, St. Louis, MO, p. 266.

Aviv H, Wolf R, Edward Davis S, Wallerstein R (2005) Fetus with a de novo supernumerary marker chromosome 16 and Dandy-Walker malformation detected on ultrasound. *Prenat Diagn* **25**: 616–618.

Balci S, Teksen F, Dokmeci F *et al.* (2004) Prenatal diagnosis of Meckel–Gruber syndrome and Dandy-Walker malformation in four consecutive affected siblings, with the fourth one being diagnosed prenatally at 22 weeks of gestation. *Turk J Pediatr* **46**: 283–288.

Benda CE (1954) The Dandy–Walker syndrome or so-called atresia of the foramen Magendie. *J Neuropathol Exp Neurot* **13**: 14–19.

Blaicher W, Ulm B, Ulm MR, Hengstschlager M, Deutinger J, Bernaschek G (2002) Dandy-Walker malformation as sonographic marker for fetal triploidy. *Ultraschall Med* **23**: 129–133.

Bureau YA, Fraser W, Fouquet B (1993) Prenatal diagnosis of trisomy 9 mosaic presenting as a case of Dandy-Walker malformation. *Prenat Diagn* **13**: 79–85.

Cazorla Calleja MR, Verdu A, Felix V (2003) Dandy-Walker malformation in an infant with tetrasomy 9p. *Brain Dev* **25**: 220–223.

Chen CP, Chang TY, Shih JC *et al.* (2002a) Prenatal diagnosis of Dandy-Walker malformation and ventriculomegaly associated with partial trisomy 9p and distal 12p deletion. *Prenat Diagn* **22**: 1063–1066.

Chen CP, Chen CP, Shih JC (2005) Association of partial trisomy 9p and Dandy-Walker malformation. *Am J Med Genet A* **132**: 111–112.

Chen CP, Lin SP, Lin CC *et al.* (2006) Spectral karyotyping and fluorescence in situ hybridization analysis of de novo partial trisomy 7p (7p21.2→pter) and partial monosomy 12q (12q24.33→qter). *Genet Couns* **17**: 57–63.

Chen CP, Liu FF, Jan SW, Yang YC, Lan CC (1996) Prenatal diagnosis of supernumerary der(22)t(11;22) associated with the Dandy-Walker malformation in a fetus. *Prenat Diagn* **16**: 1137–1140.

Chen CP, Tzen CY, Chang TY *et al.* (2002b) Prenatal diagnosis of partial trisomy 3P and partial monosomy 11q in a fetus with a Dandy-Walker variant and trigonocephaly. *Prenat Diagn* **22**: 1112–1113.

Constantini S, Pomeranz S, Hoffman B, Martin O, Rappaport ZH (1989) Coexistence of Dandy–Walker syndrome and Down's syndrome. *Neurochirugia (Stuttg)* **32**: 56–57.

Cowles T, Furman P, Wilkins I (1993) Prenatal diagnosis of Dandy-Walker malformation in a family displaying X-linked inheritance. *Prenat Diagn* **13**: 87–91.

Dandy WE, Blackfan KD (1914) Internal hydrocephalus. An experimental, clinical and pathological study. *Am J Dis Child* **8**: 406–482.

Davis E, Grafe M, Cunniff C, Jones KL, Bogart M (1991) Interstitial deletion of chromosome 2q associated with ovarian dysgenesis. *Clin Genet* **39**: 386–390.

Dean JC, Couzin DA, Gray ES, Lloyd DJ, Stephen GS (1991) Apparent Fryns' syndrome and aneuploidy: Evidence for a disturbance of the midline developmental field. *Clin Genet* **40**: 349–352.

de Azevedo Moreira LM, Neri FB, de Quadrous Uzeda S *et al.* (2005) Multiple congenital malformations including severe eye anomalies and abnormal cerebellar development with Dandy-Walker malformation in a girl with partial trisomy 3q. *Ophthalmic Genet* **26**: 37–43.

Descipio C, Schneider L, Youg TL *et al.* (2005) Subtelomeric deletions of chromosome 6p: Molecular and cytogenetic characterization of three new cases with phenotypic overlap with Ritscher-Schinzel (3C) syndrome. *Am J Med Genet A* **134**: 3–11.

de Souza N, Bingham CJ, Cox T (1994) MRI in cerebellar hypoplasia. *Neuroradiology* **36**: 148–151.

