

Evaluation of Obstetric Ultrasound Biological Hazard

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Abstract: *Ultrasound examination for pregnant women is related to some physical parameters which depends on the ultrasound examination device as well as on some physical properties of the examined women. The relation between these parameters may help in studying the cause of biological hazards by ultrasound. To do this, a sample of 150 women, were examined by using ultrasound equipment also exposure time was recorded. Some Perceptible variables like heating, headache and vomiting were not observed prior to examination and observed in most of the cases after examination even to non pregnant women. The heating effect is also observed in some recent researches. This gives strong motivation to do further studies that shows to what extent and under what conditions ultrasound may cause some side effects occur*

Keywords: pregnant, obstetric, ultrasound, biological hazards

1. Introduction

Ultrasound imaging has been in use over the three decades , the use of ultrasonic imaging as a diagnostic tool has increased considerably. Acoustic output of mechanics has also increased in some cases it can affect some potential hazards. The two damage mechanisms are heating and cavitations. Other potential mechanisms are mechanical forces, such as bulk acoustic streaming and standing wave radiation forces. (Whittingham,1998).

There are two damage mechanisms:

a) Heating

The absorption of ultrasound energy and self – heating of the probe causes heating in tissues. The tolerance of tissues to temperature elevation depends on the temperature rise and the type of tissue. Barnett (2000) has concluded : " A diagnostic exposure that produces a maximum temperature rise of no more than 1.5 c⁰ above normal physiological levels 37c⁰ may be used clinically without reservation on thermal grounds. A diagnostic exposure that elevates embryonic and fetal in situ temperature above 41c⁰ for 5minutes or more should be considered potentially hazardous" . (Whittingham,1998). Stephen Bly (2005) confirm the heating effect of temperature rise up to 6⁰ c for short exposure time (0.25 min). The fact that these side effect were not observed prior to ultrasound examination beside the experimentally observed heating effect in the above mentioned.

b) Cavitations

Cavitations refers to the production and growth of bubbles by negative pressure excursion. It is known that there are two forms of cavitations. The first is inertial cavitations. In inertial cavitations, pressure changes with large variation and that cause bubbles to form and collapse within one or two cycles, Here, tiny bubbles grow into larger bubbles and then collapse. This can create hazardous free radicals such as OH[·] . (Whittingham,1998).

The second form of cavitations is stable cavitations, is a less violent phenomenon requiring continuous waves, or very long pulses. In this case bubbles of a critical resonant size undergo large amplitude radial oscillations at the frequency of the applied ultrasound. Bubble surface area is increased,

when more gas is transferred into the bubble in negative pressure phase. Respectively, during the positive pressure the surface area is reduced. (Whittingham,1998).

The biological hazards and effects of ultrasound were studied by many authors (Williams AR, 1983), (Rowell LB, 1986). These effects are related to the heating effect, ionization which produces free radicals. The effect of frequency change of sound waves on tissues by heating or ionizing there is tackled by M.A. Hussein (M.A. Hussein, PhD thesis, SUST, 2011). He found that the frequency increase causes the voltage to decrease. This result may from the fact that ionization decrease resistance which decreases voltage in turn.

The effect of ionization is also recognized by the exposure criteria for medical diagnostic ultrasound technical report, issued by National Council on Radiation Protection and Measurements. This report mentioned that cavitations can produce free radicals like OH[·].

These free radicals OH[·] existence the medium is ionized [Ullamari Hakulinen, Report, LUT2, 2005]. He also found that the application of sound waves to any tissue in the frequency range (785 KHz to 830KHz) causes blood and water to be heated in the range of (37-53⁰c). This can be attributed to the fact that sound waves increase the molecules kinetic energy which causes temperature to rise. (M.A. Hussein, PhD thesis, SUST, 2011).

Obstetric Ultrasound Biological Effect and Safety were tackled by Stephen Bly and Michiel C. Van [PhD, at Health Canada Radiation Protection Bureau, Ottawa, June 2005]. They found that the obstetric ultrasound should be as low as reasonably achievable because of the potential for tissue heating when the thermal index exceeds 1. They also recommended that while imaging the fetus in the first trimester, Doppler and colour Doppler should be avoided. Stephen and Michiel in their study attached the table that relates the exposure duration to the temperature rise. This table (1) shows the degree of biological hazards when embryonic/fetal temperature rises above 37⁰ c.

