

IMAGING TECHNIQUES

M. Petjak · M. M. C. Tiel-van Buul · C. R. Staalman
J. C. Greve · J. de Kraker · E. A. van Royen

Diagnostic imaging in abdominal neuroblastoma: Is there a complementary role of MIBG-scintigraphy and ultrasonography?

Received: 2 August 1996 and in revised form: 8 November 1996 / Accepted: 18 November 1996

Abstract In a retrospective study we evaluated the agreement between the results of meta-iodo benzylguanidine (MIBG) scintigraphy and abdominal ultrasonography (US) in the diagnosis and follow up of neuroblastoma (NBL) with respect to the abdominal region. Data of 28 consecutive paediatric patients with NBL or suspected NBL were included (16 M/12 F, mean age 2.9 years, range 3 weeks – 13.4 years). The results (as judged by the nuclear physician or radiologist, respectively) of 60 MIBG examinations (^{123}I and ^{131}I , including 26 single photon emission computed tomography (SPECT)) and US, respectively, performed within a period of 14 days, could be evaluated. Full agreement was reached in 37 comparisons (62%), while partial and no agreement was found in 17 (28%), and 6 (10%) comparisons, respectively. In 8 out of 37 comparisons with full agreement, 12 diagnosed lesions were histopathologically proven, while 11 comparisons with negative findings were also negative in other clinical modalities. US diagnosed correctly in 68% of the histopathological proven lesions, while this was 54% for MIBG scintigraphy. In approximately 50% of the MIBG scans in which SPECT was available, SPECT provided significant additional information.

Conclusion Congruent results of MIBG scintigraphy and ultrasonography in the detection of abdominal lesions in patients with suspected neuroblastoma indicate a high reliability in the diagnosis and localisation. Due to the favourable results of additional SPECT, it is advisable to perform SPECT routinely in this diagnosis.

Abbreviations NBL neuroblastoma · MIBG meta-iodobenzylguanidine · SPECT single photon emission computed tomography

Introduction

Neuroblastoma is the most common solid tumour of infancy and the most common extracranial solid tumour of childhood. It is a typical tumour of embryonal tissue, usually arising from the adrenal (medulla), or paravertebral sympathetic nervous system and localized most frequently in the abdomen [8, 27, 29]. Symptoms or signs of neuroblastoma are often vague [19]. Approximately 50% of infants and 70% of children above the age of 1 year have metastases at the time of diagnosis. It is still controversial whether mass screening in infants can improve the prognosis of the disease. Being supported by some [13, 22, 33], (especially early) neuroblastoma screening faces scepticism by others [5, 6, 10, 14] due to the embryonic origin of the tumour paralleling with heterogeneous biologic features and clinical behaviour.

In the imaging of neuroblastoma, radiolabelled meta-iodobenzylguanidine (MIBG) scintigraphy has been regarded particularly useful in distinguishing residual active tumour from masses composed of scar tissue [34]. Using ^{123}I or ^{131}I MIBG imaging, remote disease can be detected in one examination procedure [25]. Early ^{123}I MIBG images do have superior spatial resolution and counting statistics than can be obtained by ^{131}I MIBG [2, 28]. In patients presenting with liver lesions which are not conclusive on ultrasonography, CT or MRI, delayed

M. Petjak · M. M. C. Tiel-van Buul (✉) · J. C. Greve
E. A. van Royen
Academic Medical Centre, Department of Nuclear Medicine,
Meibergdreef 9, 1105 AZ Amsterdam, The Netherlands
Tel: +31 20-566 3572; Fax: +31 20-697 6508

C. R. Staalman
Department of Radiodiagnostics, Academic Hospital University of
Amsterdam, Amsterdam, The Netherlands

J. de Kraker
Department of Paediatric Oncology, Academic Hospital University
of Amsterdam, Amsterdam, The Netherlands

tumour visualisation can be obtained using ^{131}I MIBG [17, 28]. Additional single photon emission computed tomography (SPECT) seems to improve the certainty of interpretation of the MIBG scan [11].

