Effect of Halogen Light in Fetal Stimulation for Fetal Well-being Assessment

Isarin Thanaboonyawat MD*,
Tuangsit Wataganara MD*, Dittakarn Boriboonhiransarn MD*, MPH, PhD*,
Sommai Viboonchart BN*, Pornpen Tontisirin BN*

** Department of Obstetrics and Gynecology, Faculty of Medicine, Siriraj Hospital, Mahidol University*

Objective: *To evaluate the shortening of the time of nonstress test (NST) by using transabdominal fetal stimulation with halogen light.*
Study design: *Experimental research*
Material and Method: *The authors enrolled 176 pregnant women between 32 and 42 weeks of gestation indicated for NST at the Division of Maternal Fetal Medicine, Siriraj Hospital, Mahidol University. They were randomly assigned to receive either NST (control) or halogen light stimulation test (LST). The stimulation was performed at the beginning of the test and repeated every 10 minutes until reassuring fetal heart rate (FHR) acceleration was achieved, or up to 3 times. All tracings were interpreted blindly by one investigator at the end of the tests.*
Results: *The mean (± SD) duration from starting the test to the first FHR acceleration was not significantly different between the control group and the LST group (5.6 ± 7.2 and 5.4 ± 5.2 minutes, respectively). The average testing time (± SD) to achieved reactivity was 10.5 ± 8.8 minutes in the controls and 9.6 ± 6.7 minutes in the LST group. This was not statistically different. The incidence of nonreactive tests was not significantly different between the LST and the controls (15.9% and 11.4%, respectively). Among the LST subjects, term fetuses and women with BMI < 27 kg/m^2 required less time to reach reactivity, 2.4 and 2.3 minutes respectively.*
Conclusion: *Transabdominal halogen light stimulation did not shorten the duration of NST in the presented population. However, the presented data suggests that the fetus at term could respond to visual stimulation, especially when the gestational age is more advanced.*

Keywords: *Halogen light stimulation test, Fetal well-being, Nonstress test, Fetal heart rate reactivity, Fetal physiology*

J Med Assoc Thai 2006; 89 (9): 1376-80
Full text. e-Journal: *http://www.medassocthai.org/journal*

Assessment of the health of the fetus could be achieved by a variety of venues. Hypoxia of the fetus could result in an alteration in vagal control of cardiac function. The resulting abnormal fetal heart rate (FHR) pattern could be demonstrated by a non stress test (NST) that is now an integral part of modern obstetrics[1]. The accepted reassuring result has been a FHR acceleration of at least 15 beats per minute twice and lasting longer than 15 seconds from the baseline within a 20-minute interval. This has been giving the mother a confidence of fetal well being for at least a week onward.

However, NST is a considerably lengthy test. According to a fetal behavioral study, a term healthy fetus could be in a 'quiet sleep' (state 1F) for as long as 120 minutes[2]. During this "quiet sleep", lack of FHR acceleration is anticipated. In busy obstetric service units, several methods of stimulation have been reported to alter fetal behavioral state and provoke FHR acceleration to shorten the testing time. This includes vibroacoustic stimulation, manual fetal manipulation, and elevation of maternal blood glucose by making the mother drink fruit juice[3,4].

Correspondence to : Wataganara T, Department of Obstetrics and Gynecology, Faculty of Medicine, Siriraj Hospital, Mahidol University, Bangkok 10700, Thailand. Phone: 0-2419-4666, Fax: 0-2418-2662, E-mail: sitwg@mahidol.ac.th

Lately, a group of investigators in Japan has reported a physical response of the fetus to external light stimulation[5]. By using an intense light applying on the maternal abdominal wall, Caridi et al reported a significantly shorter duration of testing to achieve a reactive result[6]. The medical literature suggested that fetal stimulation with halogen light is safe for both the mother and the fetus[5]. In this prospective randomized control trial, the authors sought to evaluate the effectiveness of halogen light stimulation to testing duration for pregnancies indicated for fetal well-being assessment.

