Combined Ultrasonographic and Clinical Evaluation of High Risk Neonates for Developmental Dysplasia of Hip: A Prospective Study.

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Abstract:

Developmental dysplasia of the hip (DDH) continues to be missed by routine physical screening examinations in the early months when treatment is most effective. Real time ultrasonography is valuable in detection of DDH in the young infants less than three months old. We performed a prospective study to evaluate the use of ultrasound screening that targets a select " high risk newborn " population for DDH aiming to increase the early diagnosis of this condition and decrease the incidence of late cases. From 2121 live births in our hospitals; we identified 188 (8.8%) newborns with risk factors for DDH. We followed these patients by clinical examination and ultrasound at birth, 6 weeks and 12 weeks of age. Initial ultrasound scan showed that 28% of the cases had findings suggestive of dysplastic hip, about half of them were clinically normal during neonatal examination. On subsequent scanning, the proportion of abnormal hip decreased gradually so that by 12 weeks, 80% had normal ultrasound appearance. Abnormality was more common in babies with breech presentation and family history of DDH. One female infant, not diagnosed by clinical examination at birth and with no risk factors, had abnormal clinical examination and ultrasound appearance of DDH by 12 weeks. From our study, we conclude that selective screening with ultrasound for the hip of newborns with specific physical and historical risk factors for DDH is more effective than clinical screening alone. It targets treatment to these infants who need it, and reveals a number of dislocated and subluxated hips that would otherwise be missed. It is better done when they are 4-6 weeks old. Clinical assessment cannot be restricted only to the first 2-3 days after birth but continued during the first year of life.

Introduction:

Developmental dysplasia of the hip (DDH) is defined as an abnormal formation of the hip joint occurring between organogenesis and maturity as a result of instability and represents a spectrum of disease from total dislocation to partial dislocation or subluxation.(1) The incidence of DDH is estimated at 2-9 per 1000 births.(2) It is well established that in treating DDH, early diagnosis improves outcome. The physical, emotional, and medical costs of delayed diagnosis of DDH are enormous for the child and parents. In addition, up to 25% of adult hip osteoarthritis requiring surgery has been attributed to the late effects of mild DDH.(3)

Most congenitally dysplastic hips are inapparent and asymptomatic during neonatal period. Although the abduction tests of Ortolani and Barlow (4,5) are the standard methods of detection in the neonate, their value and their use in screening programs has been over emphasized. This over emphasis on neonatal screening results in a false sense of security with resultant lack of continued vigilance throughout the period of infancy.(6) Thus, improved methods of increasing early diagnosis are needed.

Ultrasound examination offers a reliable, safe and non-invasive method of imaging the neonatal hip.(7) However, controversy continues about the place of ultrasonography in neonatal screening of congenital hip dysplasia.(8) Sonographic screening of all newborns has three principal drawbacks. First, in a number of infants, sonography shows minor abnormalities of both stability and acetabular development that will resolve by a later age without treatment. The second drawback is that observation and treatment of these false positive cases consumes considerable resources. The final drawback is that the few cases of dysplasia that develop after the neonatal period will be missed.(9) Another approach for the use of sonography in screening is to focus on the segment of the population with a recognized increased risk of developmental dysplasia of hip.(1) So, the main points at issue are: How should we diagnose DDH in the neonate ? and when is this best done ? We therefore made this prospective study to determine whether ultrasound examination limited to babies considered to be at risk and those with any hip abnormality detected on clinical examination would reduce the incidence of missed and late established cases of DDH.

Subjects and Methods:

From January 1st, 1996 to August 1st, 1998, we prospectively screened all live born deliveries at Al Hayat Hospital and Hai Al Jamea Hospital, Jeddah, K.S.A., which are large perinatal referral centers. A review of fetal monitoring records for identification of breech presentation or oligohydramnios were done for all neonates included in the study. Detailed history was taken from the mother of any family history of hip instability. All infants born had a comprehensive postnatal examination by a pediatrician, when possible within 24 hours of birth. This examination included both the Barlow provocative test[4] and Ortolani reduction maneuver [5] for hip instability. All abnormalities were recorded, including instability, hip click or clanks and apparent limitation of abduction.

