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The use of ultrasonography in developmental dysplasia of the hip

Gelişimsel kalça displazisinde ultrasonografi

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Kalça ultrasonografisi (USG), muayene yöntemlerinin değişmesine bağlı olarak Avrupa ve ABD'de farklı biçimde değerlendirilmektedir. Bu yüzden, sonuçlar da farklılık göstermektedir. Avusturya, İsviçre, Almanya ve diğer ülkelerde uygulanan yöntem, kesin kurallarla stardarda bağlanmış, yenilenebilir, deneyim ve yetenekten bağımsızlaştırılmış bir yöntemdir. Avusturya'da kalçaya açık redüksiyon uygulama oranı 0.13/1000 canlı doğuma düşürülmüştür. Bu oran Almanya'da 0.26/1000'dir. Bunlar, tüm dünyada bildirilen en düşük oranlardır. Sonografi öncesi döneme göre masraflar da üç kat azalmıştır. Bu gelişmelerin nedeni, eğitimin deneyimli kişiler tarafından verilmesi, USG incelemesinin doğumdan sonraki altı hafta içinde yapılması ve tedavinin sonografi tiplerine göre planlanmasıdır.

Approach to hip sonography in Europe differs considerably from that in the USA, with different examination techniques and, therefore, discrepant results. The method used in Austria, Switzerland, Germany, and other countries is strictly standardized, reproducable, and out of the experience and skill of the examiner. Open reductions have been reduced to 0.13/1000 newborn babies in Austria, and to 0.26/1000 in Germany. This is the lowest rate which ever has been reported in the world. Costs for screening and treatment are three times lower than in the presonography era. These improvements result from training given by authorized teachers, implementation of ultrasonography screening program within the first six weeks of life, and planning treatment according to the sonography types.

Congenital hip dysplasia (CDH) is known since early times and it's chracteristics have already been described by Hippocrates. The efforts to establish the earliest possible diagnosis and adequate early stage therapy as well as recommendations for their accomplishment are predominant throughout the history of pediatrics and orthopaedics. The consequences of an undiagnosed dislocated hip are horrendous for the babies. In spite of adequate therapy a late diagnosis usually leads to lasting damages and in many cases to pre-osteoarthritis.

According to estimates 10% of inserted hip joint endoprostheses which are currently being implanted are due to disorders of hip maturation[1]whereby here hip dislocation and hip dysplasia are included. Although clinical instability examinations according to Ortolani[2] have been already introduced and are widely used in practice, it was established at a crucial symposion in Vienna in 1971 that 47% of completely dislocated hip joints were only diagnosed at the end of the first year of age.[3] At that time the authors expressed with resignation: „ this development hardly leaves hope that under the given circumstances diagnosis and therapy of hip dysplasia can be mastered to some extent".

Only since the introduction of hip sonography and its increasing standardisation (1/4) has the situation decively improved, due to its excellent transparency and expressivness in respect of pathological divergencies of the infant hip joint in comparison with clinical and x-ray examinations.

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The recommendation for using ultrasound as a screening method for early diagnosis of pathological hip joints has received staunch support in Central-Europe.[5,6,7,8,9] On the other hand Anglo-American authors show restraint with regards to sonographic screening.[10] They approve of it only if there is an indication due to a suspect anamnesis or suspect clinical signs and symptoms.[11,12,13] The reason for this discussion applies not only to the professional aspect but also to different social health systems, local factors with varied endemic incidences, and to unequal medical care. For countries with an excellent functioning social health scheme which have a high incidence of hip dysplasia and dislocation, the introduction of ultrasonic screening is only a supplement or a substitute for already existing means of screening.[1] On the other hand in countries where the means are not available, the introduction of sonographic hip screening presents a considerable organisational and financial burden. Thus sonographic hip screening must give way to other medical priorities.

On the other hand value and outcome of hip sonography is discusses controversially in Europe and USA. The technique developed in early 1980[1] classifies bony and cartilaginous roof according the age of the baby and quantifies also instability. The technique is independent of the experience and skill of the examiner. The USA-technique[14] prefer the dynamic technique visualizing instability without quantification and has no standard plane for quantification the bony and cartilaginous roof.

