Thai Journal of Obstetrics and Gynaecology
September 2021, Vol. 29, No. 5, pp. 288-297.

OBSTETRICS

Prediction of Successful Normal Vaginal Delivery by Ultrasonographic Measurement of Occiput-Spine Angle during First Stage of Labor

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ABSTRACT

Objectives: To determine the accuracy of occiput-spine angle (OSA) measurement during the first stage of labor for predicting the course and outcome of labor.

Materials and Methods: A study was carried out in singleton pregnant women with cephalic presentation, who underwent labor between 37 weeks and 41 weeks and 6 days, from February 2018 to January 2019. Transabdominal ultrasound was performed to measure the OSA. The first examination was done at a cervical dilatation of 3-6 cm, and it was repeated at following 2 hours. The diagnostic values of the OSA as a predictor of the course and outcome of labor were analyzed.

Results: A total of 330 cases were studied, and 41 (12%) of them underwent a cesarean section due to cephalopelvic disproportion (CPD). There was no significant difference in mean OSA among the vaginal delivery and cesarean section groups (110.7 ± 11.1 degrees vs 110 ± 9.1 degrees, p = 0.649). The sensitivity of an OSA ≥ 100 degrees for predicting vaginal delivery was 83.7%, but its specificity was only 17.1%. The combination of an OSA ≥ 100 degrees, multiparity, and no induction of labor could predict vaginal delivery with a positive likelihood ratio 3.6.

Conclusion: The mean OSA among the vaginal delivery and cesarean section groups was not significantly different. The OSA alone was not a good predictor for vaginal delivery.

Keywords: occiput-spine angle, ultrasonography, prediction, vaginal delivery

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Received: 29 April 2019, **Revised:** 19 November 2020, **Accepted:** 10 March 2020

การทำนายความสำเร็จของการคลอดปกติทางช่องคลอดโดยใช้คลื่นเสียงความถี่สูงวัดมุม occiput-spine ในระยะที่หนึ่งของการคลอด

คัทลียา มุขดี, ฐิติมา สุนทรสัจ, ชุษณา เพชรพิเชฐเชียร

บทคัดย่อ

วัตถุประสงค์: *เพื่อศึกษาความแม่นยำของการวัดมุม occiput-spine (OSA) ในระยะที่หนึ่งของการคลอดเพื่อทำนายการดำเนินการคลอดและผลการคลอด*

วัสดุและวิธีการ: *สตรีตั้งครรภ์เดี่ยวที่ทารกมีส่วนนำเป็นศีรษะช่วงอายุครรภ์ 37 สัปดาห์ถึง 41 สัปดาห์ 6 วัน ที่มีอาการเจ็บครรภ์คลอดตั้งแต่เดือนกุมภาพันธ์ พ.ศ. 2561 ถึงเดือนมกราคม พ.ศ. 2562 จะได้รับการตรวจคลื่นเสียงความถี่สูงผ่านทางหน้าท้องเพื่อวัด OSA 2 ครั้ง โดยครั้งแรกวัดช่วงที่ปากมดลูกเปิดระหว่าง 3-6 เซนติเมตรและครั้งที่ 2 วัดอีก 2 ชั่วโมงถัดมา วิเคราะห์ค่าทางสถิติเพื่อทำนายการดำเนินการคลอดและผลการคลอด*

ผลการศึกษา: *สตรีตั้งครรภ์ 330 รายได้รับการตรวจ OSA และ 41 ราย (ร้อยละ 12) คลอดโดยการผ่าท้องทำคลอดเนื่องจากการผิดสัดส่วนระหว่างศีรษะทารกกับอุ้งเชิงกราน ค่าเฉลี่ยของ OSA ในกลุ่มที่คลอดปกติทางช่องคลอดกับกลุ่มที่ผ่าท้องทำคลอดไม่มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติ (110.7 ± 11.1 องศา และ 110 ± 9.1 องศาตามลำดับ p = 0.649) เมื่อใช้ OSA ≥ 100 องศา จะมีความไวในการทำนายการคลอดทางช่องคลอดเท่ากับร้อยละ 83.7 แต่มีความจำเพาะเพียงร้อยละ 17.1 ถ้าใช้ OSA ≥ 100 องศาร่วมกับครรภ์หลังและไม่ได้กระตุ้นการคลอดจะทำนายการคลอดทางช่องคลอดได้โดยมีสัดส่วนความน่าจะเป็นผลบวกเท่ากับ 3.6*