Targeted newborns considered to be at high risk for DDH included those with at least one of the following :

1. Abnormal findings on clinical examinations : instability, click, limited range of motion, apparent leg-length inequality, and asymmetry of the thigh or buttock skin creases.
2. Family history of hip developmental dysplasia.
3. Breech presentation at birth (frank - footling complete) whether by vaginal or cesarean section.
4. Foot deformities: talipes equinovarus, metatarsus varus.
5. Congenital postural abnormality : scoliosis, torticollis, craniofacial, and spinal anomalies.
6. Oligohydramnios.
7. Less common risk factors including : sacral dimple, and multiple pregnancy.

Newborns of less than 36 weeks gestation, who had teratologic or myelodysplastic dislocation, or who had chromosomal abnormalities were excluded.

All target newborns were transferred to orthopedic clinic where they were examined by Orthopedic Surgeon. The parents of all newborns at risk were contacted and arrangements were made for them to attend for Pediatric Clinic and Orthopedic Clinic every 2 weeks.

Sonographic examination of both hips using 7.5 or 5.0 MHZ; according to the size of the baby; short focus linear transducer was done. Two images for each hip are made. We used the technique of static and dynamic assessment of Harcke et al. [10] With the baby supine and the pelvis flat, the coronal / flexion view (figure 1) was taken with the hip and knee flexed to 90° and the transducer aligned at 90°, that was perpendicular to the long axis of the body.

The transverse /neutral view (figure 2) was obtained with the hip and the knee extended and the transducer rotated through 90°, that is perpendicular to the long axis of the body.

Grading System :

We used a grading system based on the degree of femoral head coverage as described by Harcke et al. [10] and later refined by Terjesen et al. [11] The femoral head must be clearly demonstrated and its position in relation to the acetabulum determines the grade (grade 1 to 5).

- Grade 1 (located hip): The femoral head is well contained in the acetabulum.
- Grade 2 (minimally dysplastic): The femoral head is in the acetabulum but not in contact with the floor (Figure 3).
- Grade 3 (subluxated hip): The acetabulum appears shallow in the coronal view, but there is only a small gap on the transverse view (Figure 4).
- Grade 4 (partially dislocated hip): The acetabulum appears shallow. On the transverse view, the head is displaced posteriorly and a gap is present (Figure 5).
- Grade 5 (totally dislocated hip): The femoral head lies outside the acetabulum on the coronal view, a transverse view cannot be obtained because it is obscured by the greater trochanter.

Ultrasonic examination was done for all newborns at risk within one week after birth, and repeated at 6 weeks and 12 weeks of age at the time of regular vaccination visits.

Results:

In the study period, 2121 out of 2436 live born infants were eligible for the study, after exclusion criteria. In this population, 188 newborns had either positive clinical examination of DDH (48.5%) or at least one of the risk factors with normal clinical examination (51.5%). Of these, 115 (61%) were females and 73 (39%) were males (table I). Twelve newborns did not complete the follow-up period and so, were excluded from the study. The remaining newborns, who did not fulfill the criteria for the ultrasound examination, were examined clinically including Barlow and Ortolani maneuvers with regular vaccination visits.

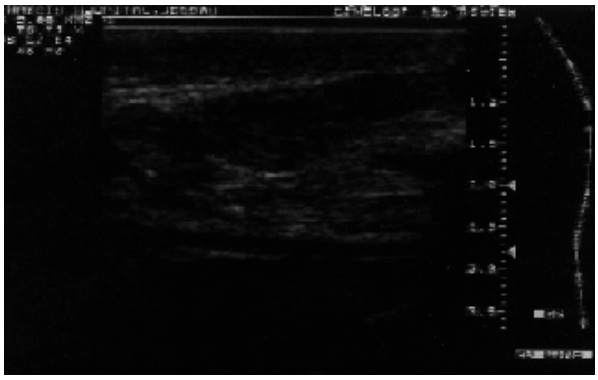

Fig 1. Coronal image of a normal hip. The femoral head is centered over the triradiate cartilage.