Ultrasonography (US) is generally accepted as initial screening procedure in the imaging of neuroblastoma to assess the extent of the disease at the time of diagnosis and during follow up [8, 21]. Despite variations in its sonographic appearance, the specific sonographic feature of neuroblastoma could be a distinctive 'lobule' of increased echogenicity in part of the larger mass [1]. In neonates, US can depict intraspinal components of neuroblastoma [30]. Presently, there is also a role for US in the prenatal diagnosis of neuroblastoma [12, 18, 19, 23, 24, 26, 32]. Difficulties occasionally occur in the differential diagnosis of nephroblastoma (Wilms tumour) [8, 27, 30]. A recent study [15] reported an identification of the primary site in 96% of the NBL cases using abdominal US, and an 84% concordance between their US grading of neuroblastoma and the clinico-pathological staging.

In this study, we analysed the agreement between the results of MIBG scintigraphy and US in the evaluation of children with abdominal neuroblastoma. Furthermore, the value of additional SPECT for the interpretation of the MIBG scan was evaluated.

Patients and methods

Patients

Data of 28 consecutive paediatric patients with neuroblastoma or suspected neuroblastoma who were referred to the Paediatric Oncology Department of the Academic Medical Centre (AMC), Amsterdam, the Netherlands between January 1993 and July 1995, were included in the study. There were 16 male and 12 female with a mean age of 2.9 years (range 3 weeks – 13.4 years). In 22 patients, neuroblastoma was histologically proven, ganglioneuroblastoma in 5 patients, and ganglioneuroma in 1 patient. All patients underwent ^{131}I or ^{123}I MIBG-scintigraphy (whole body and/or SPECT) and US. In each patient, one to four MIBG scans and also one to four ultrasonographic studies were obtained with a mean of 2.46 MIBG scans and 2.25 US, respectively.

MIBG-scintigraphy

Thyroid iodine uptake was previously blocked using a saturated solution of potassium iodide (100 mg/day per os, starting 1 day before tracer administration for a period of 3 days (^{123}I) or 7 days (^{131}I)). In diagnostic studies, the intravenously administered dose was adjusted for length and weight, varying from 74–186 MegaBecquerels (2–5 mCi) for ^{123}I MIBG, and 18–74 MBq (0.5–2 mCi) for ^{131}I MIBG. Anterior and posterior whole body scans were obtained at 24 and 48 h in case of ^{123}I MIBG. In ^{131}I MIBG studies, whole body images and uptake measurement were obtained after 48 h, at the 3rd day, 5th day, and eventually (follow up of the liver) 7th and 9th day, respectively. The tumour MIBG uptake, corrected for background, 24 and 48 h p.i. of ^{123}I MIBG or 48 and 72 h p.i. of ^{131}I MIBG, was calculated by geometric mean, and expressed as a percentage of the injected dose. Whole body scans were obtained with a large field-of-view gamma camera (Siemens body scan dual head) equipped with a high energy collimator for ^{131}I MIBG scans, or medium energy collimator for ^{123}I MIBG

scans, using a 512×256 matrix and a 20% window centered at a photopeak setting of 364 and 159 keV, respectively.

SPECT was obtained, only if indicated, at 24 h and/or 48 h post-injection with a triple headed gamma camera (Siemens).

US-imaging

US studies of upper abdominal region and urogenital tract, provided by the department of paediatric radiology, were performed by means of multi planar imaging using an ALOKA SSD 650 CLII scanner with 5.0 and 7.5 MHz real-time transducers.

Imaging analysis

A total of 132 examinations and their initial reports were selected for retrospective analysis: 69 MIBG-scintigrams (48 ^{123}I MIBG and 21 ^{131}I MIBG) and 63 US studies. In 31 out of the 69 MIBG-scintigrams, additional SPECT had been performed (27 with ^{123}I MIBG, 4 with ^{131}I MIBG). A direct comparison between the results of the two diagnostic modalities could be made in 60 examination pairs, since they had been performed in the same patient within a period of 14 days. MIBG and US findings in all 132 examinations were independently reviewed by an experienced nuclear physician and paediatric radiologist, respectively. The panel gave also an opinion about the additional value of SPECT, compared to planar images alone.

The images were judged as positive or negative if abdominal tumour masses were clearly present or absent, respectively. The result was called doubtful if the investigator was unsure about the result, or if artificial or technical problems impeded reliable judgement. Full agreement was achieved if both methods were positive on the same localisations, or if they agreed to be negative. Partial agreement was reached if both methods were not unanimous about the localisation of the pathology; or, if one of the two methods was doubtful. No agreement was concluded if one of the two methods was interpreted as negative for the whole abdominal region, while the other was positive.