Estroff JA, Scott MR, Benacerraf BR (1992) Dandy-Walker variant: Prenatal sonographic features and clinical outcome. *Radiology* **185**: 755–758.

Fan YS, Siu VM (2001) Molecular cytogenetic characterization of a derivative chromosome 8 with an inverted duplication of 8p21.3→p23.3 and a rearranged duplication of 8q24.13→qter. *Am J Med Genet A* **102**: 266–271.

Furukawa T, Azakami S, Kurosawa H, Ono Y, Ueda Y, Konno Y (2003) Cystic partially differentiated nephroblastoma, embryonal rhabdomyosarcoma, and multiple congenital anomalies associated with variegated mosaic aneuploidy and premature centromere division: A case report. *J Pediatr Hematol Oncol* **25**: 896–899.

Girnberg I, Northrup H, Ardinger H, Prasad C, Dobyns WB, Millen KJ (2004) Heterozygous deletion of the linked genes ZIC1 and ZIC4 is involved in Dandy-Walker malformation. *Nat Genet* **36**: 1053–1055.

Golden JA, Schoene WC (1993) Central nervous system malformation in trisomy 9. *J Neuropathol Exp Neurol* **52**: 71–77.

Grinberg I, Millen KJ (2005) The ZIC gene family in development and disease. *Clin Genet* **67**: 290–296.

Gul A, Cebeci A, Erol O, Ceylan Y, Basaran S, Yuksel A (2005) Prenatal diagnosis of 13q syndrome in a fetus with Dandy-Walker malformation. *Obstet Gynecol* **105**: 1227–1229.

Hannam S, Greenough A, Dawson JM (1999) An unusual presentation of trisomy 9p syndrome with a partial Dandy-Walker malformation. *Eur J Pediatr* **158**: 1012.

Hengstschlager M, Bettelheim D, Drahonsky R, Repa C, Deutinger J, Bernaschek G (2004) Prenatal diagnosis of tetrasomy 9p with Dandy-Walker malformation. *Prenat Diagn* **24**: 623–626.

Hsieh CC, Hsu JJ, Lo LM, Hsieh TT, Soong YK (1992) Non-mosaic trisomy 20 in cultures of amniotic fluid from a fetus with serious congenital malformation. *J Formos Med Assoc* **91**: 543–544.

Hunter AGW, Jimenez C, Tawagi FGR (1991) Familial renal-hepatic-pancreatic dysplasia and Dandy-Walker cyst: A distinct syndrome? *Am J Med Genet* **41**: 247–207.

Ieshima A, Takeshita K, Shirasaka Y, Nakao Y, Kisa T (1985) Distal 15q trisomy with Dandy-Walker malformation in a female infant. *Jinrui Idengaku Zasshi* **30**: 227–232.

Imataka G, Nakagawa E, Kuwashima S, Watanabe H, Yamanouchi H, Arisaka O (2006) Callosal agenesis followed postnatally after prenatal diagnosis: A case report. *Congenit Anom Kyoto* **46**: 160–162.

Imataka G, Nitta A, Suzumura H, Watanabe H, Yamanouchi H, Arisaka O (2007) Survival of trisomy 18 cases in Japan. *Genet Couns* **18**: 303–308.

Imataka G, Takaya Y, Hagisawa S, Yamanouchi H, Eguchi M (2004) Trisomy 11/22 diagnosed by spectral karyotyping. *Genet Couns* **15**: 391–394.

Kajii T, Kawai T, Takumi T *et al.* (1998) Mosaic variegated aneuploidy with multiple congenital abnormalities: Homozygosity for total premature chromatid separation trait. *Am J Med Genet* **78**: 245–249.

Katafuchi Y, Hashino K, Maeno Y *et al.* (1990) Partial trisomy 22 with Dandy-Walker malformation. *Acta Paediatr Jpn* **32**: 566–570.

Kawame H, Sugio Y, Fuyama Y *et al.* (1999) Syndrome of microcephaly, Dandy-Walker malformation, and Wilms tumor caused by mosaic variegated aneuploidy with premature centromere division (PCD): report of a new case and review of the literature. *J Hum Genet* **44**: 219–224.

Kingston HM, Nicolini U, Haslam J, Andrews T (1993) 46,XY/47,XY,+17p+ mosaicism in amniocytes associated with fetal abnormalities despite normal fetal blood karyotype. *Prenat Diagn* **13**: 637–642.