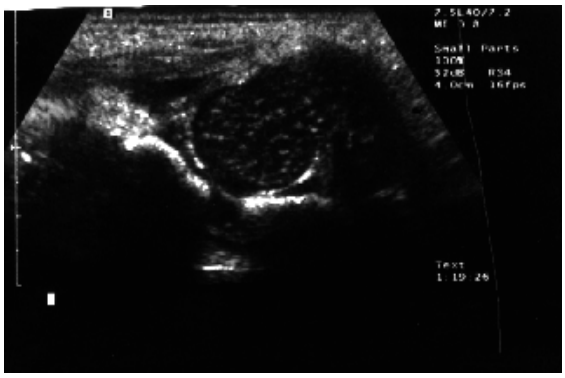

Fig 2. Transverse image of a normal hip. The rounded, hypoechoic cartilaginous femoral head is cupped within the acetabulum.

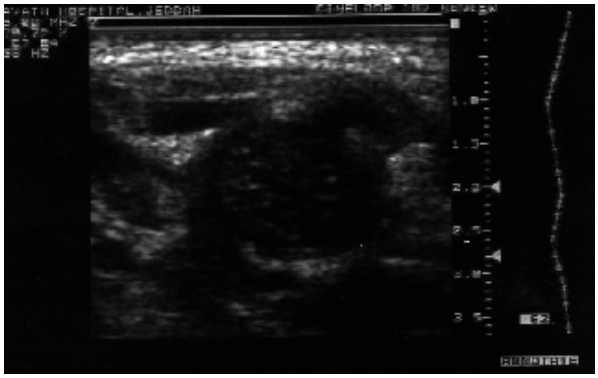

Fig 3. Transverse image of Grade II dysplastic hip. Small gap between head of femur and acetabulum.

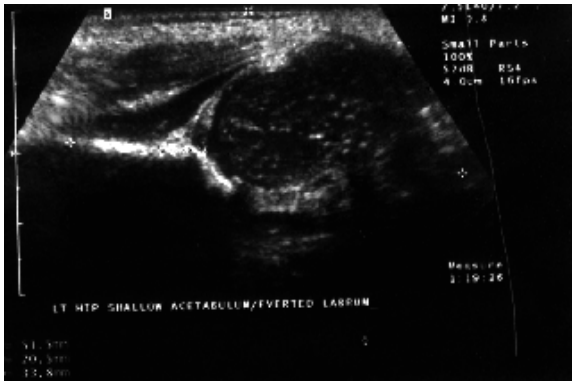

Fig 4. Shallow acetabulum with everted labrum of subluxated hip (Grade III).

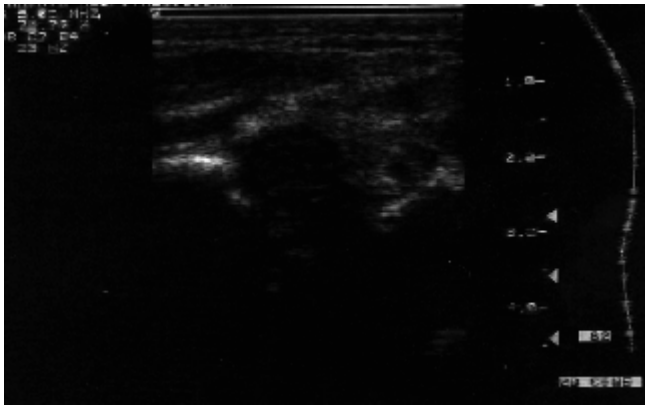

Fig 5. Transverse image of partially dislocated hip (Grade IV) with shallow acetabulum and posterior displacement of hip.

Only one case showed a limited abduction range unilaterally at 12th week examination and was referred for ultrasonogram which revealed grade IV abnormal findings (0.05%). She was a female, born by vaginal delivery and had no risk factors, with normal clinical examination at birth and at 6 weeks age. She had subcutaneous adduction tenotomy to increase the range of abduction, manipulation under general anesthesia and hip spica. She has been followed-up in the orthopedic clinic.

Initial ultrasound examination showed abnormal findings in 106 hips (table II). Bilateral hip affection occurred in 19 patient, while 68 had only unilateral affection of the right side in 30 and left side in 38 newborns. Of these, 58 hips were clinically normal during the neonatal examination. Only 65% of hips showing clinical abnormality have proved by ultrasonography to have some degree of hip dysplasia ($\geq$ Grade II) with highest percent of abnormalities with hip instability by clinical examination.