สรุป: *ค่าเฉลี่ยของ OSA ไม่แตกต่างกันในกลุ่มที่คลอดทางช่องคลอดกับกลุ่มที่ผ่าท้องทำคลอด การใช้ OSA เพียงอย่างเดียวไม่สามารถทำนายการคลอดทางช่องคลอดได้ดี*

คำสำคัญ: *มุม occiput-spine, คลื่นเสียงความถี่สูง, การทำนาย, การคลอดทางช่องคลอด*

Introduction

For several decades, the ultrasound has played an important role in the diagnosis of many obstetric problems. Currently, additional benefits of the ultrasound are being proposed, e.g., for the evaluation and prediction of the course and outcome of labor in pregnant women with a cephalic presentation fetus[1-7]. Transabdominal and/or translabial scans such as occiput-spine angle (OSA)[1-2], fetal head position[3,5], angle of progression (AoP)[4,6], midline angle (MLA)[6], and head-perineum distance (HPD)[7] are used in the first and/or second stage of labor. However, some studies have shown that the ultrasound has a higher accuracy than a per-vaginal examination to evaluate labor progression[3,6].

Data collected from 1990 to 2014 revealed that the rate of cesarean sections has increased globally from 16.7% in 1990 to 19.1% in 2014[8]. In Thailand, the cesarean section rate has increased as well, from 20.7% in 2001 to 39.4% in 2014[9]. More than half of the cases are as a result of a cesarean section in the first pregnancy due to the arrest of labor progression[8-10]. The term, cephalopelvic disproportion (CPD), is commonly used as an indication for a primary cesarean section. This condition is caused by a contracted maternal pelvis, fetal macrosomia, and an abnormal fetal head position such as persistent occiput posterior, deflexion, and asynclitism[11-13]. The accurate diagnosis of the causes of an abnormal labor progression is quite important to avoid an unnecessary cesarean section in the first pregnancy and also decrease morbidity and mortality associated with a repeated cesarean section in subsequent pregnancies.

In clinical practice, the abdominal and digital vaginal examinations are the standard methods to evaluate the causes of the arrest of labor progression. However, they are dependent on the skill and experience of the physician. To improve the accuracy of labor assessment, currently, the ultrasound has come to the fore. Some ultrasound parameters could be used in assessing the progress of labor as well as predicting labor outcomes. One of such parameters, the occiput-spine angle (OSA), which is performed by measuring a line tangential to the fetal occiput and a line tangential to the cervical spine on the sagittal plane, has shown a high sensitivity, specificity, and accuracy in the prediction of the mode of delivery and overall complications. Fetuses with a smaller OSA (<125 degrees) are at an increased risk for obstetric intervention (cesarean or vacuum delivery) due to labor arrest[1-2] and have a higher incidence of maternal and fetal complications[2]. However, data concerning this parameter are limited, and, to our knowledge, there are no reports from countries in Asia. Therefore, the objective of this study was to determine the accuracy of OSA during the first stage of labor in predicting the course and outcomes of labor.

Materials and methods

A prospective study was performed from February 2018 to January 2019 at two major tertiary hospitals in Songkhla Province, Thailand (Songklanagarind Hospital and Hat Yai Hospital). After the ethics committee of our institutional research board (IRB) approved the study, 330 nonconsecutive series of singleton pregnant women with cephalic presentation, which had completed between 37 weeks and 41 weeks and 6 days of gestation and were experiencing labor pain, were enrolled. A full description of the study aims and measurement methods was provided before the recruited participants agreed to give their informed consents. The exclusion criteria were multiple gestations, non-cephalic fetus, fetal anomaly, dead fetus in utero, planned elective cesarean section and cesarean section by other indications except labor arrest. Then, all of the pregnant women with a cervical dilatation between 3 cm and 6 cm and regular uterine contractions were scanned using a 2-dimensional transabdominal ultrasound (Toshiba SSA-590A with a 3.75 MHz curvilinear transducer or Samsung Sonoace R5 with a 4.6 MHz curvilinear transducer) at labor rooms. Fetal biometry, amniotic fluid volume, and placental position were examined. The fetal spine position was described using a clock face reference. The occiput posterior position (between the 4 and 8 o'clock position) was excluded. Only fetuses with