Screening results of hip sonography in babies from Austria

Nationwide results are available from Austria which introduced screening in 1991 and from Germany which introduced screening in 1996. Screening is also performed in Poland and the Czech-Republic. In a report 1997 by Grill et al.[15] the main statistics were published a year after the introduction of hip screening in Austria.

In 1985 in the pre-sonographic era the rate of infants treated with conventional methods was still 13,6 %.! In 1992 the rate was only 6, 57%. Thus the preliminary apprehension that hip screening could lead to excess therapy was clearly discredited. This rate of therapy however is 2% higher than the average quota of dysplasia with 4, 69% in large Central european studies.[15] The explanation for this seemingly discrepancy lies in the fact that the dysplasia –rate of 4,69 % applied only to infants diagnosed by means of X-ray and clinical evaluation, whereas „silent“ cases of dysplasia diagnosed exclusively by sonographic screening remained primarily undiscovered. They become suspect only in adolescence and are then submitted to surgical intervention. (acetabuloplasty, osteotomies) Sonoscreening of the hip also diagnoses „ silent“ dysplasias –thus the ini-

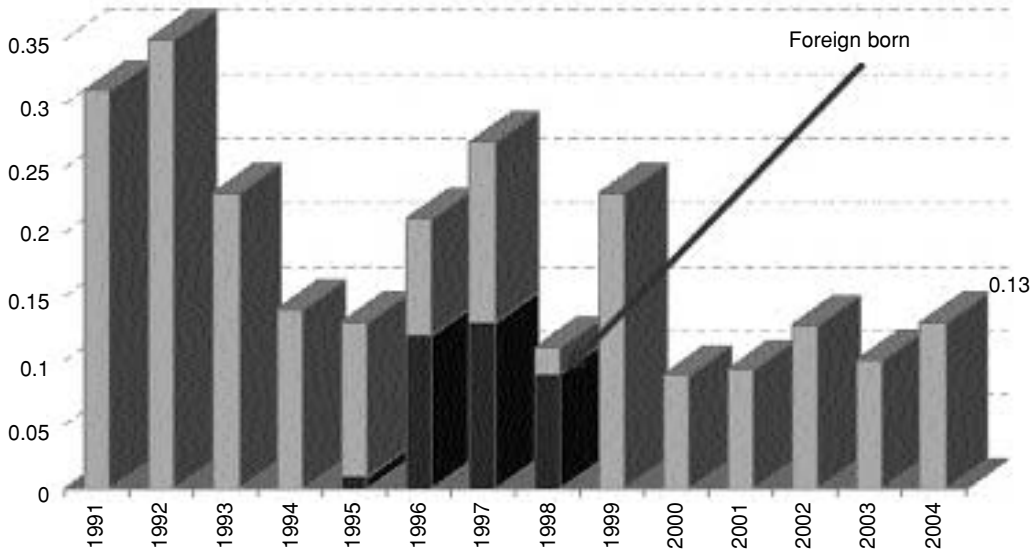

Figure 1. Rate of open reduction per 1000 live births in late diagnosed cases between 1991 and 2004. Note the decrease of open reduction to 0,13/1000 in 2004. Black columns: unscreened in foreign countries born babies.