Second ultrasound examination showed decline in the number of positive ultrasonograms (table III). Fifty hips (13%) had abnormal findings ($\geq$ Grade II

) by sonography. Thirteen infants had bilateral affection and 24 had unilateral hip abnormality. Of those with risk factor and normal clinical examination at birth, breech presentation had the highest percentage (31%) followed by a positive family history (17%). The female to male affection ratio was 28:9. All infants with ultrasonic evidence of hip dysplasia had the Pavlik harness applied. Parents were instructed about the care of their infants in the harness.

Third ultrasonographic examination showed only 21 hips with persistent abnormal findings (5.5%) (table IV). This represented 0.09% of all live births. Of these, 3, all females, had grade V dislocated hips. They were treated by manipulation under general anesthesia with subcutaneous adductor tenotomy, and hip spica. Other newborn infants who had persistent sonographic abnormal findings of DDH were followed-up in Pavlik harness, and there has been no need for further orthopedic interferences. Thirty-eight percent (8 hips) of all hips had persistent abnormal ultrasound findings and were clinically normal at birth, 2 infants had bilateral affection and 6 infants had unilateral affection. This means that about 6% of the total number of high-risk infants with clinically silent hip dysplasia at birth had persistent ultrasonic evidence of dysplasia by 12 weeks age.

Figure 6. IMPROVEMENT OF ULTRASOUND SCAN ON FOLLOW UP

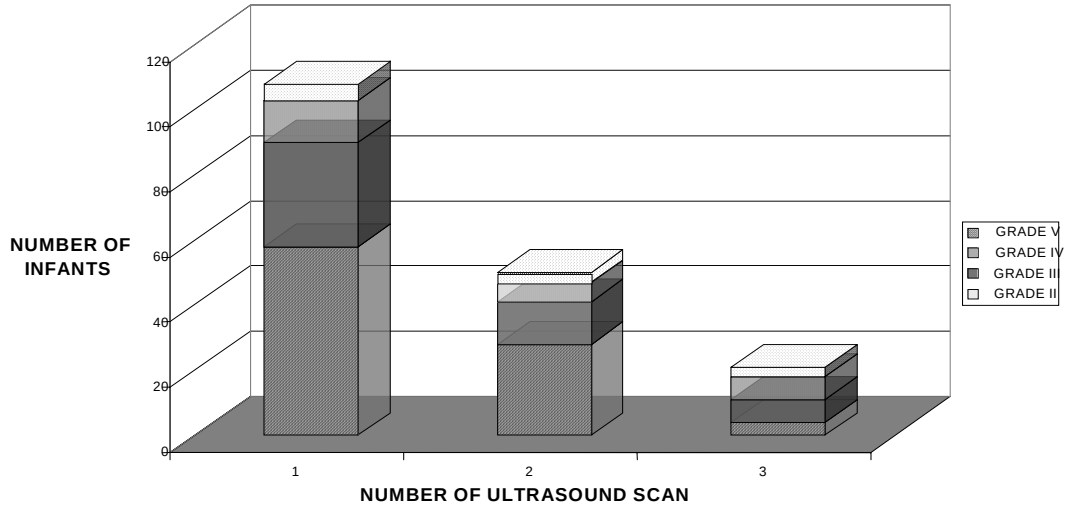

Table I. Incidence of causes of ultrasonic examination for DDH in the study group.

Causes	Females	Males	Total Number	Percent
I. Hip abnormality by clinical examination.				
- Click	40	18	58	31%
- Apparent limited abduction	15	6	21	11%
- Instability	8	3	11	6%
- Leg asymmetry	1	0	1	0.5%
II. Risk factor with normal clinical examination.				
- Breech presentation	28	21	49	26%
- Family history	4	5	9	4.9%
- Foot deformity	11	13	24	13%
- Congenital postural anomalies	3	5	8	4%
- Multiple pregnancy	3	1	4	2.1%
- Oligohydramnios	2	1	3	1.5%
TOTAL	115	73	188	100%

Table II. Ultrasound grades of the initial examination of both hips in the study group results.