anterior (between the 10 and 2 o'clock position) or transverse (between the 2 and 4 o'clock, and the 8 and 10 o'clock positions) occiput positions were proceeded to find a sagittal view of the fetal head and upper spine. On the sagittal-view image, the angle formed by the line tangential to the occipital bone and another one tangential to the first vertebral body of the cervical spine (occiput-spine angle, OSA) was measured as described by Ghi et al[1] and showed in Fig. 1. Two measurements were performed on two different pictures in each case. Subsequently, OSA was repeated at the following two hours. The first 30 cases were used to evaluate the intra- and inter-observer variations between the first author (C.M.) and the third author (C.P.).

Fig. 1. Angle A: The occiput-spine angle (OSA) on the sagittal plane.

The in-charge physicians were not informed about the ultrasound results. The labor management of all participants followed the standard intrapartum care, and the course and outcomes of labor were recorded. CPD was diagnosed by the in-charge physicians based on clinical examinations and abnormal labor progression findings: 1) a protracted first stage of labor was defined as a cervical dilatation < 1.2 cm/hr or a fetal head descent < 1 cm/hr in nulliparous women and a cervical dilatation < 1.5 cm/hr or a fetal head descent < 2 cm/hr in multiparous ones; 2) arrest disorders were defined as a non-progression of cervical dilatation or no fetal-head descent for > 2 hours; and 3) a prolonged second stage of labor was defined as a second stage of labor lasting > 2 hours in nulliparous women and > 1 hour in multiparous ones (an additional 1 hour was allotted if an epidural block was performed)[12].

The participants who underwent cesarean sections due to any other causes such as fetal distress were also excluded from the study.

Statistical analysis

The study sample was calculated using 80% sensitivity and 80% specificity for the prediction of vaginal delivery. The defined α value was 0.05, and the value for an acceptable error was 0.15; this indicated that 312 women were required.

All of the collected data were double entries and validated using the Epidata version 3.1 program, while the statistical analysis was performed using the R program, version 3.5.1. The demographic and clinical characteristics were compared between the vaginal delivery (VD) group and the cesarean section due to CPD group using student's t-test or Pearson's chi-squared test. The intraclass correlation coefficients (ICC) were calculated to determine intra-observer and inter-observer variability. Only the OSA measurements by C.M. were used in the analysis.

The changing trend of OSA vs cervical dilatation and OSA vs fetal head station are shown by box plots. The OSA values at the first measurement and the one performed at the following two hours in both the VD

and CPD groups were compared using the paired t-test. The association between OSA and the duration of the first and second stage of labor in both groups were analyzed using correlation coefficients.

A multiple logistic regression analysis was employed to analyze the factors that associated with a cesarean section due to CPD. The receiver operating characteristic (ROC) curves of OSA at the first measurement and at two subsequent hours for the prediction of a successful VD were also plotted. The diagnostic values of OSA have also been presented in terms of sensitivity, specificity, negative predictive value (NPV), positive predictive value (PPV) and positive likelihood ratio (LR+). A p value of less than 0.05 was considered statistically significant.

Results

Three hundred and thirty pregnant women were recruited during the study period. Their median age was 27 years, and the median gestational age at delivery was 39.3 weeks. Cesarean section due to CPD was found in 41 cases (12.4%). There was no significant difference in demographic data and outcomes of labor among the VD and cesarean section due to CPD groups, except for parity, oligohydramnios, epidural analgesia, induction of labor, duration of first stage of labor, duration of second stage of labor, and birth weight (Table 1).

Table 1. Demographic data and outcomes of delivery.

