ULTRASOUND DIAGNOSIS OF NEONATAL CONGENITAL DISLOCATION OF THE HIP

A DECISION ANALYSIS ASSESSMENT

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Routine ultrasound evaluation of neonates and young infants for congenital dislocation of the hip has been recommended. We have used the methods of decision analysis to determine whether every neonate should be examined by ultrasound or just those at increased risk. We have also studied the reliability and accuracy of ultrasound in following infants during observation and treatment, using published data.

We find that ultrasound is not the preferred strategy for the screening of neonates, and that its role in evaluating high-risk patients depends on the point of view. For an individual, when third parties are bearing the cost, ultrasound is useful. For society as a whole, the routine ultrasound evaluation of the high-risk patient is not advantageous. For follow-up, ultrasound using the methods of Graf has a low reliability and there are no adequate data for methods using dynamic assessment.

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Many reports have supported the routine use of ultrasound to screen all neonates for congenital dislocation of the hip (CDH) or to evaluate those infants at increased risk (Clarke et al 1985; Clarke 1986; Graf and Schuler 1987; Langer 1987; Castelein and Sauter 1988; Szöke, Kühl and Heinrichs 1988; Clarke, Clegg and Al-Chalabi 1989; Harcke and Grissom 1990; Tönnis, Storch and Ulbrich 1990). Despite these claims the place of ultrasound is not clear, partly because of the various timings and methods of examinations employed.

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We have used decision analysis methods to assess the need for examination of every neonate, or just those at increased risk of CDH. We have also reviewed published data to assess the reliability of ultrasound evaluation during follow-up.

METHODS

The clinical examination of neonates or infants by the Barlow or Ortolani tests has been the primary means of diagnosis, especially in those with increased risk of CDH. Accepted risk factors include a positive family history, an equivocal physical examination revealing a stable clicking hip or a lax non-dislocatable hip, breech presentation, torsional abnormalities of the lower extremities, torticollis, and oligohydramnios. Less common risk factors are sacral dimple, scoliosis, any other congenital anomaly, a birth weight above 4 kg, twin pregnancy and plagiocephaly.

Ultrasound examination can assess the morphology of the acetabulum, the relationship of the femoral head to the acetabulum, and the stability of the hip. Two methods have emerged: the static method proposed by Graf and Schuler (1987) and the dynamic technique described by Harcke and Grissom (1990), and some have used a combination of these two methods (Donaldson 1989). Ultrasound findings are classified as:

- 1) *normal*, with no displacement on dynamic assessment or Graf type I,
- 2) *uncertain*, with minor displacement on dynamic assessment or Graf type IIa, and
- 3) *abnormal*, with major displacement on dynamic assessment or Graf type >IIa.

The early or late diagnosis will depend on both clinical and ultrasound findings. Hips can be categorised as *normal* if there are no risk factors, no instability on physical examination and normal ultrasound findings. The status is *uncertain*, and requires further observation if risk factors are present, physical examination is normal or indeterminate, or there are uncertain ultrasound findings. The hip is *abnormal*, and requires treatment, if it is dislocated or dislocatable and shows abnormal findings on ultrasound. We define late dislocation as that occurring in a hip originally classified as normal by physical examination or ultrasound, since these cases will

Fig. 1a

Fig. 1b

Decision trees for the assessment of the role of ultrasound in screening neonates for CDH. The symbols are a rectangle for a decision node, a rectangle with rounded corners for a chance node, and an oval for a terminal node. The black numbers represent the probabilities, the outlined numbers the utilities. Figure 1a – The decision tree for the screening of all neonates. Figure 1b – The decision tree for the screening of high-risk infants.

not be monitored; early dislocations are those occurring in infants who had uncertain or abnormal findings at the initial evaluation.

Decision analysis methods. The fundamental tool of decision analysis is the decision tree (Fig. 1), which comprises decision, chance, and terminal nodes. Tree branches emanate from the chance and terminal nodes, with probabilities and utilities assigned respectively.

Probability is the frequency of an event in a population.