Table 1: Exposure time and temperature rise

| Degree above normal 37 ⁰ c | Exposure duration per minute |
|---------------------------------------|------------------------------|
| 2 | 60 |
| 3 | 15 |
| 4 | 4 |
| 5 | 1 |
| 6 | 0.25 |

These values are a compromise between conclusions of the National Council on Radiation Protection and the World Federation for Ultrasound in Medicine and Biology. This research indicates that considerable temperature rise (6⁰ c) may take place in a very short exposure time (0.25 minute) which may cause biological hazard.

2. Materials and Methods

This section is devoted for the equipments and instruments used in relating the attenuation coefficient and the penetration depth of ultrasound to average of parameters for pregnant ultrasound test. These parameters include the women age, height, weight, body mass index BMI, acoustic power, ultrasound intensity, frequency and exposure duration time. The data is collected at Dongola city in Sudan, the specification of the ultrasound system used and the statistical beside mathematical techniques are presented in this section. The data collected and the relation between ultrasound attenuation coefficient and Perceptible variables and other parameters are displayed graphically and in the form of tables.

3. Instrumentation

The ultrasound examination for women was done by using the ultrasound system at Dongola Hospital Educational and the Dongola Clinic Model with the following specification the model of ultrasound system used for the following survey was Mindry – DP3300 with curve linear probe of frequency 3.5MHz, 6.5MHz as shown in fig(1) from operation manual.



Figure 1: Ultrasound System. (Operation manual .Mindry Bio- medical electronics Co, ltd.)

Calibration of the devices

The ultrasound device in Dongola Hospital starts operation, less than two months ago. This means that no calibration is needed.

Data Collection: Criteria and Requirements

The following study was carried out as clinical experimental study in the realm of allied medical science inclusively as ultrasound imaging. The experiment was applied among married and virgin women, the samples subjected for survey

was 150, sample were selected according to the following equation:

$$\begin{aligned} \text{Sample size } (n) &= N/(1+N e^2). \text{ (Israel D.G , 2} \\ N &= 240: \text{ population size from primary health ministry} \\ \text{of health.} \\ e &= 0.05: \text{ the level of precision when this formula applied.} \\ \text{Sample size} &= 240/(1+240 \times 0.0025). \\ &= 240/(1+0.6) = 240/1.6 \\ &= 150. \end{aligned}$$

The study adopted two conditions for the selection of samples:

- a. women pregnant for the first time.
- b. virgins after two weeks of period cycle.

To achieve these objectives, the research was carried out at Dongola Hospital Educational and Dongola Clinic Model under the supervisor of doctor Ismail Satty who is a specialist Obstetrics and Gynecology. During the period from 2010 up to 2012. When samples are subjected to pregnancy test information such as body mass index BMI, age, resident, marital status and beside intensity, depth, frequency, physiological status, ultrasound side effect and exposure duration time are collected.

To reveal the uterus requirement for this study longitudinal and transverse technique were utilized. The obtained data related to intensity of wave were plotted versus BMI, depth, frequency, age and ultrasound side effect. The acoustic power of the ultrasound device at Dongola Hospital Educational is 12 watt, while the power at Dongola Clinic Model is 15 watt. The probe is the same for both, where it is equal to 6cm².

To find the pressure change, reflected and transmitted power through uterus and abdominal fats (lipid) the following numerical impedance values were used:

$$\begin{aligned} Z_1 &= 1.38 \times 10^{-5} \text{ rayl. Acoustic impedance for fat.} \\ Z_2 &= 1.6 \times 10^{-5} \text{ rayl. Acoustic impedance for soft tissue.} \\ &\text{(Hassan.M.S, et al, 2004).} \end{aligned}$$

To reveal the uterus requirements for this study longitudinal and transverse techniques were utilized. The obtained data related to exposure duration time were plotted versus attenuation rate and ultrasound side effect. The significance relationships are examined by using Statistical Package for Social Science version 16 (SPSS – 16) and word 2010.

4. Results and Discussion

Table and Graph

Table 2: ultrasound side effect distribution

| Acoustic power Watt/cm | Frequencies | Side effect | T (min) | f MHz | Att. R dB |
|------------------------|-------------|-------------|---------|-------|-------------|
| 15* | 86 | Heating | 5 | 6.5 | 0.44 – 0.61 |
| 15 | 37 | Headache | 7 | 6.5 | 0.62 – 0.79 |
| 15 | 27 | Vomiting | 9 | 6.5 | 0.80 – 0.97 |
| 12* | 122 | Heating | 5 | 3.5 | 0.44 – 0.61 |
| 12 | 25 | Headache | 7 | 3.5 | 0.62 – 0.79 |
| 12 | 3 | Vomiting | 9 | 3.5 | 0.80 – 0.97 |

Questionnaire data, Dongola, 2010.