Material and Method

The present study was approved by the Ethics Committee of the Faculty of Medicine Siriraj Hospital. One hundred and seventy six pregnant women who underwent NST in the Division of Maternal-Fetal Medicine, Department of Obstetrics and Gynecology, Faculty of Medicine Siriraj Hospital were enrolled. Signed informed consents were obtained from all the participants. The authors enrolled only singleton pregnant women in their 32 to 42 weeks of gestation. Exclusion criteria included gestational age of less than 32 weeks, regular uterine contraction (of at least once every 8 minutes), ruptured amnionic membranes, and dead fetus *in utero*. These pregnant women were randomly assigned to receive the NST or light stimulation test (LST) using the randomization table.

Nonstress test

All patients underwent NST in the semi-fowler position. The authors used Philips Antepartum Monitor Series 50A (Philips, Andover, MA, USA) for NST, with paper speed of 1 cm per minute. FHR baseline was recorded. Reactive pattern was defined as twice adequate FHR acceleration (amplitude of $\geq$ 15 beats per minute above baseline, lasting $\geq$ 15 seconds) within 20-minute period. All the tests were performed by specially trained residents and perinatal nurses. They were interpreted by one investigator (TW) without preexisting knowledge of the clinical information for each subject.

External light stimulation

In the LST group, the authors used the flashlight-like halogen light source of 1,000,000 candle light (CE Spotlight, Grand Globalization Group Co. Ltd., Bangkok Thailand) that could be purchased locally. Its luminosity is equivalent to Vector Compact Sport Spot (Ft Lauderdale, FL, USA) previously reported for fetal stimulation[6]. The 10-cm diameter light surface was placed gently on the mother's abdominal wall over the fetal head for 10 seconds.

In cases where fetal position was questionable, ultrasonography was performed prior to the light source placement. The fetus was stimulated for 10 seconds at the beginning of the test. It was repeated every 10 minutes until an adequate FHR acceleration was obtained or up to 3 times if no adequate FHR acceleration was observed. Without adequate FHR accelerations, the test was extended to up to 40 minutes before that test was interpreted as nonreactive.

Statistical analysis

Based on the evaluation of duration to obtain the first FHR acceleration and reactive test result from the pilot study of 30 cases, the mean reduction of testing time for a reactive test was 1.6 minutes. Using the power of 80% to achieve the 5% significant level, the calculated sample size was 60 in each arm. Descriptive statistics, including means and standard deviations (SDs), were generated for all studied variables. The authors compared duration time obtaining the first FHR acceleration and reactive test result between the two methods by using Student's t test. Chi square test for categorical variables was used as appropriate, clinical co-variables that potentially affect the reactivity of the test in the LST group were also determined. All statistical analyses were performed using SPSS for Windows Release 11.5 (SPSS Inc, Chicago, IL). Statistical significance was assigned where p value was less than 0.05.

Results

The authors enrolled 176 pregnant women in the present study, of which 88 received standard NST and 88 received LST. The indications for performing fetal-well being assessment are shown in Table 1. Poor maternal weight gain (less than 0.5 kg/week) and decreased fetal movement were the 2 most common indications for the test. Medical complications of the participants included valvular heart disease, hyperthyroidism, gestational diabetes, and HIV infection.

The mean ($\pm$ SD) maternal age was 27.0 ($\pm$ 6.2) years in the NST group and 27.7 ($\pm$ 5.8) years in LST group, which were not statistically different. There was no significant difference in the parities between these two groups. Preterm cases were slightly more prevalent in the LST group compared to the control (34.1% and 27.3%, respectively), but was not statistically significant (p = 0.33). BMI in the LST group was signifi-

cantly lower than the NST group. The rest of the demographic variables are shown in Table 2.

The authors found nonreactive results in 15.9% of LST and 11.4% of controls, which were not significantly different. None of the subjects had adequate FHR acceleration within 2 minutes from the beginning of the test. The mean (± SD) test duration for the first acceleration was 5.4 (± 5.2) minutes in LST and 5.6 (± 7.2) minutes in control group, which were not statistically different. The average (± SD) time to obtain reactive results was slightly shorter in the LST group than the controls (9.6 ± 6.7 and 10.5 ± 8.8 minutes, respectively, but without statistical significance). The reactivity of the test in each arm is shown in Table 3.