Kleczkowska A, Fryns JP, Moerman P, Vandenberghe K, Van den Berghe H (1987) Trisomy of the short arm of chromosome 5: autopsy data in a malformed newborn with inv dup (5) (p13.1–p15.3). *Clin Genet* **32**: 49–56.

Klein O, Pierre-Kahn A, Boddaert N, Parisot D, Brunelle F (2003) Dandy-Walker malformation: Prenatal diagnosis and prognosis. *Childs Nerv Syst* **19**: 484–489.

Kolomietz E, Godbole K, Winsor EJ, Stockley T, Seaward G, Chitayat D (2005) Functional disomy of Xp: Prenatal findings and postnatal outcome. *Am J Med Genet A* **134**: 393–398.

Kuroki Y, Kurosawa K (2004) No sex differences in 18 trisomy birth in the Kanagawa Birth Defects Monitoring Program. *Congenit Anom Kyoto* **44**: 97–98.

Lee W, Vettraino IM, Comstock CH *et al.* (2005) Prenatal diagnosis of herniated Dandy-Walker cysts. *J Ultresound Med* **24**: 841–848.

McCormack WM Jr, Shen JJ, Curry SM *et al.* (2003) Partial deletions of the long arm of chromosome 13 associated with holoprosencephaly and the Dandy-Walker malformation. *Am J Med Genet* **118**: 384–389.

McDuffie RS Jr. (1994) Complete trisomy 9: case report with ultrasound findings. *Am J Perinatol* **11**: 80–84.

Melaragno MI, Brunoni D, Patricio FR *et al.* (1992) A patient with tetrasomy 9p, Dandy-Walker cyst and Hirschsprung disease. *Ann Genet* **35**: 79–84.

Metzke-Heidemann S, Kuhling-von Kaisenberg H, Caliebe A *et al.* (2004) Phenotypical variation in cousins with the identical partial trisomy 9 (pter-q22.2) and 7 (q35-pter) at 16 and 23 weeks gestation. *Am J Med Genet A* **126**: 197–203.

Murray JC, Johnson JA, Bird TD (1985) Dandy-Walker malformation: Etiologic heterogeneity and empiric recurrence risks. *Clin Genet* **28**: 272–283.

Murru P, Coscia A, Martano C *et al.* (2002) Complex cerebral malformation including Dandy-Walker in a newborn with trisomy 9 mosaicism. *Radiol Med (Torino)* **103**: 261–263.

Nakamura Y, Nakashima H, Fukuda S, Hashimoto T, Maruyama M (1985) Bilateral cystic nephroblastoma and multiple malformations with trisomy 8 mosaicism. *Hum Pathol* **16**: 754–756.

Nakamura Y, Takaira M, Sato E, Kawano K, Miyoshi O, Niikawa N (2003) A tetraploid liveborn neonate: Cytogenic and autopsy findings. *Arch Pathol Lab Med* **127**: 1612–1614.

Nyberg DA, Cyr DR, Mack LA, Fitzsimmons J, Hickok D, Mahony BS (1988) The Dandy-Walker malformation prenatal sonographic diagnosis and its clinical significance. *J Ultrasound Med* **7**: 65–71.

Nyberg DA, Mahony BS, Hegge FN, Hickok D, Luthy DA, Kapur R (1991) Enlarged cisterna magna and the Dandy-Walker malformation: Factors associated with chromosome abnormalities. *Obestet Gynecol* **77**: 436–442.

Ounap K, Ilus T, Bartsch O (2005) A girl with inverted triplication of chromosome 3q25.3→q29 and multiple congenital anomalies consistent with 3q duplication syndrome. *Am J Med Genet A* **134**: 434–438.

Ozkunay F, Ozyurek AR, Bakiler AR *et al.* (1995) A case of Marden–Walker syndrome with Dandy-Walker malformation. *Clin Genet* **47**: 221–223.

Pallotta R, Ehresmann T, Fusilli P (2000) Occurrence of Dandy-Walker anomaly in a familial case of distal arthogryposis type 2B. *Am J Med Genet* **95**: 477–481.

Patacchiola F, Carta G, Iovenitti P *et al.* (1999) Apropos of a case of Dandy–Walker syndrome associated with chromosome abnormalities. *Minerva Ginecol* **51**: 95–98.

Poot M, Kroes HYVD, Wijst SE *et al.* (2007) Dandy-Malker complex in a boy with a 5 Mb deletion of region 1q44 due to paternal t (1; 20) (q44; q13.33). *Am J Med Genet A* **143**: 1038–1044.