Analysis of results

The results of both diagnostic methods, as judged by the attending nuclear physician and radiologist, respectively, were used for the evaluation of agreement. Outcome of agreement was measured in all 60 examination pairs. Furthermore, the outcome of agreement was compared in 14 patients (15 examination pairs) in which histological results after biopsy or surgery within one month after diagnostic imaging were available.

The grade of echogenicity of the primary tumour or metastases on US, the grade of tumour differentiation based on pathological findings after surgery and the (grade of) uptake of corresponding (neuroblastoma) tumour lesions in MIBG scintigraphy were compared in 13 neuroblastoma lesions.

In 11 patients, the tumour MIBG uptake was calculated and compared with tumour size measurements (in three dimensions) in cm obtained by US.

Results

The results of the 60 comparisons between MIBG scintigraphy and US with regard to the detection and localisation of suspected abdominal neuroblastoma lesions are shown in Table 1. Full agreement between the two imaging methods was found in 37 comparisons, 26 with pathology, and 11 without pathology. All 11 patients without pathology on both imaging methods were

Table 1 Results of agreement between MIBG scintigraphy and ultrasonography

Agreement (comparisons)	Full agreement		Partial agreement	No agreement
	Positive	Negative		
¹²³ I MIBG versus US	15	11	14	4
¹³¹ I MIBG versus US	11	0	3	2
Totals	26	11	17	6

also negative by other clinical parameters (physical examination, blood chemistry, vanillylmandelic acid in the urine, CT or MRI). In 8 out of the 26 “pathological” comparisons, surgery and histopathology were available. In all eight comparisons (in eight patients), a total of 12 lesions seen by US and scintigraphy could be confirmed, while six other lesions had not been detected by both methods. Figure 1 shows the posterior ¹³¹I MIBG scan of a male of 10 months old, in which pathological MIBG uptake was reported in the region left paravertebral T10-L2. US diagnosed a tumour in the same area. This was proven by histopathology. Partial agreement was reached in 17 comparisons. In six comparisons (in five patients), 18 tumour lesions could be histopathologically proven, of which 12 were diagnosed correctly with US and 8 with MIBG scintigraphy. In one child, pathological lymph nodes were suspected on US examination, which could not be confirmed at surgery, while MIBG was true negative. Figures 2 and 3 show two patients in which partial agreement was reached. No agreement was found in six comparisons, of which US in one of the patients was correct in one histopathological proven lesion. Figure 4 shows the ¹²³I MIBG scan and US of an 8-year-old girl in which the MIBG scan was completely negative, while the US diagnosed a large tumour in the right ovarian region. This was histopathologically confirmed as neuroblastoma.

In summary, out of the 37 histopathologically proven lesions in 14 patients who underwent surgery within one month after the examinations, MIBG scintigraphy diagnosed correctly 20 (54%) of them, while US detected 25 (68%) of the lesions (Table 2).

According to the opinion of the panel, 12 out of 26 SPECTs had significant additional value to planar images: seven SPECTs had a decisive role in the degree of agreement, of which two were positive on SPECT, while negative or doubtful on planar whole body scintigraphy, and five showed a higher number of detectable lesions, compared to the planar images. Another 5 out of the 26 SPECTs contributed considerably to the topographic information of the lesions.

Eight out of nine hyperechoic lesions (89%) were based on undifferentiated neuroblastoma, while in three out of four hypoechoic lesions (75%) were histopathologically recognized as neuroblastoma with various extents of ganglionic differentiation. Two out of the three cases of differentiated neuroblastoma did not show pathological MIBG-uptake at all. Another two patients demonstrated conversion of hyperechoic into hypoechoic lesions on serial sonograms, while there were clinical signs of spontaneous tumour regression in one

and therapy induced tumour regression in the other case, respectively.

The tumour MIBG uptake after 24 h (seven patients) and 48 h (four other patients) after tracer administration was mean 2.5% (range 0.02%–9.9%) and 7.52% (range 0.7%–26%), respectively. Ultrasonographically obtained tumour diameters were mean 5.1 cm (range 1–16 cm). No correlation could be found between MIBG uptake and ultrasonographically measured tumour size.

Discussion

In the diagnostic management of a child with suspected neuroblastoma, US is currently the most frequently used imaging modality because of its non-invasiveness [8, 21]. There is no doubt about its suboptimal position with respect to CT and/or MRI in the assessment of the extent of disease at any clinical condition [4, 27, 31]. On the other hand, the role of radionuclide MIBG scintigraphy, showing vital neuroblastoma tissue sensitively and selectively, is increasing, not only for the diagnosis and staging, but also for the follow up of the therapy [4, 16].