Demographic data and outcomes of delivery	Vaginal delivery (n = 289)	Cesarean delivery (n = 41)	p value
Age, median (IQR), years	26 (22, 32)	27 (23, 31)	0.76
Weight, median (IQR), kg	66 (59.3, 77)	69.7 (58, 81)	0.23
Body mass index, median (IQR), kg/m^2	26.8 (23.8, 31.2)	27.7 (25.6, 32.3)	0.11
Nulliparous (%)	127 (43.9)	31 (75.6)	< 0.001
Gestational age at delivery, median (IQR), weeks	39.3 (38.3, 40.1)	39.3 (38.7, 40.3)	0.28
Medical disease			
Hypertension (%)	4 (1.4)	2 (4.9)	0.16
Thyroid disease (%)	2 (0.7)	0 (0)	1
Cardiovascular disease (%)	4 (1.4)	1 (2.4)	0.49
Obstetric complications			
Gestational diabetes mellitus (%)	18 (6.2)	5 (12.2)	0.18
Preeclampsia (%)	10 (3.5)	3 (7.3)	0.21
Premature rupture of membrane (%)	52 (18)	7 (17.1)	1
Fetal growth restriction (%)	5 (1.7)	1 (2.4)	0.55
Oligohydramnios (%)	1 (0.3)	4 (9.8)	< 0.001
Epidural analgesia (%)	0 (0)	3 (7.3)	0.002
Induction of labor (%)	15 (5.2)	10 (24.4)	< 0.001
Augmentation of labor (%)	185 (64)	30 (73.2)	0.33
Length of first stage , mean (SD), minutes	520.4 (239.6)	659 (217.2)	< 0.001
Length of second stage, mean (SD), minutes	21.4 (25)	148.5 (50.4)	< 0.001
Birth weight, mean (SD), grams	3049.1 (418.2)	3222.9 (463.8)	0.015
Apgar score < 7 at 1 minute (%)	2 (0.7)	2 (4.9)	0.08

IQR: interquartile range, SD: standard deviation

The mean OSA of the first and second measurements was 110.1 ± 9.4 degrees and 113.5 ± 9.2 degrees, respectively. There was no significant difference in mean OSA among the two groups regarding either time of measurement. However, the time from first measurement to delivery and the time from second measurement to delivery were significantly shorter in the VD group compared with the cesarean section due to CPD group (Table 2).

Table 2. Ultrasound measurements.

Ultrasound measurements	Vaginal delivery (n = 289)	Cesarean delivery (n = 41)	p value
First measurement			
OSA, mean (SD), degrees	110 (9.1)	110.7 (11.1)	0.649
Position of fetal head			
OA (%)	135 (46.7)	14 (34.1)	0.178
OT (%)	154 (53.3)	27 (65.9)	
Time to delivery, mean (SD), minutes	191.1 (128.2)	334.9 (150.5)	< 0.001
Second measurement			
OSA, mean (SD), degrees	113.9 (8.7)	112.2 (11.4)	0.360
Position of fetal head			
OA (%)	62 (43.1)	9 (26.5)	0.176
OT (%)	75 (52.1)	22 (64.7)	
OP (%)	7 (4.9)	3 (8.8)	
Time to delivery, mean (SD), minutes	168.4 (101.6)	249.3 (130.6)	< 0.001
OSA change after 2 hours, mean (SD), degrees	6.7 (8.9)	3.7 (8.2)	0.093

OSA: occiput-spine angle, OA: occiput anterior, OT: occiput transverse, OP: occiput posterior, SD: standard deviation

The OSA measurement yielded low intra- and inter-observer variability. The ICC of the intra-observer OSA measurements by C.M. and C.P. was 0.79 (95% confidence interval (CI) 0.74-0.82) and 0.85 (95%CI 0.71-0.93), respectively. The ICC of the inter-observers was 0.76 (95%CI 0.55-0.88).

There was a positive correlation between the first OSA measurement and cervical dilatation (Fig. 2) as well as the second OSA measurement and fetal head station (Fig. 3).

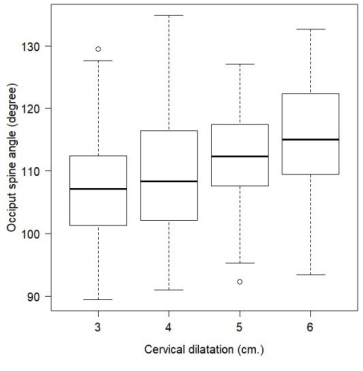

Fig. 2. The distribution of the first OSA measurement values according to cervical dilatation.