Causes	No. of examined	Grade I	Grade II	Grade III	Grade IV	Grade V	Total nº of abnormal	Percent

	hips						hips	
Hip click	104	88	9	7	0	0	16	15%
Limited abduction	32	23	4	3	1	1	9	28%
Hip instability	14	1	5	4	3	1	13	93%
Breech presentation with abnormal clinical examination	32	10	11	6	4	1	22	70%
Breech presentation with normal clinical examination	98	69	20	5	3	1	29	30%
Family history	18	11	3	2	1	1	7	38%
Foot deformities	48	42	4	2	0	0	6	12%
Postural anomalies	16	12	1	2	1	0	4	25%
Multiple pregnancy	8	7	1	0	0	0	1	12.5%
Oligohydramnios	6	5	0	1	0	0	1	17%

Table III. Ultrasound grades of both hips of the study group at 6 weeks.

Causes	No. of examined hips	Grade I	Grade II	Grade III	Grade IV	Grade V	Total nº of abnormal hips	Percent
Hip click	104	100	2	2	0	0	4	4%
Limited abduction	32	27	2	2	1	0	5	16%
Hip instability	14	7	3	2	1	1	7	50%
Breech presentation with abnormal clinical examination	32	22	6	2	1	1	10	31%
Breech presentation with normal clinical examination	98	82	12	2	2	0	16	16%
Family history	18	15	1	1	0	1	3	17%
Foot deformities	48	46	1	1	0	0	2	4%
Postural anomalies	16	14	0	1	1	0	2	12%
Multiple pregnancy	8	7	1	0	0	0	1	12%
Oligohydramnios	6	6	0	0	0	0	0	0%

Table IV. Ultrasound grades of both hips of the study group at 12 weeks.

Causes	Nº. of examined hips	Grade I	Grade II	Grade III	Grade IV	Grade V	Total nº of abnormal hips	Percent
Hip click	104	102	1	1	0	0	2	2%
Limited abduction	32	30	0	1	1	0	2	6%
Hip instability	14	9	0	2	2	1	5	35%
Breech presentation with abnormal clinical examination	32	28	2	0	1	1	4	12.5%
Breech presentation with normal clinical examination	98	94	1	2	1	0	4	4%
Family history	18	16	0	1	0	1	2	11%
Foot deformities	48	47	0	0	1	0	1	2%
Postural anomalies	16	15	0	0	1	0	1	6%
Multiple pregnancy	8	8	0	0	0	0	0	0%
Oligohydramnios	6	6	0	0	0	0	0	0%

Discussion:

The first few days of life are the best time to detect DDH, but the belief that a simple abduction screening test is totally reliable during this period is incorrect. Failure to detect DDH during this " golden period ", during which such detection is said to be the easier, results in a false sense of security.[6] In

the 1970's,[12,13] doubt was cast on the overall effectiveness of clinical screening. Concerns have continued about the difficulty of ensuring effective screening and the persisting incidence of late - presenting cases.

Clinical examination may fail to detect hip instability or dislocation for a number of reasons. The hip may be irreducible. Signs of instability may disappear soon after birth or may be too subtle to be appreciated.[7] Not all cases are diagnosable at birth, or hips that are found to be normal at birth and even in the first few months of life can subsequently be found to be abnormal later on.[16, 17] In our study, 44% of the hips found to be dysplastic by the initial ultrasound scan were clinically normal at birth. This observation has been reported by Walter et al.,[1] Boeree et al., [7] and Clarke et al. [8]

If an alternative method of screening is to be considered it must be more effective, harmless, and reproducible. Ultrasonography has several advantages over radiography. Exposure to ultrasound is harmless and examination can be repeated as often as required. Ultrasound demonstrates the uncalcified tissues without the aid of contrast medium, an advantage in the immature hip.[19] We have found ultrasound screening to be more sensitive than clinical examination in detecting hip instability and no baby who had a normal scan at birth developed clinical instability later on. Our findings were similar to those of Walter et al., [1] Boeree et al., [7] and Marks et al. [20]