Table 4 reveals the lack of benefit of LST in reducing the testing time as stratified by gestational age and maternal BMI. However, among the patients who received light stimulation, the authors found shorter test duration to achieve reactivity in those

Table 1. Indications for NST (control) and light stimulation test (LST) (n = 176)

Indications	NST (n = 88)	LST (n = 88)	p-value
Poor maternal weight gain	58 (65.9%)	55 (62.5%)	0.72
Decreased fetal movement	17 (19.3%)	16 (18.2%)	
Medical complications	13 (14.8%)	17 (19.3%)	

Table 2. Patient's characteristics in NST (control) and light stimulation test (LST) (n = 176)

Characteristics	NST (n = 88)	LST (n = 88)	p-value
Age (years)	27.0 ± 6.2	27.7 ± 5.8	0.49
BMI (kg/m^2)	27.1 ± 3.9	25.8 ± 4.1	0.03*
GA (weeks)	37.3 ± 1.8	36.9 ± 1.8	0.20
Preterm(GA 32-36 weeks)	24 (27.3%)	30 (34.1%)	0.33
Nullipara	55 (62.5%)	53 (60.2%)	0.76

* (p value < 0.05) statistical significance

Table 3. Comparison of fetal reactiveness results

Results	NST (n = 88)	LST (n = 88)	p-value
Time to first acceleration (minutes)	5.6 ± 7.2	5.4 ± 5.2	0.86
Time to reactive (minutes)	10.5 ± 8.8	9.6 ± 6.7	0.49
Nonreactive result	10 (11.4%)	14 (15.9%)	0.38

Table 4. Results of nonstress test stratified by gestational age and BMI

Result	Factor	NST	LST	p-value
Time to first acceleration (minutes)	Preterm	4.4 ± 5.4	5.9 ± 6.2	0.39
	Term	6.0 ± 7.6	5.1 ± 4.5	0.48
	BMI < 27	5.6 ± 7.4	5.0 ± 4.5	0.67
	BMI ≥ 27	5.6 ± 6.9	6.0 ± 6.2	0.76
Time to reactive (minutes)	Preterm	8.1 ± 7.4	10.9 ± 6.8	0.18
	Term	11.2 ± 9.1	8.8 ± 6.6	0.12
	BMI < 27	11.1 ± 9.9	8.8 ± 6.1	0.21
	BMI ≥ 27	9.8 ± 7.4	10.9 ± 7.7	0.56

whose fetuses were term and maternal BMI less than 27 kg/m^2. From univariate analysis, the authors were able to decrease the testing duration 2.4 minutes and 2.3 minutes in pregnant women at term and BMI of less than 27 kg/m^2 respectively but without significant difference.

Discussion

Assessment of fetal health through the evaluation of FHR pattern has become an integral part of modern obstetrics. However, the naturally long sleep-wake cycle of the fetus could result in an unnecessarily prolonged testing time. "Waking" the fetus using light stimulation from outside the uterine cavity has been reported to accelerate the FHR reactivity, and may be beneficial in busy obstetric services. In the present study, the authors demonstrated a considerably large sample size for fetal light stimulation study, compared to the previous reports[5-7]. The light source was a halogen light with 1,000,000 candle lights that could be purchased locally. Its power was equivalent to Vector Compact Sport Spot that has been proven to be the most intense light source to penetrate the thick tissue[8]. Exposure to halogen light source for less than 10 seconds each time with 10 minutes' interval is not harmful to the fetus. Furthermore, maternal discomfort or thermal injury of the contacted skin is negligible[8]. Counter intuitively, the present study did not show that fetal light stimulation offers the benefits of decreasing the incidence of nonreactive cardiotocography or shortening the testing time. This is in contradiction to Caridi B et al who reported 2.1 minutes saving for the first acceleration detection and 4.2 minutes saving for a reactive result in LST group[6]. The data, however, suggested that the fetus could respond better to light stimulation when it is approaching term gestation.