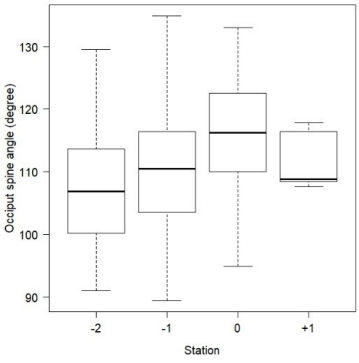

Fig. 3. The distribution of the first OSA measurement values according to fetal head station.

The multivariate analysis found the factors that increased the risk for cesarean section due to CPD were nulliparity (OR 2.86; 95%CI 1.26-6.48), induction of labor (OR 10.77; 95%CI 3.66-31.67), first stage of labor > 500 minutes (OR 2.6; 95%CI 1.06-6.34), time from the first OSA measurement to delivery > 180 minutes (OR 3.53; 95%CI 1.43-8.73), and birth weight > 3,000 gm (OR 3.01; 95%CI 1.3-7.0) as shown in Table 3.

Table 3. Multivariate analysis of factors correlated with cesarean delivery due to CPD.

Factors	Adjusted Odds ratio	95%CI	p value
Nulliparous	2.86	1.26-6.48	0.012
Induction of labor	10.77	3.66-31.67	< 0.001
Length of first stage > 500 minutes	2.6	1.06-6.34	0.036
Time to delivery after first OSA > 180 minutes	3.53	1.43-8.73	0.006
Birth weight >3,000 grams	3.01	1.3-7	0.01

CPD: cephalopelvic disproportion, CI: confidence interval, OSA: occiput-spine angle

The ROC curves of OSA were plotted, and the best cut-off value for the first measurement to predict a successful VD was 100 degrees (AUC = 0.516) as demonstrated in Fig. 4. For the second OSA measurement, the best cut-off value was 110 degrees (AUC = 0.565) as shown in Fig. 5.

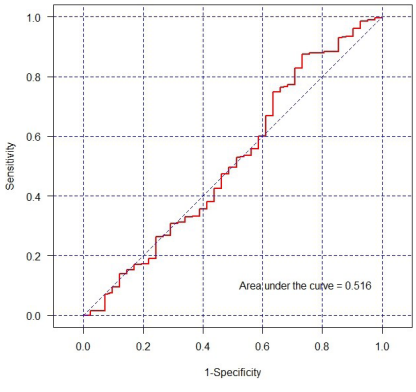

Fig. 4. Receiver operating characteristic (ROC) curve of the first OSA measurement for predicting vaginal delivery.

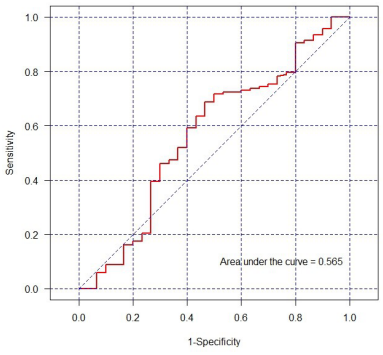

Fig. 5. Receiver operating characteristic (ROC) curve of the second OSA measurement for predicting vaginal delivery

The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and positive likelihood ratio (LR+) of the parameters for the prediction of a successful VD are presented in Table 4. The combination of the first OSA ≥ 100 degrees, multiparous status, and no induction of labor could predict a successful VD with a LR+ 3.6 and a PPV 96.2%.

Table 4. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and positive likelihood ratio (LR+) of parameters for predicting vaginal delivery.

Parameters	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	LR+ (95% CI)
First OSA ≥ 100 degrees	83.7 (79-87.8)	17.1 (7.2-32.1)	87.7 (86-89.2)	13 (6.7-23.5)	1 (0.9-1.2)
First OSA ≥ 100 degrees + multiparous	46.4 (40.5-52.3)	80.5 (65.1-91.2)	94.4 (89.9-96.9)	17.6 (15-20.4)	2.4 (1.3-4.5)
First OSA ≥ 100 degrees + no induction	79.9 (74.8-84.4)	39 (24.2-55.5)	90.2 (87.8-92.2)	21.6 (15-30.1)	1.31 (1-1.7)
First OSA ≥ 100 degrees + multiparous + no induction	43.9 (38.1-49.9)	87.8 (73.8-95.9)	96.2 (91.7-98.3)	18.2 (16-20.6)	3.6 (1.6-8.3)