We selected a probability value for each event, using the figure most frequently quoted in the literature or that which seemed most representative. We took the probabilities for high-risk neonates from Clarke et al (1989) and for the whole population from Tönnis et al (1990). The probabilities for classification of hips are different in these two populations (Fig. 1). For screening the whole population, we obtained data using Graf's method; for the high-risk group we obtained data using the dynamic

method. The probabilities for clinical examination, of all neonates and of those at increased risk, were obtained from Jones (1977) and Vergnes et al (1986).

Utility represents the value of an outcome. Late dislocations often require surgical treatment and there is a higher risk of late osteoarthritis: late diagnosis has therefore less utility than early diagnosis. We assigned values of 0.1 for late dislocation and 1 for no dislocation. Early dislocation was assigned a utility value of 0.9, since the outcome after appropriate treatment is nearly equal to that of a normal hip.

The performance of a diagnostic test, by clinical examination or ultrasound, requires the expenditure of resources, and utilities are therefore reduced accordingly. We used reductions of 0.01 (minimal resources expended) for physical examination, 0.04 for ultrasound in a high-risk neonate, and 0.1 when ultrasound is used for every neonate. The ratio between high-risk ultrasound and routine clinical examination (0.04 to 0.01) is based on the relative resources expended, and utility discounting is increased to 0.1 for ultrasound screening of every neonate, because of the cost of setting up such a surveillance programme.

Tree evaluation. After the decision tree is constructed, a 'tree foldback' is performed to obtain the expected utilities, that is, the utilities weighted by the probabilities. When the expected utilities have been obtained, the preferred strategy for decisions is that which gives the higher expected utility.

As explained above, our first assumptions used single probability values selected from the literature, placing the utility of early dislocation (0.9) close to the utility of no dislocation (1.0), and utility discounting of 0.04 for screening high-risk neonates and 0.1 for screening all infants. The conclusions of decision analysis greatly depend on the chosen values for probabilities and utilities and it is therefore essential to assess the validity of the conclusions over a range of possible values for these parameters.

We used a sensitivity analysis, with determination of threshold values, to estimate the effect of the chosen probabilities. This allowed us to examine the validity of a particular conclusion over a range of possible estimates of a given probability. The threshold value of a probability is the value at which the previously optimal strategy becomes no better than its near competitor.

The selection of values for utility also may have an effect on the conclusions. The selection of utility values for late dislocation (0.1) and for no dislocation (1.0) is arbitrary and does not influence the conclusions; even if we selected values of 1 and 1000 the conclusions would not alter. Two utility assumptions, however, do need to be tested: the utility of early dislocation and the level of utility discounting when ultrasound is used. We tested the conclusions for five sets of utility values for early dislocation (Fig. 2), ranging from a value close to no

Fig. 2

Diagram of the five sets of values of the utility of early dislocation.

dislocation (0.9) to a midpoint between no dislocation and late dislocation (0.5). The impact of different levels of utility discounting for ultrasound was evaluated by changing the *expected value of clinical information* which is a measure of the information contributed by a test such as ultrasound. It is obtained by subtracting the averaged-out utility of the physical examination strategy from the averaged-out utility of the ultrasound strategy. Our calculations for utility reduction ranged, in increments of 0.01 from a value of 0 (ultrasound consumes no resources – no discounting) to 0.04.

RESULTS AND DISCUSSION

Ultrasound evaluation of every neonate. Our analysis indicated that ultrasound is not the preferred strategy for screening all neonates, since its expected utility is lower than that of physical examination. Unless the incidence of CDH in the normal risk child is greater than 13%, the strategy using ultrasound will always be inferior, and the reported incidence in the literature ranges from 0.02% to 0.09%. The strategy of using ultrasound to screen all neonates will always be inferior whatever percentage of neonates is at increased risk; the decision to use ultrasound is therefore not influenced by the use of lax or strict criteria for increased risk. The superiority of the physical examination strategy persisted even if ultrasound was assumed to consume no resources and to have no risk, in other words, was 'free'.