In this study, we compared retrospectively the results of abdominal ultrasonography and ¹²³I or ¹³¹I MIBG scintigraphy in 60 examination pairs, performed in 28 consecutive paediatric patients who were suspected for (abdominal) neuroblastoma. In 62% of the comparisons, full agreement between the two methods was reached. All 11 negative patients were clinically proved to be true negative. It was also found that in this group, in 12 histopathologically proven lesions in 8 patients, both diagnostic methods demonstrated corresponding findings, while six other lesions were missed by both methods. These six missed lesions were not relevant to the clinical pathological status of the patients and had therefore no therapeutical consequences. Thus, a similar result of US and MIBG scintigraphy seems to be reliable in diagnosing and locating abdominal lesions of neuroblastoma.

Partial and no agreement were found in a total of 38% comparisons. Out of the 19 histopathological proven lesions, 13 were true positive with US, and 8 with MIBG scintigraphy. None of the 19 lesions were missed by one of the two method, suggesting a complementary role of both imaging methods. A reason for disagreement was for instance the difficulty of the interpretation of the adrenal region in planar MIBG scintigraphy if there was physiological adrenal uptake or overprojection of physiological liver uptake (four comparisons)

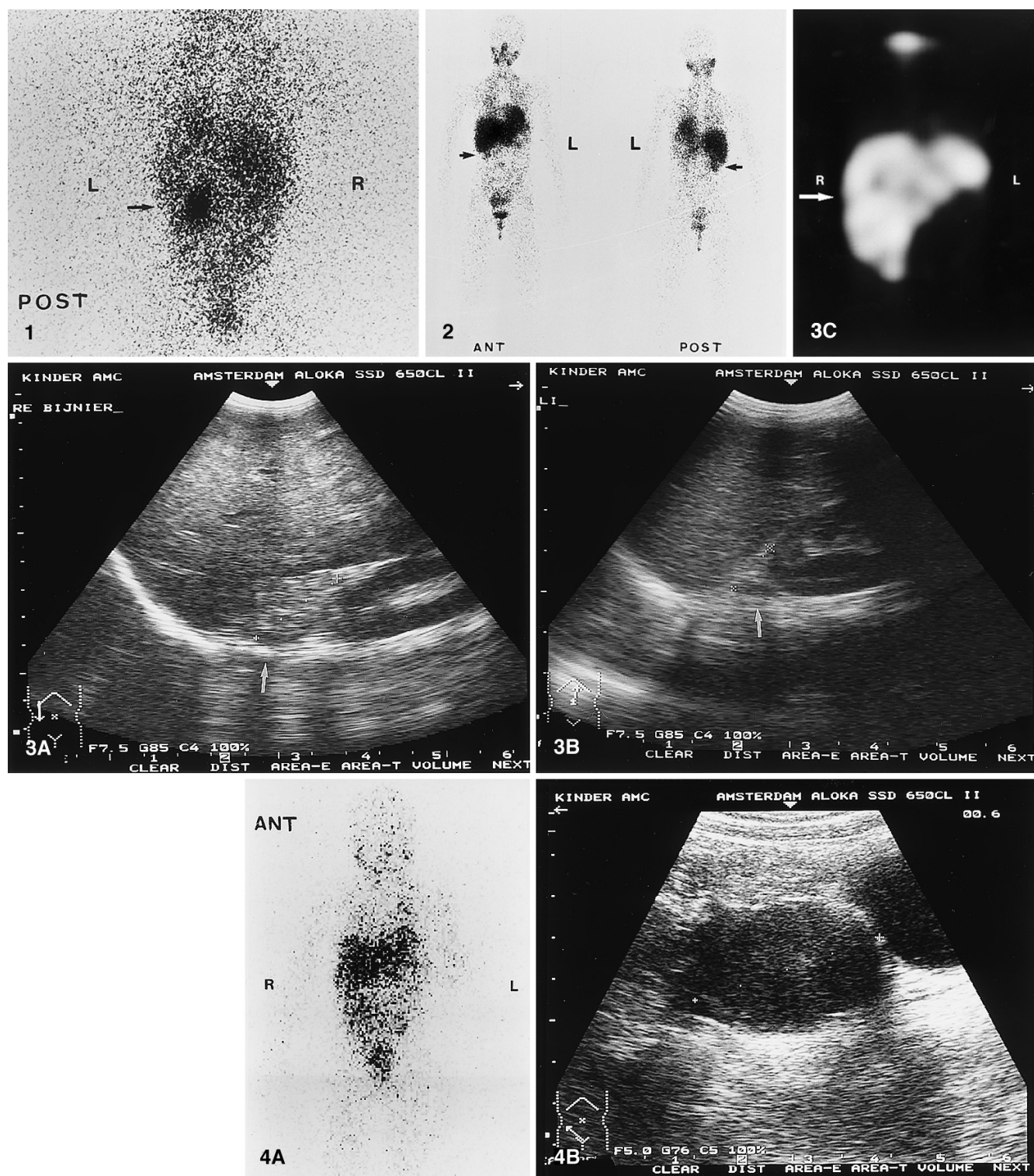


Fig. 1 Posterior ^{123}I MIBG scan of a 10-month-old male, with an abdominal hot spot left paramedian (arrow) in which US agreed with the diagnosis of a tumour left paravertebral T10-L2

Fig. 2 ^{123}I MIBG scan, anterior and posterior, in which the right adrenal was diagnosed as positive for neuroblastoma (arrow). US was negative. At surgery, the right adrenal had a normal aspect

Fig. 3 US of a male of 9 months old, with ultrasonographically enlarged adrenals, (A) right adrenal 3.2 cm (also: liver echogenicity is

inhomogenous and increased in some areas of the liver) (B) left adrenal 1.2 cm, both suspected for tumour. (C) Coronal slice of ^{123}I MIBG SPECT with high pathological uptake in the enlarged liver and right adrenal (overprojection), while the left adrenal region was interpreted as normal. At surgery, the left adrenal was indeed negative

Fig. 4 A ^{123}I MIBG whole body scan of an 8-year-old girl, which was interpreted as normal. **B** US of the small pelvis with a large hypoechoic solid mass in the right adnexal region, sized $4 \times 3 \times 3$ cm. A neuroblastoma was histopathologically confirmed