OSA: occiput-spine angle

Discussion

Several studies have reported that the ultrasound examination is a useful method for assessing the progress of labor and predicting labor outcomes. In the normal physiology of labor, after fetal head engagement and descent, the fetal head will flex more before rotation, extension, and expulsion-these are the cardinal movements of labor[12-13]. The more fetal head flexes, the greater the OSA. Ghi, et al[1] found that an OSA < 125 degrees (OR 1.08; 95%CI 1.00-1.16) and nulliparous status (OR 16.06; 95%CI 1.71-150.65) were risk factors for operative delivery due to labor arrest. Meanwhile, an OSA > 125 degrees was associated with a shorter duration of labor (hazard ratio = 1.62; 95%CI

1.07-2.45). In addition, Maged and colleagues[2] reported that there was a significantly longer duration of both the first and second stages of labor with a higher rate of cesarean section as well as maternal and fetal complications in women with an OSA < 126 degrees. Their sensitivity, specificity, PPV, and NPV of an OSA < 126 degrees for predicting the mode of delivery were 82%, 64.6%, 45%, and 96.2%, respectively. However, our results were different from those of the Ghi and Maged studies. We found no statistical significance in the variance of mean OSA in the VD and CPD groups, and the best cut-off OSA was 100 degrees. These could be explained by the possibility that the CPD in our group may not have been caused by fetal head deflexion or different criteria for CPD diagnosis. Moreover, pelvic shapes and sizes differ with ethnicity.

Another ultrasound parameter that can predict a successful VD is an AoP ≥ 113 degrees at the second stage of labor[4]. For predicting delivery within 120 minutes after measurement in nulliparous women, the LR+ of an AoP ≥ 160 degrees and an MLA < 10 degrees have been reported at 3.6 and 2.0 respectively. Meanwhile, for predicting delivery within 60 minutes after measurement in multiparous women, the LR+ of an AoP ≥ 150 degrees and an MLA < 20 degrees have been reported at 2.4 and 1.3[6]. Moreover, Kahrs and colleagues[7] found that the sensitivity, false positive rate, PPV, and NPV of an HPD > 35 mm for predicting cesarean delivery were 56%, 16%, 22%, and 96%, respectively.

Our study indicated that the factors correlating with cesarean section due to CPD are parity, induction of labor, length of first stage of labor, time to delivery after the first OSA measurement, and birth weight. This was similar to the findings of a previous study by Ghi and colleague[1]. According to our study results, the mean OSA among the vaginal delivery and cesarean section groups was not significantly different. Then, OSA alone was not a good predictor for vaginal delivery. To improve the diagnostic accuracy in predicting vaginal delivery, a combination of all three parameters (a first OSA measurement value ≥ 100 degrees, multiparous status, and no induction of labor) is suggested (LR+ 3.6, PPV 96.2%).

The strengths of our study were its description of the complete delivery outcomes and the small variability in ultrasound measurements because they were only performed by the first author. However, there were some limitations. Firstly, the diagnosis of CPD was dependent on and varies among obstetricians. Secondly, in some cases, no data regarding the estimated fetal weight and clinical pelvimetry assessment were available. Thirdly, there might be a selection bias of participants because of nonconsecutive recruitment. However, we used the same method as Ghi, et al[1].

A suggestion for future research is evaluation of other ultrasound parameters (AoP, MLA or HPD) in order to improve the accuracy of predicting the progression of labor and successful vaginal delivery.

Conclusion

The OSA measurement by ultrasound in first stage of labor showed good reliability in both intra and inter-observers. However, the OSA alone is not a good predictor for successful vaginal delivery and it cannot be performed in occiput posterior position. The combination of OSA with other clinical and ultrasound parameters such as parity, induction of labor, AoP, MLA and HPD should improve the accuracy of prediction.

Acknowledgements

This study was granted from the Faculty of Medicine, Prince of Songkla University.

Potential conflicts of interest

The authors declare no conflict of interest.

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