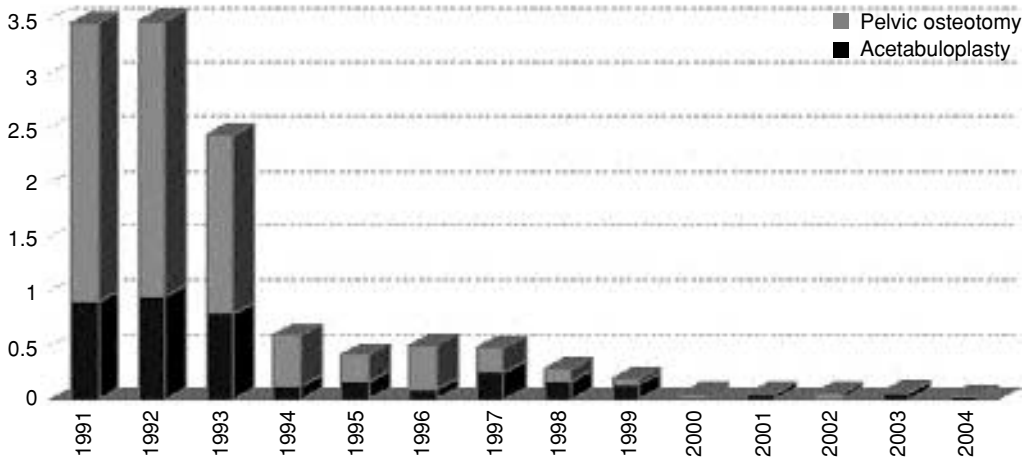

Figure 2. Rate of surgical intervention (pelvic osteotomy, acetabuloplasty) until 2 years of age per 1000 live births in Austria between 1991 and 2004. Note the decrease of surgical interventions from 1991 to 2004

tially higher treatment rate; in return however as experience shows surgical intervention in adolescence has been considerably reduced. Even more impressive is the number of surgical interventions in hips of infants .which were effectively reduced to 0, 24/1000 live births. The last evaluation in Austria in 2006 [12] confirmed the trend: in 2004 only 0,13/1000 needed an open reduction (Tab1). This is the lowest number, that ever been has published in world literature. Also pelvic osteotomy and acetabuloplasty had been reduced dramatically (Tab 2).

Appropriate time for screening

Due to results attained the authors[12,15] recommend sonography immediately after birth in cases of suspect clinical diagnosis or risk babies as well as general routine screening in the 4th to 6th week after birth.

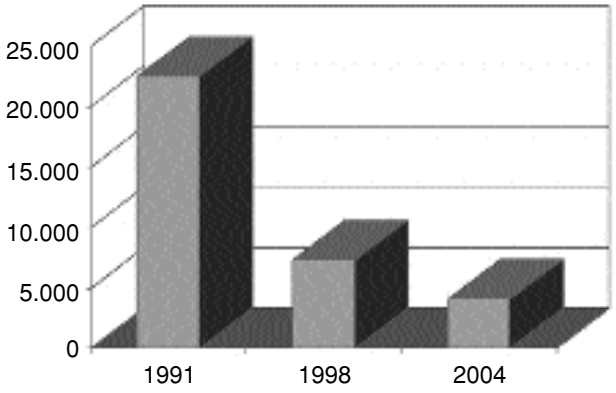

Figure 3. Treatment costs of DDH/1000 newborns until 2 years of age in Austria (in Euros). Note the dramatic decrease of costs till 2004.

Costs

Regarding total costs including it's many aspects a tendency to cost reduction can be ascertained. (Tab. 3)

The decrease of surgical interventions (and ensuing hospitalisation) and through the falling by half of conventional cases, a reduction of the costs automatically results. Comparing entailing costs of screening and therapy in relation to costs of treatment in the presonographic era a reduction of 1/3 of total costs [12,15] can be expected. Not included are the follow up costs for coxarthrosis of the hip with sick leave, convalescent homes, early retirement pay, etc.

Late results

We examined 40 DDH patients (51 cases) who get early sonography between 1980-1986 (23,1 years average follow up), They had only 2 open reductions and 3 acetabuloplasty. No late pelvic osteotomy or femur osteotomy was necessary. 31 patients did not know, that they had a hip problem as a baby!!!

Screening results from Germany

In Germany the proof of the efficiency of general sonographic screening of the hip is published,[16] the authors have been distinguished recently for their work with the Hufeland Award 2004-. During the period 1997 -2002 using registration forms and questionaires all hospitalised children needing treatment, were assessed. 66% having primary surgical intervention underwent a closed and 11 % an open

reduction. 23% underwent also an osteotomy of the pelvis or femur. Therefore the incidence of „first surgical intervention“is 0,26/ 1000 live births for the 1997 age-group. During the period of assessment the number of registered children with „primary surgical intervention“, decreased yearly by 31%. The allocated percentage of operations did not alter.

Through the ultrasonic hip screening in Germany the rate of surgical interventions was reduced to 1/3 in comparison to the pre-screeening era.[16] 81% of the children needing surgery who were examined on time, presented a pathological diagnosis at the first ultrasonic screening. However 19% (!) were classified as “without pathological findings“. If at the latest by the 6th week examination, the children did not undergo ultrasonic hip screening but at a later date, the diagnosis of hip displasia was confirmed on an average with a delay of 167 days: without screening there was an average of 276 days. If children were misdiagnosed with no pathological findings the correct diagnosis became apparent after 277 days. The fact of the matter is that the final diagnosis by sonographic misdiagnosing was established just as late as by those children who never underwent hip screening.