Ultrasound evaluation of high-risk infants. Our analysis also indicated that ultrasound is not the preferred strategy for the evaluation of infants with increased risk for CDH: its expected utility is still lower than that for physical examination. There were no threshold values for any of the probabilities, except for the incidence of dislocated hips in the high-risk child. These threshold values ranged from 44% if the utility of early dislocation is considered to be close to that of a normal hip, to 12% when the utility of early dislocation is placed at the midpoint between late dislocation and no dislocation. The reported incidence in the literature ranges from 4% to 9%.

When evaluating high-risk patients by ultrasound, the levels of utility discounting had variable effects (Fig. 3). If the utility of ultrasound was not reduced at all (assuming no expenditure of resources), it became the preferred strategy regardless of the utility of early dislocation. On the other hand, if the utility of ultrasound

Fig. 3

Line graphs of the expected value of clinical information (EVCI, left) plotted against the five utility values of early dislocation. The EVCI of ultrasound in the evaluation of neonates at increased risk was obtained by subtracting the averaged-out utility of ultrasound (see text). Each oblique line represents the values of EVCI obtained after discounting the utility of ultrasound for a range of values from 0 to 0.04 (on right).

was reduced by 0.04, physical examination became the preferred strategy regardless of the utility of early dislocation. Reductions in the utility of ultrasound by intermediate values resulted in different combinations of superior strategies. For example, if it was reduced by the same amount as for physical examination (0.01) and the utility of an early dislocation is considered to be closer to the utility of a normal hip (0.9), then the physical examination is the superior strategy. If the perspective is from the individual's point of view, with third-party payers (private insurance or government) bearing the cost, then ultrasound is a superior strategy. On the other hand, from a societal perspective of cost containment physical examination is a superior strategy.

Ultrasound in later observation and treatment. Ultrasound is not reliable enough for use in the follow-up either of children with CDH or of those at risk of CDH. The Graf method of determining the α angle has a large variability (mean = 2.3° SD 10° ; Engesaeter et al 1990); the interval within which two separate measurements in the same patient could fall is approximately 40° . There is poor interobserver and intraobserver agreement (Dias et al 1993). We have found no reports of the interobserver and intraobserver errors in abnormal hips using dynamic assessment, but for normal hips the intraobserver error by dynamic assessment is reported to be ± 1.2 mm (95% confidence interval) (Keller et al 1988).

Our review may have overlooked some reports, but our conclusions are supported by the differences between the threshold values obtained in our decision model and the range of values obtained from the literature.

The factors which contribute to the inferior expected utility of ultrasound are:

- 1) the low prevalence of CDH,
- 2) the spontaneous resolution of abnormalities detected in the immediate neonatal period, and
- 3) the late presentation of CDH after the neonatal period.

Patients with a clearly abnormal Ortolani or Barlow test should be treated, and our analysis indicates that patients at increased risk are best evaluated by repeated physical examination during infancy, supplemented by radiographs at three to four months of age. The radiographic evaluation should be performed regardless of the clinical findings, since physical examination at this age

may fail to detect an abnormal hip (Krikler and Dwyer 1992; Poul et al 1992).

We suggest radiographic evaluation rather than ultrasound at three to four months, because the former has been proved to be effective (Garvey et al 1992), less costly, and less operator-dependent than the latter. An additional factor is that when an ultrasound abnormality has been found in infants of three to four months of age it has to be documented by radiography. A disadvantage of radiography is the dose of radiation of approximately 20 mrem of the total body dose for frontal and 'frog' views of the pelvis (NCRP 1981), but since the background radiation is 100 mrem per year in the USA (NCRP 1975) this is a reasonable risk. The suggested timing for radiography allows for the spontaneous resolution of minor instability, a delay which is acceptable since there is little difference in outcome between infants treated at birth or at five months of age (Burger et al 1990).

We conclude that ultrasound is not the preferred strategy for screening all neonates. Its role in evaluating high-risk patients depends on the viewpoint; from an individual perspective when a third party is bearing the cost ultrasound is useful, since any test that causes no harm and is 'free' may help; from the point of view of society in general, however, ultrasound evaluation even of high-risk patients is not advantageous.

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