Table 2 Agreement between MIBG scintigraphy and US in histopathologically proven lesions

Agreement	No. of lesions proven by histopathology	No. of lesions detected by	
		MIBG scintigraphy	US
Full	18	12	12
Partial	18	8	12
None	1	—	1
	37	20	25

[27, 30]. Especially after surgery of a suprarenal neuroblastoma, intense uptake may be found in the remnant non-tumorous adrenal medulla due to functional compensation (hyperplasia) which leads to increased uptake of the radiolabelled MIBG [3, 25]. With US, the interpretation of the adrenal glands in children under the age of 1 year seems to be difficult, because of the difference in (physiological) volume of the adrenals (left > right in two instances), and also because the echogenicity changes from hyperechoic in younger children to hypoechoic above the age of 1 year due to the disappearance of fibrous tissue [20]. Planar MIBG scintigraphy may miss pathological lymph node metastases (three instances) [23, 25]. On the other hand, pathological lymph nodes can be false positively suspected on US examination which can be explained by reactive and inflammatory mechanisms due to (tumour) disease (one instance). Controversely, the interpretation of US is easier if pathological lymph nodes involved by neuroblastoma are calcified [27]. Spleen infiltration, suggested by MIBG scintigraphy in two of our patients, is generally unusual in neuroblastoma, while massive hepatomegaly, secondary to tumour infiltration, might simulate spleen involvement, especially in children with stage IVs disease younger than 6 months [7]. A false-negative MIBG scan may occur in a patient with liver involvement if ^{123}I MIBG is used (one instance) [9]. Although there is no characteristic sonographical appearance of metastatic disease in the liver, US seems to be superior to MIBG scintigraphy in this matter [27, 35].

In approximately 50% of the MIBG scans in which SPECT was available, SPECT provided significant additional information by means of the visualisation of a higher number of lesions and/or improvement of the topographic information of the lesions. Therefore, it seems to be advisable to perform abdominal MIBG SPECT routinely in the diagnosis and follow up of neuroblastoma. This is contradictory to the statement of Gelfand et al. [11] that ^{123}I MIBG-SPECT does not increase the number of lesions detected in the torso compared with the results of planar imaging.

