USING COMPUTER EXPERT SYSTEM TO SOLVE COMPLICATIONS PRIMARILY DUE TO LOW AND EXCESSIVE BIRTH WEIGHTS AT DELIVERY

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Abstract

This paper discusses the provision of a Computer Expert System solution to the problems of complications primarily due to low and excessive birth weights at delivery. Foetal weight has been found to be a function of Foetal Head Circumference (HC), Femur Length (FL), Abdominal Circumference (AC), and Biparietal Diameter (BPD), and predictable with a polynomial equation. Also, Foetal age lias been found to be a function of Foetal Weight and predictable with an equation. The equations for the determination of conception and deliver dates have been derived by using the fact that pregnancy typically lasts 40 weeks, or nine (9) months. The Expert System (ES) primarily estimates Ibolal parameters (foetal weight, foetal age or gestational age, conception date, and delivery date) in the first trimester using ullrasonographic foetal biometric data. Relevant system analyses, including literature review were carried out in other to transform system objectives, analyses and inputs into the required Expert System solution.

Introduction

Most medical - related software addresses very specific problems. These problems are typically procedural, methodological and tutorial intensive. Until recently the approach has been the effective use of computers and human resources. Today both cultural and procedural changes are needed to support the medical profession of the future, and these changes will require Expert Software Systems involving Object-relational database System and deductive Databases (rules and facts). In this article, the needs for the design, implementation, and application of a Computer Software which can mimic human thought, understand logic, and handle the range of problems, which are coextensive with the range of problems to which (he human mind has been applied to the topic discussed, :is examined, with the objective of solving the problems of complications primarily due to both low-birth weight and excessive foetal weight at delivery usually associated with an increased risk "of newborn complications during labour and the prepartum. The introduction provides some background of the topic and includes the motivation, and the need for ES solution to problems identified. The last sections discuss the design and implementation plan.

Motivation

A woman wants to know if she is pregnant even before she sees her menses. Also she wants to know how old the pregnancy is and consequently determine due date of delivery. Determination of gestational age is an important factor in planning appropriate care for the foetus. It provides important information regarding expected or potential problems.and directly impacts the medical treatment plan for the baby. Traditionally, the due date was based on the following: *- date of the last menstrual period, - an early pelvic examination, - measurement of the size of the uterus, - quickening, or feeling the baby's first movements.* All of the above are still part of routine obstetrical care, but they are very unreliable for some groups of women, such as: *-overweight or obese women, - those who are unsure of their last menstrual period, - women who have been taking oral contraceptives, -women who have irregular menstrual cycles* (Eva, 1984). Although oral interview has a very important advantage as a method of clinical diagnosis because it allows the clinician an opportunity to hear the details of the situations directly from the patient involved, however, the patients' account of the intensity of the situation might not suffice, because the patient might attempt to withhold some facts which he or she assumes not respectable or shameful, or even unnecessary to effect a reliable conclusion as it might be an evasive one (Michael, 1989). The prenatal complications associated with low birth weight are *attributable to - preterm delivery, - intrauterine growth restriction (IVOR), or both.* For excessively large foetuses, the potential complications associated with delivery include, - *shoulder dystocia, -brachialplexus injuries, - bony injuries, and, - intrapartum asphyxia* While maternal risks associated

with the delivery of an excessively large foetus include — *birth canal and pelvic floor injuries and, postpartum haemorrhage* . Newborn and Maternal complication associated with Birth Weight greater than 4000gms has been compiled (Gerard, 2002).