This emphasises the demand for hip sonography also at the “final examination.” In the case of a faulty diagnosis the patient returns only when the damages are irreparable.

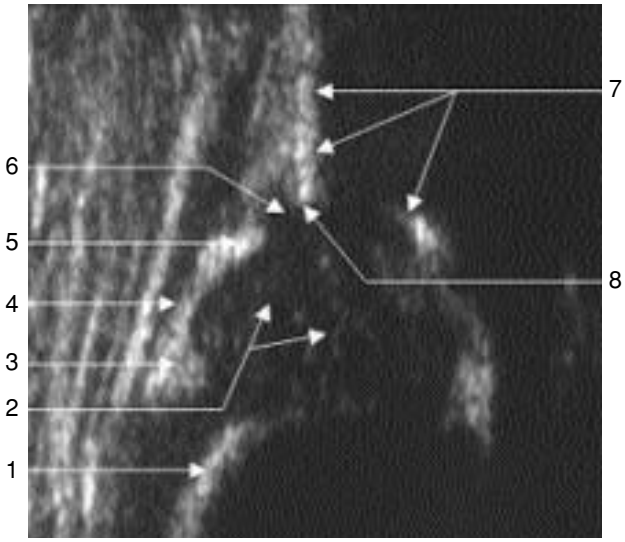

Figure 4. Correct order of the anatomical identification of an infant hip sonographic image. 1) Chondro – osseous junction, 2) Femoral head, 3) Synovial fold, 4) Joint capsula, 5) Acetabular labrum, 6) Hyaline cartilaginous preformed acteabular roof, 7) Bony part of acetabular roof, 8) Bony rim: turning point from concavity to convexity

Preliminary results

The exceptional significance of hip sonography in comparison with clinical or x-ray examination is evident. The rate of hospitalisation, the days spent in hospital and the incidence of surgical intervention has been considerably reduced. The tendency to cost reduction is apparent. Infants running risks or showing suspect clinical findings should be examined immediately post-partum. The routine screening should occur in the 4th up to the beginning of the 6th week of age. Delated ultrasonic examinations lead to an increase of open reductions and osteotomies.

Screening results are significant in many aspects:

The results of the Austrian and German screening are almost identical[12,16] The main concern is that the results are nationwide and not the achievement of itemised assessments of individual groups.[11,14,17] Thus the results are of considerable importance for health scheme policies. The hip sonography was carried out by orthopaedists, paediatricians and radiologists with different professional aptitudes. The quality standard therfore can not be matched with that of hip sonography experts.

Thus the rate of faulty diagnosis is relatively high! Nonetheless sonography leads to an improved early diagnosis.

What can be done, where is there potentiality for improvement as regards method, timing, organisation?

1. Specific time of examination.

The prevailing facts advocate general screening to be left to take place in the 4th up to the 6th week of age on precondition that infants showing any risk are examined immediately after birth. However an intensified explanation is essential in order to point out the necessity of having the examination done really at the right time and at the latest in the sixth week of age.

2. Technical Problems of examination methods

The technique of hip- sonography as developed by us is a standardised method of examination, reproducible anytime. The sonograms must fulfil strictly defined criteria Otherwise faulty diagnosis is inevitable. The high percentage of 19 % of sonographic „inconspicuous „ children in screening carried out in Germany who later had to undergo