Att. R → Attenuation Rate

* The researcher found that competent using a device that uses the largest value of acoustic impedance is 15 and 12, although the manual of manufacturer determined that the value does not exceed 7 watts / cm.

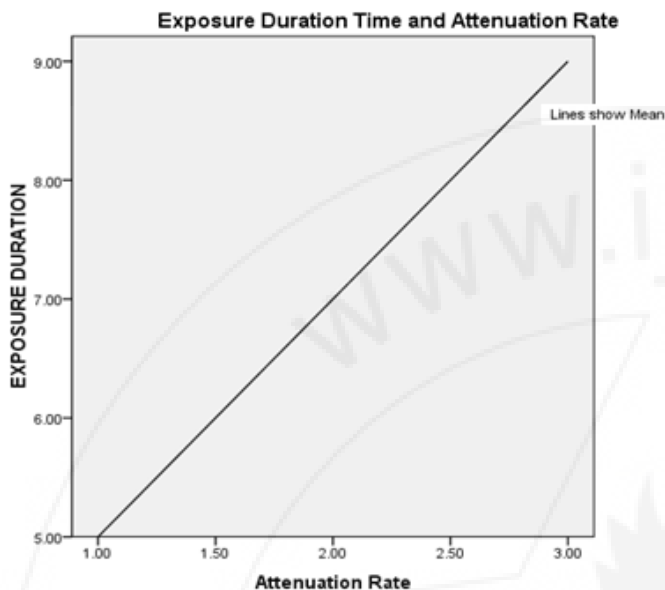


Figure 2: Relation between Exposure Duration Time and Attenuation Rate

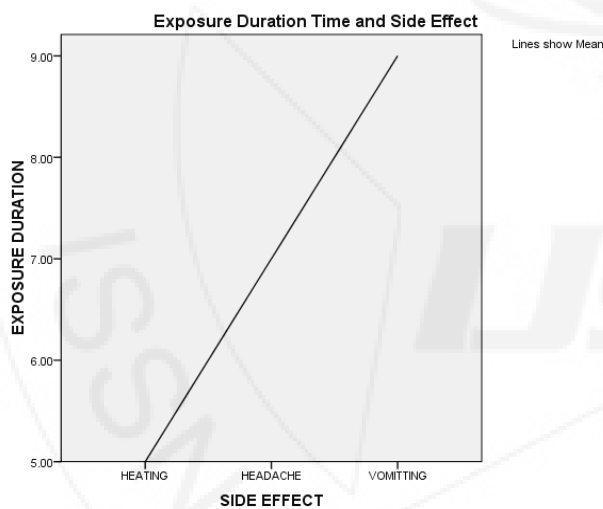


Figure 3: Relation between Exposure Duration time and Side Effect

5. Discussion

In view of table (2) and fig (2) the relation between Exposure duration time and Attenuation Rate shows a linear relation between them, where the attenuation rate increases as the time increase.

Table (2) and fig(3) which relates the Exposure Duration Time and Side Effect shows also a linear relation, where the increase of Time increases the Side Effect.

Side effects like heating and vomiting was observed for the frequency 6.5MHz in the attenuation rate range (0.44-0.65), and for the frequency 3.5MHz in the range(0.54-0.80). These effects are also observed even for non pregnant. Some recent

researches [M.A. Hussain, PhD thesis, SUST, 2001,] , [Stephen Bly and Michiel C. Van, PhD, Health and Radiation Protection Bureau, 2005] confirm the heating effect of temperature rise up to 6⁰ c for short exposure time (0.25 min). The fact that these side effects were not observed prior to ultrasound examination beside the experimentally observed heating effect in the above mentioned research, gives strong motivation to do further studies on the relation between these side effect and the ultrasound parameters like exposure time, frequency and Acoustic Power.

6. Conclusion

This study shows a direct relation between Attenuation Rate, Side Effect and Exposure Duration Time. Side effects like heating, headache and vomiting accompanied with frequency, acoustic power, attenuation rate and exposure duration time, may be related to some ultrasound parameters, specially the heating effect which is observed by more than one study.

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