Table 1: Newborn and Maternal Complications Associated with Birth Weight of Greater **than** 4000 Grams

Complication	**Relative Risk**	**Attributable Risk, %**
Shoulder dystocia	2-38	**2-18**
Brachial plexus palsy	**16-216**	**0.2-8**
Bony injuries/fracture	**1.4-97**	**0.2-6**
Prolonged **labor**	2.2-3.2	2-7
Birth **aspliyxia/low Apgar** scores	1.7-5.6	**0.6-6**
Forceps/vacuum extraction	**1.5-3.6**	**8-14**
Birth canal/perinea! lacerations	**1.6-5.1**	3-7
Postpartum hemorrhage	**1.6-5.2**	2-5
Cephalopelvic disproportion	**1.9-2.2**	**4-5**
Cesarean delivery	1.2-2.9	4-14

Source: **Gerard** (2002)

According to Gerard (2002), data were compiled from 15 studies that investigated both the relative risk and the attributable risk of complications associated with the birth of macrosomic foetuses. The ranges reported reflect the differences among studies in the patient populations under investigation and differences in the criteria used for the diagnosis of each complication. Relative and attributable risks are for foetuses weighing more than 4000 grams at delivery compared to controls weighing less than 4000 grams. The P values associated with each relative risk are less than .001 in all cases, except for birth canal / perineal lacerations, for which the P value is less than .05 (Gerard, 2002). Tablel, above therefore, suggests that birth weight and gestational age are both important' determinants of postpartum outcome. Any design that provides accurate and effective estimation of same is highly welcome. In the case of macrosomic foetuses, attempts to predict birth weight from foetal measurements obtained via ultrasonography have proved difficult from the standpoint of improving clinical outcomes. Some studies claim that ultrasonographic foetal biometric assessments are no more predictive of foetal macrosomia than clinical assessments of foetal size by simple external abdominal palpation (Bossak, 1972). They claimed that the method of ultrasonographic foetal biometry is both complicated and labour-intensive, potentially being limited by suboptimal visualization of foetal structures, and that it also requires costly sonographic equipment and specially trained personnel. With a computerised ultrasonographic foetal predictions, these problems will be eliminated drastically. By contrast, clinical palpation is a subjective methodology that must be employed at or near the date of delivery, and it is both patient - and clinician-dependent for its success (i.e, less accurate for obese than nonobese gravidas, significant for inter-observer variation in birth weight predictions even among experienced clinicians). Ultrasonographic foetal biometry predictions are inevitable (Eva, 1984).

Need for Expert System Solution

In the future, combining the different methods of foetal weight prediction to improve their overall accuracy may be possible. By combining the independent information about foetal size obtained from the three different approaches (i.e, clinical examination, quantitative assessment of maternal characteristics, ultrasonographic foetal biometry)., the predictive value of foetal weight estimations can be improved dramatically (Wikstrom, 1993). Undergoing an ultrasound procedure early during the first trimester (WEEK 1 - WEEk 12) allows a more accurate due date (Eva, 1984).

Mean birth weight has been described as a function of gestational age (Abramowitz, 1999). Some studies subdivide such results into those that apply to women of different races, male versus female foetuses, and primiparous versus multiparous gravidas. Standard foetal growth curves are useful for estimating the range of expected foetal weight at any particular gestational age. Without adequate gestational dating, the standard foetal growth curves cannot be interpreted successfully (Amini, 1994).

Therefore then, this paper provides computerized clinical and private solutions to these problems accompanying accuracy, effectiveness and efficiency. With the advent of 3-dimensional foetal imaging, optimism that these new technologies can provide even better foetal weight estimations may be justified, but the advantages of estimating foetal weight using these newer techniques have not yet been demonstrated. There is therefore, an existing problem of empirically and accurately estimating these foetal parameters. This can be achieved with an Expert System which is seen to unite the accumulated expertise of individual disciplines such as gynaecology, ultrasonography, Computer Software Design and Engineering, into a framework that best addresses the specific, on-site needs of clinicians required for accurate and empirical estimation of foetal parameters.