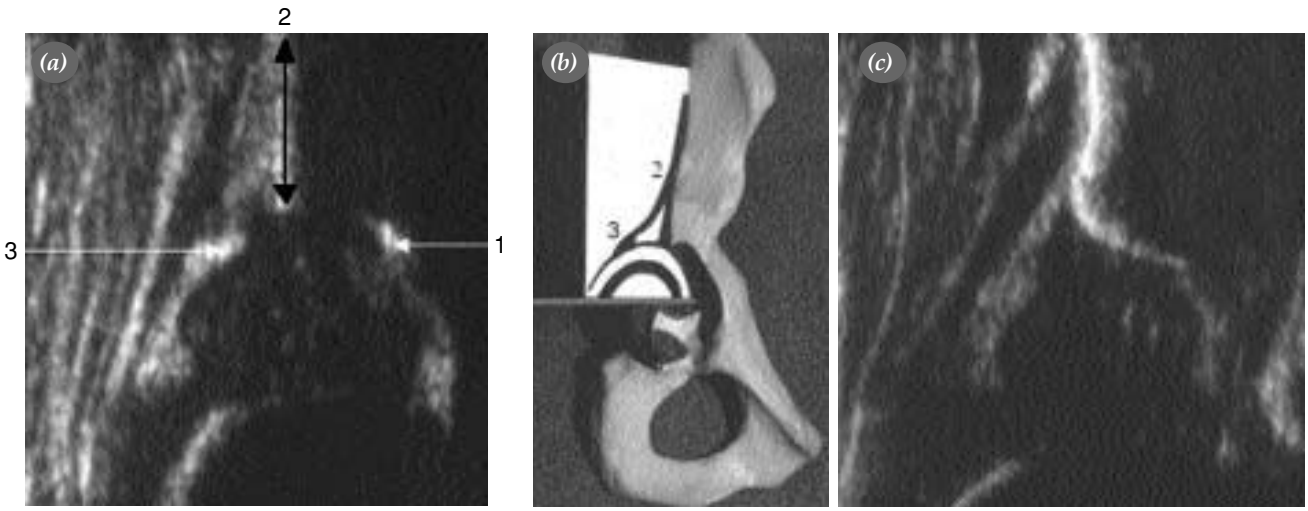

Figure 5. (a) Checking the landmarks, 1) Lower limb of the os ilium, 2) Standard sectional plane, 3) Acetabular labrum. (b) The standard plane. (c) Image with posterior tilting error. Compare with the correct image in fig. 5a

surgery is inacceptably high. This result coincides with our experience as regards the meanwhile increasing number of court cases due to faulty diagnoses. Naturally parents do not accept the fact that their children when diagnosed at first examination as " no pathological findings" still have to undergo surgery at a later date.

The argument fostered by the medical "ego defense - mechanism "that a Type I may also deteriorate must be opposed. Type I deteriorates only in cases of (listed according to frequency):

1. Faulty diagnosis- (It was never a Type I)

2. Coxitis

3.Neuromuscular imbalance (CP, Meningomyelocele, Syndroms, etc.)

4. Secondary dysplasia[4]

(i) Analysis of court cases shows a uniform picture of causes of faulty diagnoses.

- Wrong identification of anatomic structures.

- Deficient utility tests including error of tilting.

- Measuring mistakes

(ii) The identification of the anatomical structures listed below must be unmistakable. (Fig. 1)

- Chondro – osseous border

- Femoral head

- Synovia fold

- Capsula

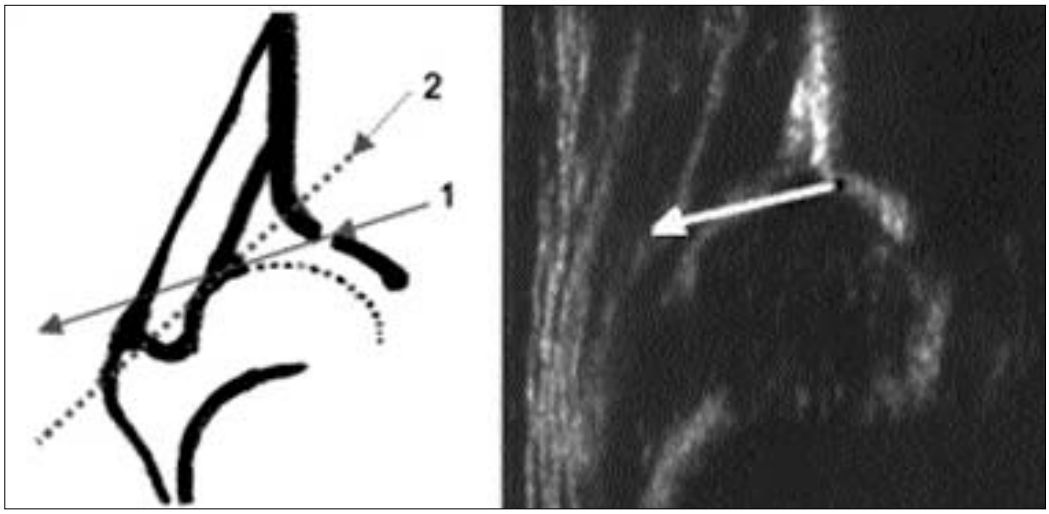

Figure 6. 1) Correctly drawn cartilaginous roof line, 2) Incorrectly drawn cartilaginous roof line.