Even though it has been proven in vitro that the fetal optic pathway is completed at the gestational age of 22 weeks, the effectiveness of fetal stimulation in early gestation is still elusive[5]. Neural connections in the brainstem, which control FHR response, may not be fully established until later on in gestation. Boos et al reported a null result in fetal stimulation using halogen light[7]. Factors that might affect the success of fetal visual stimulation might include abdominal wall thickness of the mother, and the gestational age. In addition, the location of fetal eye related to the light source was not controlled in the present study, since it is unlikely to be practical in daily practice. Finally, the slightly more prevalent preterm cases in the LST group might contribute to the lack of difference in the present study.

The presented data indicated that term gestation positively affected the reactivity of LST. Vibroacoustic stimulation, on the contrary, could satisfactorily be applied to stimulate premature fetuses, and significantly reduce the testing time[9]. This finding agreed with the previous publication by Tatsumura that the fetus consistently responds to light stimulation only after the gestational age of 37 weeks[10]. Thin abdominal barrier in the mothers with low BMI naturally help the *in utero* illumination, and thus, could enhance the FHR reactivity, as shown in the LST group. To the authors' knowledge, there are no specific contraindications for this fetal light stimulation test. No serious untoward effects of this light stimulation to the mother or the fetus have been reported to date.

In conclusion, LST might be suitable only in selected fetuses of advanced gestational age. LST could be an alternative of stimulation in the fetus with impaired hearing pathway[11,12]. However, in an active obstetric service, it is not very convenient to select only favorable patients to receive light stimulation. Fetal light stimulation may not replace routine vibroacoustic stimulation until the authors better understand the developmental neurophysiology of the growing fetus.

References

1. Phelan J. The nonstress test: a review of 3,000 tests. Am J Obstet Gynecol 1981; 139: 7-10.
2. Brown R, Patrick J. The nonstress test: how long is enough? Am J Obstet Gynecol 1981; 141: 646-51.
3. Tongsong T, Piyamongkol W. Comparison of the acoustic stimulation test with nonstress test. J Reprod Med 1994; 39: 17-20.
4. Miller D. External stimuli. Clin Obstet Gynecol 2002; 45: 1054-62.
5. Kiuchi M, Naoki N, Ikeno S, Terakawa N. The relationship between the response to external light stimulation and behavioral states in the human fetus: how it differs from vibroacoustic stimulation. Early Hum Dev 2000; 58: 153-65.
6. Caridi B, Bolnick JM, Fletcher BG, Rayburn WF. Effect of halogen light stimulation on nonstress testing. Am J Obstet Gynecol 2004; 190:1470-2.
7. Boos R, Gnirs J, Auer L, Schmidt W. Controlled acoustic and photic stimulation of the fetus in the last pregnancy trimester. Z Geburtsh Perinatol 1987; 191: 154-61.
8. Rayburn B, Theele D, Bolnick J, Rayburn W. Selection of a light source for fetal biophysical

testing. J Reprod Med 2004; 49: 563-5.
9. Bartnicki J, Dimer JA, Hertwig K, Dudenhausen JW. Computerized cardiotocography following vibroacoustic stimulation of premature fetuses. Gynecol Obstet Invest 1998; 45: 73-6.
10. Tatsumura M. Study on features of fetal movement and development of human fetus with use of fetal actogram. Nippon Sanka Fujinka Gakkai Zasshi 1991; 43: 864-73.
11. van Heteren CF, Boekkooi P, Jongsma HW, Nijhuis JG. The responses to repeated vibroacoustic stimulation in a fetus with trisomy 18. Eur J Obstet Gynecol Reprod Biol 2001; 96: 123-5.
12. van Heteren CF, Boekkooi P, Jongsma HW, Nijhuis JG. Responses to vibroacoustic stimulation in a fetus with an encephalocele compared to responses of normal fetuses. J Perinat Med 2000; 28: 306-8.