Determination of Foetal Parameters

Gestation is the period between conception and birth of a baby, during which the foetus grows and develops inside the mother's uterus. Gestational or foetal age is the time measured from the first day of the woman's last menstrual cycle to the current date and is measured in weeks. A pregnancy of normal gestation is approximately 40 weeks, with a normal range of 38 to 42 weeks. Today, there are several methods for determining gestational age. Whatever method used, if a process is ineffective. definitely the output or product will equally be ineffective. Thus, the more accurate the process used in estimation of foetal age, the more excellent results is obtained. There is the need to quickly and periodically estimate foetal age without mathematical stress on the doctors, clinicians or patients. Foetal weight has been found to be a function of Foetal Head Circumference (HC), Femur Length (FL), Abdominal Circumference (AC), and Biparietal Diameter (BPD), and is predictable with a polynomial equation. Foetal age has also been found to be a function of foetal Weight and predictable with an equation. Modern algorithms that incorporate standardly defined foetal measurements (e.g. some combination of AC. FL, and either BPD or HC) are generally comparable in terms of overall accuracy in predicting birth weight is compiled as shown in Table 2. Eqn. 11 of Table 2 guarantees 71.4% reliability in predicting foetal weight with a mean absolute weight difference of 22 Ig for the complete study (Merz, 1988). Validity for this formula could be defined as follows:- BPD 7.0-10.5 cm AC 21.8-36.5 cm (all measurements from outer to outer margin) compared prospectively in an evaluation group of foetuses (n=87) with six currently available equations for estimating weight in the preterm foetus and applying stepwise regression analysis with gestational age (in days and foetal biometric parameters was employed to yield the best-fit formula for predicting foetal weight at birth. This is an implementable formula for predicting foetal weight at birth.

Table 2. Ultrasonograohic Foetal Biometric Algorithms For Calculating Estimated Foctii] Weight.

SOURCE	YEAR	EQUATION
Shepard	1982	$Log_{10} BW^* = -1.7492 + 0.0166 (BPD^{\dagger}) + 0.0046 (AC^{\ddagger}) - 0.00002646 (AC X BPD)$ ... Eqn.. 1
Campbell	1975	$Ln^{\S} BW = -4.564 + 0.0282 (AC) - 0.0000331 (AC)^2$ ... Eqn.. 2
Hadlock 1	1985	$Log_{10} BW = 1.326 - 0.0000326 (AC X FL^{\|}) + 0.00107 (HC^{\P}) + 0.00438 (AC) + 0.0158 (FL)$ ... Eqn.. 3
Hadlock 2	1985`	$Log_{10} BW = 1.304 + 0.005281 (AC) + 0.01938 (FL) - 0.00004 (AC X FL)$ Eqn.4
Hadlock 3	1985	$Log_{10} BW = 1.335 - 0.000034 (AC X FL) + 0.00316 (BPD) + 0.00457 (AC) + 0.01623 (FL)$ ... Eqn.. 5
Warsof 1	1986	$Ln BW = 4.6914 + 0.00151 (FL)^2 - 0.0000119 (FL)^3$ ... Eqn.. 6
Warsof 2	1986	$Ln BW = 2.792 + 0.108 (FL) + 0.000036 (AC)^2 - 0.00027 (FL X AC)$ Eqn.. 7
Combs	1993	$BW = [0.00023718 X (AC)^2 X (FL)] + 0.00003312 (HC)^3$ ... Eqn.. 8
Ott	1986	$Log_{10} BW = 0.004355 (HC) + 0.005394 (AC) - 0.000008582 (HC X AC) + 1.2594 (FL/AC) - 2.0661$ Eqn.. 9
Schild,	2004	$BW = 5381.193 + 150.324 X HC + 2.069 X FL^3 + 0.0232 X AC^3 - 6235.478 X log(HC)$ ... Eqn.. 10
Merz	1988	$BW = -3200.40479 + 157.07186 AC (cm) + 15.90391 (BPD)^2 (cm)$. Eqn.. 11

*BW - Estimated Fetal Weight (G)
*AC - Fetal Abdominal Circumference

†BPD - Fetal Biparietal Diameter (Mm)
§Ln – Natural Logarithm
¶HC - Fetal Head Circumference (Mm)

(Mm)
LIFL - Fetal Femur Length (Mm)

Predicting Gestational Age

Foetal Age (T) can be estimated from weight (W) with the equation

T = (3VW + 2.730) /0.091 (Suzuki, 1996) Eqn. 12 Where W = weight

Conception date can then be calculated back from date of kill of pregnant female, using gestational age.