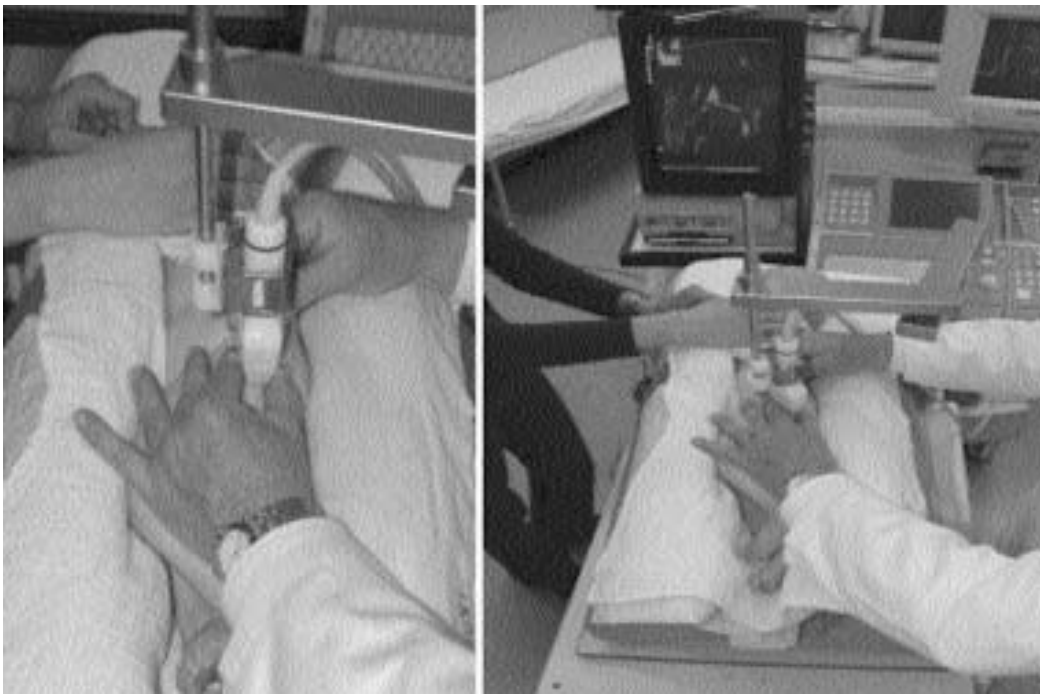

Figure 7. Correct scanning technique with cradle and probe guiding system (sonoguide)

- Labrum–hyaline cartilagineous roof – bony roof (short: labrum – cartilage - bone)

- Bony rim

It is mandatory n o t to use any sonogram if not all above listed structures are clearly identified.

(iii) Usability check

In testing the usefulness of a sonogram it is mandatory to identify the lower limb of the os ilium, the precise middle plain of the acetabulum roof and the labrum (lower limb – plain - labrum); errors of

Table 1. Therapeutic consequences.

Phase	Hip type	Therapy	Alternative	Annotation
Phase of Preparation	III and IV	overhead extension; medical gymnastics;if necessary tenotomy of adductors		Necessary in cases of limited movement or shortening of adductor muscles
1. Phase of Reduction	D, III and IV	Manual reduction	Reduction orthosis (for example according to Pavlik, Hanausek,...)	Dynamic hip examination monitored by ultrasound can show whether normal reduction is possible or phase of preparation is necessary
2. Phase of Retention	IIc unstable (exeption: newborn), reducted D, III und IV	modified plaster cast according to Fettweis in human position; newborns for 2 weeks, others for 4 weeks	Retention orthosis (for example according to Pavlik or Fettweis-orthosis,....)	Compliance of the parents?
3. Phase of Maturity	II a (-), II b and II c stable	abduction device according to Mittelmeier-Graf (size 1 to 3)	Maturity orthosis (abduction device for example according to Pavlik, Bernau)	Compliance of the parents? Sonographic follow up till type I
Exception	Newborn hip type II c unstable	try abduction device according Graf for 4 weeks	a) Becomes stable after 4 weeks ⇒ abduction device b) Still unstable or becomes worse ⇒ modified plaster cast according to Fettweis in human position	

tilting must be excluded. (fig.2a-2c). It is essential to use 5 resp. 7 MgHz linear ultrasonic units .Further a fixation device for the baby and a sonoguide are indispensable