The timing of the ultrasound examination is important when it is used for screening. A criticism of ultrasound screening in the first few days of life is that it detects minor degrees of abnormality which spontaneously resolve and need no treatment.[20] This is confirmed by our figures, which showed that nearly 80% of all such babies became normal within 12 weeks. Logically, it is necessary to perform scans early enough for conservative treatment to have a high chance for success. Although, some have suggested that infant screening could be delayed until age 2 months, this is not a universally accepted concept. Most pediatric orthopedic surgeons prefer to begin treatment not later than 6-8 weeks after birth.[9] Non operative conservative treatment, such as the Pavlik harness, may be most effective when started early, [21] and in our study, only 46% of abnormal dysplastic hips diagnosed by initial ultrasound scan had persistent changes by second scan at 6 weeks. This is much fewer than the rate of up to 44 per 1000 who will be treated in a splint on the basis of abnormality at post natal examination. Splintage is not without risks : avascular necrosis of the capital epiphysis, epiphysitis and full thickness pressure sores are recognized complications in a small proportion of treated infants.[22] When all these findings are considered, the optimal period for sonographic screening seems to be when the infant is 4-6 weeks old. The same was suggested also by Boeree et al., [7] Harche et al.,[9] and Donaldson. [22]

Adoption of a standard method for sonography would make training easier to accomplish and improve the quality management process. Unfortunately, Graf's technique,[23] that employs static B-scan imaging, is technically complicated and requires a high degree of skill and meticulous attention to patient positioning. A major disadvantage of this technique is its inability to demonstrate the dynamic relationship of the femoral head to the acetabulum. Stability of the hip joint and degree of subluxation cannot be assessed.[24] Dias et al.,[25] have reported poor inter-observer and intra-observer agreement by using Graph method. The dynamic assessment of hip joint we used in our study is well suited and allows rapid and consistently reproducible scans to be taken. Keller et al.,[26] had reported intra-observer error to be $\pm$ 1.2mm (95% confidence interval).

Ultrasound evaluation of every neonate is not practical and Hernandez et al.,[27] reported that unless the incidence of DDH in the normal risk child is greater than 13%, the strategy using ultrasound will always be inferior. Reported incidence in the literature ranges from 2-9 in 1000 live births.[2] In our study, the 12th week ultrasound scan showed that only 22 infants had persistent dysplastic changes. This is about 0.09% of the total live births included in the study. So, introduction of sonography in a way that corrects areas of deficiency in clinical screening is the most attractive alternative.[9]

In the population of 2121 infants studied, 188 (8.8%) were screened by sonography because of risk factors. Although this process was effective in detecting unsuspected cases of DDH and did appear superior over clinical screening alone, it did not eliminate the appearance of 1 late case (0.04% of all live births during period of study). This case occurred in the population that had normal finding on clinical examination in the neonatal period and no known risk factor. Whether this case could be detected with universal sonographic screening or be included in the group of cases of delayed onset, we cannot judge.

No one of our infants proved to be normal by ultrasound initial scanning developed clinical instability or ultrasound abnormalities on follow-up scans, also our study indicated that early clinical

instability which ultrasound later confirmed to have resolved completely, did not recur. The same findings, were reported by Walter et al., [1] and Boeree et al.,[7] and Marks et al.[20] However, Schimmer et al., [28] reported that some hips found to be normal by clinical and ultrasound examinations in the neonatal period have developed dysplasia in the ensuring months.

Debate continues about the significance of a click in an otherwise stable hip. Clarke et al.,[29] showed that a proportion of such hips will have a significant abnormality when imaged by ultrasound. In our study, we have again confirmed that hip click cannot be ignored. Fifteen percent of those who had hip click were proved to have ultrasound abnormalities in initial scan and 2 of them had persistent abnormalities at 12th week scan.

Female subjects are known to have at least a four-fold to 10-fold higher rate of DDH than male subject.[30] All the established cases of DDH at 12 weeks (Grade V) were females, in our study. Whether the inclusion of female sex as a risk factor for ultrasound screening would have eliminated all our late presenting cases needs to be further studied.

Conclusion:

DDH is a potentially serious condition and when diagnosed early, treatment is simple and effective. Routine clinical screening should be augmented by sonographic examination in cases of recognized risk. Clinical screening of newborns should remain the method for evaluating the entire population. However, clinical assessment cannot be restricted only to the first 2-3 days after birth. Whenever an infant encounters the health care system during the first year of life, the hip should be checked.

Sonography is better to be done when they are 4-6 weeks old for the infants who have risk factor or positive clinical finding. If the hip is abnormal, it is still early enough to begin treatment within the recommended window for success.

Although ultrasound screening of infants at risk would not eliminate all late cases of DDH, it would correct areas of deficiency in clinical screening. It also attempts to apply resources in a cost-effective way and eliminate unnecessary treatment.

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