Rasmussen SA, Wong LY, Yang Q, May KM, Friedman JM (2003) Population-based analysis of mortality in trisomy 13 and trisomy 18. *Pediatrics* **111**: 777–784.

Reece EA, Goldstein I, Pilu G, Hobbins JC (1987) Fetal cerebellar growth unaffected by intrauterine growth radiation: A new parameter for prenatal diagnosis. *Am J Ovstet Gynecol* **157**: 632–638.

Sepulveda W, Wimalasundera RC, Taylor MJ, Blunt S, Be C, De La Fuente S (2003) Prenatal ultrasound findings in complete trisomy 9. *Ultrasound Obstet Gynecol* **22**: 479–483.

Sudha T, Dawson AJ, Prasad AN, Konkin D, de Groot GW, Prasad C (2001) De novo interstitial long arm deletion of chromosome 3 with facial dysmorphism, Dandy-Walker variant malformation and hydrocephalus. *Clin Dysmorphol* **10**: 193–196.

Taggart JK Jr, Walker AE (1942) Congenital atresia of the foramens of Luschka and Magendie. *Arch Neurol Psychiatry* **48**: 583–612.

Tarani L, Colloridi F, Raguso G *et al.* (1994) Trisomy 9 mosaicism syndrome. A case report and review of the literature. *Ann Genet* **37**: 14–20.

Teksam M, Ozyer U, McKinney A, Kirbas I, Cakir B (2005) Fetal MRI of a severe Dandy-Walker malformation with an enlarged posterior fossa cyst causing severe hydrocephalus. *Fetal Diagn Ther* **20**: 524–527.

Thurmond AS, Nelson DW, Lowsensohn RI, Young WP, Davis L (1989) Enlarged cisterna magna in trisomy 18: Prenatal ultrasonography. *Am J Obstet Gynecol* **161**: 83–85.

Titomanlino L, Pierri NB, Romano A *et al.* (2005) Cerebeller vermis aplasia: Patient report and exclusion of the candidate genges EN2 and ZIC1. *Am J Med Genet A* **136**: 198–200.

Ulm B, Ulm MR, Deutinger J, Bernaschek G (1997) Dandy-Walker malformation diagnosed before 21 weeks of gestation: Associated malformations and chromosomal abnormalities. *Ultrasound Obstet Gynecol* **10**: 167–170.

Ulm B, Ulm MR, Deutinger J, Bernaschek G (1999) Isolated Dandy-Walker malformation: Prenatal diagnosis in two consecutive pregnancies. *Am J Perinatol* **16**: 61–63.

Vialard F, Robyr R, Hillion Y, Molina Gomes D, Selva J, Ville Y (2005) Dandy–Walker syndrome and corpus callosum agenesis in 5p deletion. *Prenat Diagn* **25**: 311–313.

von Kaisenberg CS, Caliebe A, Krams M, Hackloer BJ, Jonat W (2000) Absence of 9q22–9qter in trisomy 9 does not prevent a Dandy-Walker phenotype. *Am J Med Genet* **95**: 425–428.

Waters BL, Allen EF, Gibson PC, Johnston T (1993) Autopsy findings in a severely affected infant with a 2q terminal deletion. *Am J Med Genet* **47**: 1099–1103.

Weimer J, Cohen M, Wiedemann U, Heinrich U, Jonat W, Arnold N (2006) Proof of partial imbalances 6q and 11q due to maternal complex balanced translocation analyzed by microdissection of multicolor labeled chromo-

somes (FISH-MD) in a patient with Dandy-Walker variant. *Cytogenet Genome Res* **114**: 235–239.
Wells SR, Kuller JA, Rao KW, Aylsworth AS (1996) Multiple congenital malformations in an infant prenatally diagnosed with mosaicism for dup (1q) and del (Xq). *Clin Genet* **49**: 216–219.
Yoder BJ, Prayson RA (2002) Shah–Waardenburg syndrome and Dandy-Walker malformation: An autopsy report. *Clin Neuropathol* **21**: 236–240.
Zacharias S, Nazer J, Lacassie I, Ibarra A, Valencia JM (1983) Prenatal diagnosis of the Dandy–Walker syndrome associated with partial trisomy of chromosome 9. *Rev Chil Obstet Ginecol* **48**: 414–418.
Zhang WS, Tan JX, Yue SJ (2004) A case of Dandy-Walker malformation futus and 18-trisomy. *Zhong Nan Da Xue Xue Bao Yi Xue Ban* **29**: 10.