(iv) Measurement mistakes

The most common error in measuring is to put the inclination line automatically through the intersection of the base line with the roof line of the acetabulum. The Beta value is also necessary. If this is omitted hips Type II c- stable, Type II c instable and Type D cannot be classified. A missing inclination-line demonstrate, that the examiner did not accurately identify neither the bony rim nor labrum acetabulare (fig. 3).

Accurate Sonograms without fixations device and sonoguide (fig. 4) are nowadays hardly possible. Is the measurement of the sonograms missing or defective, it is impossible to classify the important type II c in preventive check up. Undiagnosed Type II c combined with centred joint- relation is prone to glide into hip displacement. A substantial amount of so called hips“ without pathological findings“ are allocated to Type II c. These cases were in fact neglected and not treated in time.

Final outcome

The quality of results is indicated by the in-patient treatments e.g the frequency of surgical open or closed reductions, osteotomy on the acetabulum or the proximal femur. The problem is summarized in a single formula:

Final result =diagnosis +therapy

Hip sonography is only responsible for the diagnosis but not for the way of treatment. It is simply alarming, if 47% of the examined children are later in life in need of surgery in spite of adequate diagnostic and initiated therapy.[16] Apart from a few exceptions current therapeutic procedures were not challenged. According to our experience it would be of paramount importance to adapt and improve historic standards of treatment which are basically correct. Uncritical splinting which is not adapted to the patho- anatomical situation of the hip joint as classified by sonogram, must end in disaster i.e. the need for surgery even when early diagnosed.

Hip sonography depicts quasi a virtual antibiogramm guiding to the most effective and cheapest antibiotic with the least side effects for the given situation. Each sonographic type can be assigned to a specific phase of treatment congruent with a specific procedure effective in the given patho- anatomical situation.[1] Missing the best time for diagnosis and treatment (up to the beginning of the 6th week of life) is just as disastrous as the wrong choice of treatment. Acetabular dysplasia needing maturation does not need extension. A decentric hip, primarily needing reduction, cannot be treated with a splint or simple abduction device. Remarks like “ it also works “ “ or it was done so always“ show that besides historical tradition , the surgeon is willing to take risks at the patients expense but little readiness to use the reliable consistent course of treatment.. The most critical phase during treatment is the phase of retention. Independent of cooperative parents the foolproof retention by means of a cast in squatting position; (not to be confounded with the old Lorenzcast) is preferably the method to be applied in place of all other appliances.

Recommendations

Hip- screening is highly efficient. The method to perform hip ultrasound must be standardized to make it reproducible and realizable. The technique is independent of examiners experience and skill. Quantification of the bony and cartilaginous roof according the age of the baby is mandatory. Timing and way of screening presently illustrate the best possible compromise between organisation, feasibility and cost efficiency. Hip sonography is a final examination. Sonographic evaluation of the hip must be attained by proper teaching. Autodidacticism is disastrous. Courses meanwhile are offered by qualified teachers in many countries. Bed side teaching must be rejected since it promotes habitual faults being passed on. The continuous advancement of hip sonography necessitates extra tuition of instructors.

Criteria concerning quality and controls of quality are well established. Quality controls in medicine have become common place and should not precipitate reservations.

Correct technical equipment , an adequate ultrasound machine , fixation device, sonoguide to avoid tilting effects, which lead to misdiagnosis are mandatory. Historically unsystematic, splinting abduction devices has to be reconsidered. Changing to well established classifications of therapeutic

intervention is essential if the benefits of earliest diagnoses should not be lost through inadequate therapy.

Acknowledgment

Fig. 4-7 are taken from Graf R (2006) hip sonography Springer Heidelberg.[1] We thank also Prof. F. Grill Vienna Speising for Fig. 1-3.[12]

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