In conclusion, in the diagnostic management of patients with suspected or known abdominal localisations of neuroblastoma, full agreement between US and MIBG scintigraphy indicates a high reliability in diagnosing and localising abdominal neuroblastoma. In 50% of the MIBG scans in which SPECT was available, a

higher number of lesions could be found or an improvement of the topographic information of the lesions was reached. Routinely performance of additional MIBG SPECT and combined judgement of both imaging modalities may therefore improve the accuracy of the diagnostic procedure.

References

- Amundson GM, Trevenen CL, Mueller DL, Rubin SZ, Wessenberg RL (1987) Neuroblastoma: a specific sonographic tissue pattern. *Am J Roentgenol* 148:943–945
- Bomanji J, Levinson DA, Flatman WD, Horne T, Bouloux PM, Ross G, Britton KE, Besser GM (1987) Uptake of iodine-123 MIBG by pheochromocytomas, paragangliomas, and neuroblastomas: a histopathological comparison. *J Nucl Med* 28:973–978
- Bonnin F, Lumbroso J, Tenenbaum F, Hartmann O, Parmen-tier C (1994) Refining interpretation of MIBG scans in children. *J Nucl Med* 35(5):803–810
- Brodeur GM, Pritchard J, Berthold F, Carlsen NL, Castel V, Castelberry RP, De Bernardi B, Evans AE, Favrot M, Hedborg F (1993) Revisions of the international criteria for neuroblastoma diagnosis, staging and response to treatment. *J Clin Oncol* 11(8):1466–1477
- Carlsen NL (1992) Neuroblastoma: epidemiology and pattern of regression. Problems in interpreting results of mass screening. [Review] *Am J Pediatr Hematol Oncol* 14(2):103–110
- Craft A, Parker L (1992) Poor prognosis neuroblastoma: is screening the answer? *Br J Cancer [Suppl]* 18:S96–101
- De Bernardi B, Pianca C, Boni L, Brisigotti M, Carli M, Bag-nulo S, Corciulo P, Mancini A, De Laurentis C, Di Tullio MT (1992) Disseminated neuroblastoma (stage IV and IV-S) in the first year of life, outcome related to age and stage. *Cancer* 70(6):1625–1633
- Dershaw DD, Helson L (1988) Sonographic diagnosis and follow-up of abdominal neuroblastoma. *Urol Radiol* 10:80–84
- Dessner, DA, Dipietro MA, Shulkin BL (1993) MIBG detection of hepatic neuroblastoma: correlation with CT, US and surgical findings. *Pediatr Radiol* 23:276–280
- Esteve J, Parker L, Roy P, Hermann F, Duffy S, Frappaz D, Lasset C, Hill C, Sancho-Garnier H, Michaelis J (1995) Is neuroblastoma screening evaluation needed and feasible? *Br J Cancer* 71(6):1125–1131
- Gelfand MJ, Elgazzar AH, Kriss VM, Masters PR, Golsch GJ (1994) Iodine-123 MIBG SPECT versus planar imaging in children with neural crest tumors. *J Nucl Med* 35:1753–1757
- Goldstein I, Gomez K, Copel JA (1994) The real-time and color Doppler appearance of adrenal neuroblastoma in a third-trimester fetus. *Obstet Gynecol* 83(5 Pt 2):854–856
- Hachitani Y, Ishimoto K, Hata J, Shimada H (1994) One hundred neuroblastomas detected through a mass screening system in Japan. *Cancer* 74(12):3223–3226
- Hayashi Y, Ohi R, Yaoita S, Nakamura M, Kikuchi Y, Konno T, Tsuchiya S, Shiraishi H (1995) Problems of neuroblastoma screening for 6 month olds and results of second screening for 18 month olds. *J Pediatr Surg* 30(3):467–470
- Hirata T, Tataru H, Zaizen Y, Suita S, Matsuzaki A, Ueda K (1995) Role of ultrasound in managing neuroblastoma detected by mass screening: a proposed ultrasonographic grading for children with neuroblastoma. *J Clin Ultrasound* 23(5):305–313
- Hoefnagel CA (1994) Metaiodobenzylguanidine and somato-statin in oncology of fetal adrenal neuroblastoma. *J Clin Ultrasound* 14:225–227
- Hoefnagel CA, Voûte PA, De Kraker J, Marcuse HR (1985) Total-body scintigraphy with ^{131}I Meta-Iodobenzylguanidine for detection of neuroblastoma. *Diagn Imag Clin Med* 54:21–27
- Jaffa AJ, Many A, Hartoov J, Kupfermanc J, Peyser MR (1993) Prenatal sonographic diagnosis of metastatic neuroblastoma:

- report of a case and review of the literature. [Review] *Prenat Diagn* 13(1):73–77
19. Jennings RW, LaQuaglia MP, Leong K, Hendren WH, Adzick NS (1993) Fetal neuroblastoma: prenatal diagnosis and natural history. *J Pediatr Surg* 28(9):1168–1174
 20. Kangarloo H, Diamant MJ, Gold RH, Barrett C, Lippe B, Geffner M, Boechat MI, Dietrich RB, Amundson GM (1986) Sonography of adrenal glands in neonates and children: changes in appearance with age. *J Clin Ultrasound* 14:43–47
 21. Kangarloo H, Fine RN (1985) Sonographic evaluation of children with urinary retention caused by an extragonadal pelvic mass. *Int J Pediatr Nephrol* 6:137–142
 22. Kusafuka T, Nagahara N, Oue T, Imura K, Nakamura T, Kobayashi Y, Komoto Y, Fukuzawa M, Okada A, Nakayama M (1995) Unfavourable DNA ploidy and Haras p21 findings in neuroblastomas detected through mass screening. *Cancer* 76(4):695–699
 23. Lastoria S, Maurea S, Caraco C, Vergara E, Maurelli L, Indolfi P, Casale F, Di Tullio MT, Salvatore M (1993) Iodine-131 metaiodobenzylguanidine scintigraphy for localization of lesions in children with neuroblastoma: comparison with computed tomography and ultrasonography. *Eur J Nucl Med* 20(12):1161–1167
 24. Liyanage IS, Katoch D (1992) Ultrasonic prenatal diagnosis of liver metastases from adrenal neuroblastoma. *J Clin Ultrasound* 20(6):401–403
 25. Lumbroso JD, Guermazi F, Hartmann O, Coornaert S, Rabarison Y, Leclere JG, Couanet D, Bayle C, Caillaud JM, Lemerle J (1988) Metaiodobenzylguanidine (MIBG) scans in neuroblastoma: sensitivity and specificity, a review of 115 scans. *Prog Clin Biol Res* 271:689–705
 26. Martinez-Mora J, Castellvi A, Coroleu W, Isnard R, Javier G, Lopez P, Montserrat E, Natal A, Ojanguren J, Orazabal A (1995) Cystic adrenal neuroblastoma: prenatal diagnosis by ultrasonography [clinical conference]. *Med Pediatr Oncol* 24(2):109–115
 27. Ng YY, Kingston JE (1993) The role of radiology in the staging of neuroblastoma. *Clin Radiol* 47:226–235
 28. Paltiel HJ, Gelfand MJ, Elgazzar AH, Washburn LC, Harris RE, Masters PR, Grolsch GJ (1994) Neural crest tumors: ¹²³I MIBG imaging in children. *Radiology* 190:117–121
 29. Parisi MT, Matthay KK, Huberty JP, Hattner RS (1992) Neuroblastoma: dose-related sensitivity of MIBG scanning in detection. *Radiology* 184:463–467
 30. Patel RB (1985) Sonographic diagnosis of intraspinal neuroblastoma. *J Clin Ultrasound* 13:565–569
 31. Petrus LV, Hall TR, Boechat MI, Westra SJ, Curran JG, Steckel RJ, Kangarloo H (1992) The pediatric patient with suspected adrenal neoplasm: which radiological test to use? *Med Pediatr Oncol* 20(1):53–57
 32. Rubenstein SC, Benacerraf BR, Retik AB, Mandell J (1995) Fetal suprarenal masses: sonographic appearance and differential diagnosis. *Ultrasound Obstet Gynecol* 5(3):164–167
 33. Sawada T (1992) Past and future of neuroblastoma screening in Japan. *Am J Pediatr Hematol Oncol* 14(4):320–326
 34. Voûte PA, Hoefnagel CA, Marcuse HR, Kraker J de (1985) Detection of neuroblastoma with ¹³¹I-meta-iodobenzylguanidine. In: Evans AE, D'Angio GJ, Seeger RC (eds) *Advances in neuroblastoma research*. Liss, New York, pp 389–398
 35. White SJ, Stuck KJ, Blane CE, Silvern TM (1983) Sonography of neuroblastoma. *Am J Roentgenol* 141:465–468