ผลของการใช้แสงฮาโลเจนในการกระตุ้นทารกเพื่อการประเมินสุขภาพทารกในครรภ์

อิสรินทร์ ธนบุณยวัฒน์, ตวงสิทธิ์ วัฒกนารา, ดิฐกานต์ บริบูรณ์หิรัญสาร, สมหมาย วิบูลย์ชาติ, พรเพ็ญ ตันติศิรินทร์

วัตถุประสงค์*: เพื่อศึกษาถึงการลดระยะเวลาในการตรวจความแข็งแรงของทารกโดยการกระตุ้นทารกในครรภ์ด้วยแสงฮาโลเจน*

รูปแบบงานวิจัย*: การวิจัยเชิงทดลอง*

วัสดุและวิธีการ*: ใช้ตารางสุ่มสตรีตั้งครรภ์จำนวน 176 รายที่มารับการตรวจเพื่อประเมินสุขภาพของทารกในครรภ์ที่หน่วยเวชศาสตร์มารดาและทารกของโรงพยาบาลศิริราช ในช่วงอายุครรภ์ระหว่าง 32 ถึง 42 สัปดาห์ ให้ได้รับการตรวจประเมินสุขภาพของทารกในครรภ์แบบมาตรฐาน (กลุ่มควบคุม) และแบบที่ทารกได้รับการ กระตุ้นด้วยแสงฮาโลเจนผ่านทางหน้าท้องมารดา ทารกที่อายุครรภ์ไม่เข้าเกณฑ์ หรือเสียชีวิตในครรภ์ ครรภ์แฝด หรือมารดาที่มีการหดรัดตัวของมดลูกอย่างสม่ำเสมอหรือมีน้ำเดินแล้วจะถูกคัดออกจากการทดลอง การกระตุ้นจะทำเมื่อเริ่มการตรวจประเมินสุขภาพของทารกในครรภ์ และซ้ำทุก 10 นาทีจนกระทั่งพบว่า อัตราการเต้นของหัวใจทารกเพิ่มขึ้นอย่างน้อยสองครั้ง (reactive) โดยจำนวนครั้งของการกระตุ้นรวมกันไม่เกิน 3 ครั้ง การแปลผลการตรวจจะทำโดยผู้วิจัยเพียงคนเดียวโดยไม่ทราบว่าได้รับการกระตุ้นด้วยแสงหรือไม่*

ผลการศึกษา*: ระยะเวลาเฉลี่ย (± ค่าเบี่ยงเบนมาตรฐาน) ตั้งแต่เริ่มทดสอบจนถึงเวลาที่ทารกมีอัตราการเต้นของหัวใจเพิ่มขึ้นครั้งแรกนั้นไม่แตกต่างกันระหว่างกลุ่มควบคุมและกลุ่มกระตุ้นด้วยแสงฮาโลเจน (5.6 ± 7.2 และ 5.4 ± 5.2 นาทีตามลำดับ) ระยะเวลาเฉลี่ย (± ค่าเบี่ยงเบนมาตรฐาน) ตั้งแต่เริ่มทดสอบจนถึงที่ได้ผล reactive ในกลุ่มควบคุมและกลุ่มกระตุ้นด้วยแสงคือ 10.5 (± 8.8) และ 9.6 (± 6.7) นาทีตามลำดับ ซึ่งไม่แตกต่างกันอย่างมีนัยสำคัญ อัตราการตรวจพบผล nonreactive ในกลุ่มควบคุมและกลุ่มกระตุ้นด้วยแสงคือ 11.4% และ 15.9% ซึ่งไม่แตกต่างกันอย่างมีนัยสำคัญ เมื่อพิจารณาเฉพาะในกลุ่มกระตุ้นด้วยแสงพบว่า ทารกที่มีอายุครรภ์มากกว่า 37 สัปดาห์ และมารดาที่มีดัชนีมวลกายน้อยกว่า 27 กิโลกรัมต่อตารางเมตรจะใช้เวลาในการทดสอบเพื่อให้ได้ผล reactive สั้นกว่าทารกในอายุครรภ์ก่อนกำหนดและในมารดาที่มีดัชนีมวลกายสูง เท่ากับ 2.4 และ 2.3 นาทีตามลำดับ*

สรุป*: การกระตุ้นทารกในครรภ์ด้วยแสงฮาโลเจนไม่สามารถร่นเวลาการตรวจสุขภาพทารกในครรภ์ในกลุ่มประชากรที่ศึกษา อย่างไรก็ตามข้อมูลของการศึกษานี้บ่งชี้ว่าทารกที่อายุครรภ์ครบกำหนดสามารถตอบสนองต่อแสงได้ดีกว่าทารกอายุครรภ์ก่อน 37 สัปดาห์*