Determination of Conception Date

Pregnancy typically lasts 40 weeks, or 9 months and at conception, the unborn child is already considered two weeks old (Egipee,2004). We submit that if gestational Age is T wks, and measured on a date DM, Then **(CD) = DM - (T - 2) wks Eqn. 13**

Where CD = Conception Date *(dd/mm/yy);* DM = Date gestational age was measured *(dd/mm/yy);* and T- Gestational Age in weeks.

Determination of Delivery Date

Therefore then, we estimate Delivery Date (DD), if we know the Gestational Age using the equation DD = DM + (40 -T) wks **Equ.** 14 Where DD = Delivery Date *(dd/mm/yy);* DM = Date gestational age was measured *(dd/mm/yy);* and T= Gestational Age in weeks

Expert System Design and Implementation

An ES is a computer program designed to simulate the problem- solving behaviour of an expert in a narrow domain or discipline and consists of (i) knowledge base (facts), (ii) production or inference rules ("if... then"), and (iii) inference engine (controls how "if...,then..." rules are applied towards facts) (Wikipedia, 2005). ES is a wizard software). The most important modules that make up a rule-based Expert System can be identified as the Expert System Shell (Turban, 1992) as shown in Figure 1.

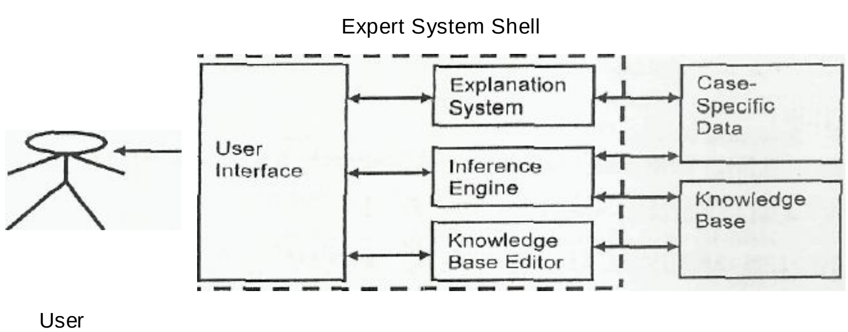
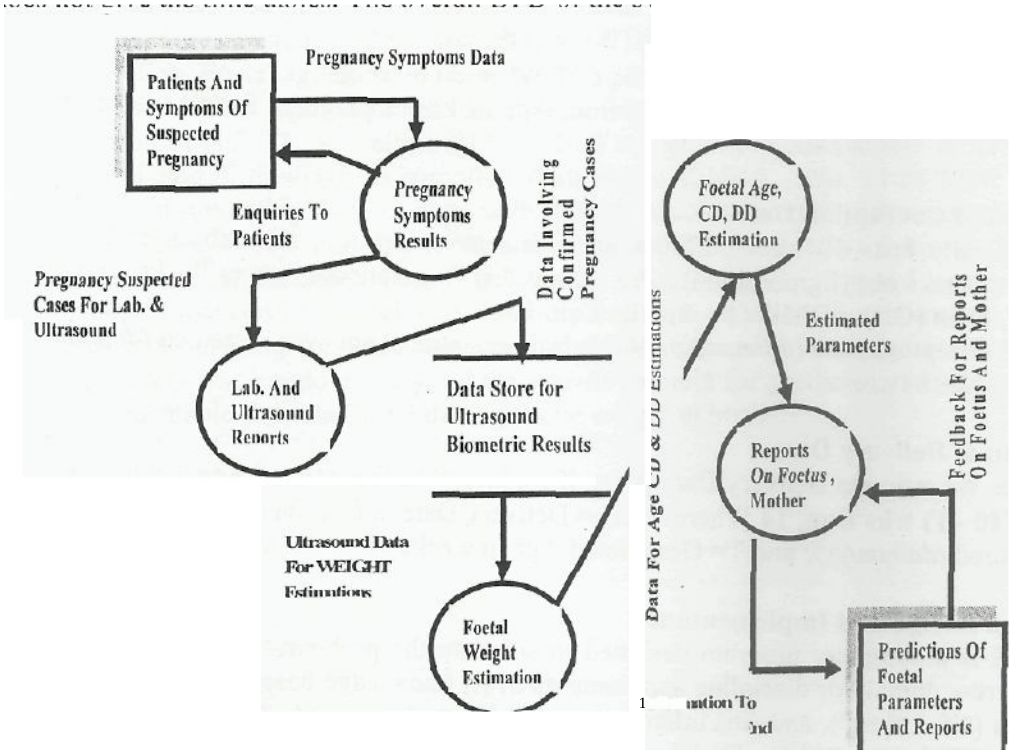


Fig. 1 Expert System Shell

The user interface may use menus, natural language or any other style of interaction, while an inference engine used to reason with both the expert knowledge (extracted from our friendly expert) and data specific to the particular problem being solved. The expert knowledge will typically be in the form of a set of IF THEN rules; the explanation subsystem, which allows the program to explain its reasoning to the user. The knowledge - base editor helps the expert or knowledge engineer to easily update and check the knowledge base. The IIS Shell codes are done with PROLOG **(Programming** in LOGic). Tools for System Design include among others System Organizational Structure, Data Dictionary, Data Flow Diagram, Systems Flow diagram etc.

Data Flow Diagram of the System

Data Flow Diagram (DFD) is a graphical representation of the "flow" of data through the information system. It shows the flow of data or information, and can be partitioned into single processes or functions or grouped together or decomposed into multiple processes (Vicki, 2005). It illustrates how data are processed by a system in terms of inputs and outputs (Tony, 2005), and used to visualize data processing (Bruza, 2005). It is like a railroad map that shows where the train are laid, but docs not give the time tables. The overall DFD of the system is



shown in Figure 2.

System Implementation

System Implementation is the activity of proceeding from a design of a system to a working version (known also as implementation) of that system, or the specific way in which some part of the system is made to fulfill its function. For this study, we shall define System Implementation as the use of Expert System software to ensure that all major design decisions have been made so that the implementation activity could be relatively straightforward. This is achieved using a number of distinct implementation activities such as shown in Fig. 3.

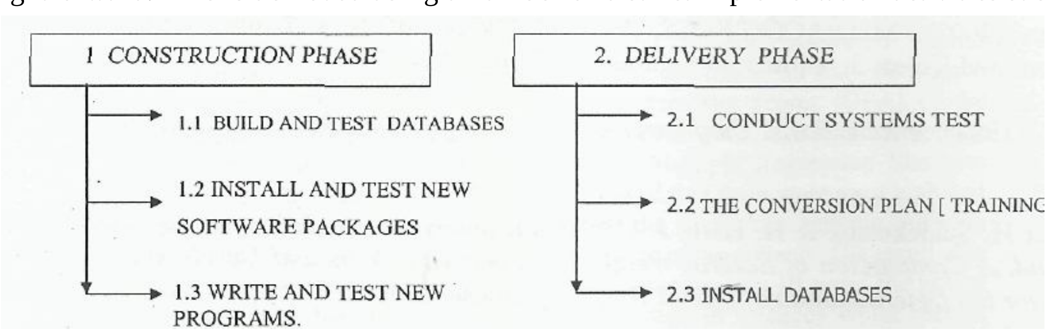


Fig. 3 Expert System [ES Implementation Activities

Conclusion

We have attempted in this paper to discuss a particular possibility of an ES to solve problems of complications primarily due to low and excessive birth weights at delivery by accurately estimating foetal parameters *(Foetal Weight, Foetal Age Conception Date, And Delivery Date)* using Ultrasonographic Foetal Biometric Data. The primary goal of expert system research is to make expertise available to decision makers and technicians who need answers quickly. There is never enough expertise to go around - certainly it is not always available at the right place and the right time. But computers loaded with in-depth knowledge of specific subjects can bring decades worth of knowledge and solution to a problem. If we must investigate and solve those utrasonographic foetal biometry method of estimation that has been described over the decades as complicated, labour -intensive, limited by suboptimal visualization of foetal structures, costly and specially requiring trained personnel, we will have to build into the estimation the use of a Computer Wizard (An Expert System). Otherwise, these problems continue because many of us feel that they are too complex for us to solve. We submit that they are not.

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