



CHALMERS

UNIVERSITY OF TECHNOLOGY



STAN Trainer

An interactive training tool for assessing Cardiotocography traces with and without ST analysis, focusing on fetal physiology

Master's thesis in Biomedical Engineering

BERGLIND FRIDRIKSDOTTIR
SIGRUN H. DAVIDSDOTTIR

REPORT NO. EX049/2018
**STAN Trainer - An interactive training tool for
assessing Cardiotocography traces with and
without ST analysis, focusing on fetal physiology**

BERGLIND FRIDRIKSDOTTIR
SIGRUN H. DAVIDSDOTTIR



Department of Electrical Engineering
Division of Signal Processing and Biomedical Engineering
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2018

STAN Trainer - An interactive training tool for assessing Cardiotocography traces with and without ST analysis, focusing on fetal physiology

BERGLIND FRIDRIKSDOTTIR
SIGRUN H. DAVIDSDOTTIR

© BERGLIND FRIDRIKSDOTTIR, 2018.

© SIGRUN H. DAVIDSDOTTIR, 2018.

Supervisor: Annika Mårtendal and Mats Kjellstrand, Neoventa Medical AB

Examiner: Ants Silberberg

Report No. EX049/2018

Department of Electrical Engineering

Division of Signal Processing and Biomedical Engineering

Chalmers University of Technology

SE-412 96 Gothenburg

Telephone +46 31 772 1000

Abstract

Understanding the fetus's physiological reactions in the event of oxygen deficiency is crucial for optimal fetal monitoring. The fetal heart rate (FHR) can provide valuable information. Changes in the FHR are related to normal adaptation by the fetus to changes in the environment as well as to oxygen deficiency. Today, personnel working in the labour ward and midwifery students need to rely on their visual interpretation of Cardiotocography (CTG) traces. A company called Neoventa Medical has developed a method, the STAN Method, that combines CTG and ST Analysis. CTG is used for continuous monitoring of the FHR and the uterine contractions. ST Analysis can provide extended and more accurate information about the fetus during birth. Becoming skilled at interpreting recordings of CTG and ST Analysis requires time devoted to training and practice, and time is usually of limited source when working in hospitals. The use of eLearning in medical education and continuous education can change the way of learning to become more learner centered. It can provide midwives, midwifery students and obstetricians with more time flexibility and better understanding of the topic. The aim of this thesis was to investigate, analyze and propose a design for a simple and user friendly interactive web-based training tool, assessing CTG traces with and without ST Analysis, focusing on fetal physiology during labour. The thesis work consisted of brainstorming sessions, mind mapping and most importantly interviews. Interviews were conducted through the internet as well as in a two day event, CTG Master Class, attended by the authors. The results were non-functional and functional requirements for implementing the STAN Trainer, along with a high-fidelity prototype of the STAN Trainer. The non-functional requirements describe navigational and design guidelines on how to develop the trainer. The functional guidelines describe the function of the trainer and how to implement the exercises, and the prototype presents an idea on how the trainer can look and function. There is a great need for a training tool such as the STAN Trainer. The authors hope that with the introduction of an easy accessible training tool, it can help obstetric staff recognize and interpret the fetal response to oxygen deficiency.

Keywords: Cardiotocography, ST Analysis, STAN Method, Fetal Physiology, Oxygen Deficiency, User Experience, eLearning, Medical Education.

Acknowledgements

First and foremost, we would like to thank our supervisors at Neoventa Medical, Annika Mårtendal and Mats Kjellstrand, for their valuable input and assistance regarding the creation and completion of this Master's Thesis. We would also like to thank the employees at Neoventa Medical for all their help and kindness during the project.

Furthermore, we would like to thank family and friends for moral support and proof-reading the report. We would also like to thank the interviewees and the usability testing participants for assisting us, this project would not have been possible without them. Finally, we would like to thank our supervisor and examiner at Chalmers University of Technology, Ants Silberberg, for his guidance and support throughout this project.

Berglind Fridriksdottir & Sigrun H. Davidsdottir, Gothenburg, May 2018

Contents

List of Figures	xi
List of Tables	xiii
1 Introduction	1
1.1 Aim & Objectives	3
1.2 Neoventa Medical AB	3
1.3 Ethical & Sustainability Aspects	4
2 Background	5
2.1 Cardiotocography (CTG)	5
2.2 ST Analysis	7
2.3 STAN Method	8
2.4 Clinical Evidence of the STAN Method	8
2.5 Fetal Response During Labour	9
2.6 eLearning in Medical Education	10
3 Previous work	13
3.1 CTG-utbildning	13
3.2 Neoventa Academy	14
3.2.1 STAN Cases	14
3.2.2 eLearning with Certification	15
3.3 Electrical Fetal Monitoring	16
3.4 Previous STAN Trainer	17
4 Methods	19
4.1 Define the Problem	20
4.1.1 Interviews	20
4.2 Analyze & Brainstorm Solutions	22
4.2.1 User Personas	23
4.2.2 Mind Mapping	24
4.3 Choose & Design a Solution	26
4.3.1 Usability Testing	28
5 Results	31
5.1 Non-Functional Requirements	31
5.2 Functional Requirements	33

5.2.1	Exercise Guidelines & Recommendations	34
5.3	High-Fidelity Prototype	39
5.3.1	Home Page	39
5.3.2	Exercises	40
5.3.3	Other Functions	44
6	Discussion	47
6.1	Interviews	47
6.2	The STAN Trainer	49
6.3	Other Functions	50
7	Conclusion	53
7.1	Suggestions for Future Development	53
	Bibliography	55
A	Interviews	I
A.1	Summary from Interviews with Three Midwives and Midwifery Students from Iceland	I
A.2	Summary from Interviews during the CTG Master Class	III
A.3	Summary from Interviews with Midwives & Professors at the Midwifery Science Program at University of Iceland	IV
A.4	Summary from an Interview with a Professor at Chalmers University of Technology	IV
B	Personas	V
B.1	Midwife Persona	V
B.2	Midwifery Student Persona	VI
C	Screen Captures	VII
C.1	Results - ST Analysis	VII
C.1.1	Mobile Prototype View	IX
D	Multiple Choice Questions	XI
D.1	Questions for CTG Trace Exercises	XI
D.2	Questions for CTG trace with ST Analysis Exercises	XV

List of Figures

1.1	Fetal ECG complex marked where the ST segment is located.	2
2.1	The five features evaluated in CTG interpretation, ©Neoventa Medical AB.	6
2.2	Normal ECG complex displayed with explanations, along with an example of how to calculate the T/QRS ratio, ©Neoventa Medical AB.	7
2.3	The interpretation principle of ST waveform changes, ©Neoventa Medical AB.	8
2.4	Three phases of fetal response to oxygen deficiency, ©Neoventa Medical AB.	10
3.1	A screen capture of all the different exercises offered by CTG-utbildningen.	14
3.2	A screen capture from stancases.com.	15
3.3	A screen capture from neoventaeducation.com.	16
3.4	A screen capture from a eLearning eFM session.	17
3.5	A screen capture of the old version of the STAN Trainer.	18
4.1	The five-step problem solving cycle that was followed.	19
4.2	A template for a rich description of a persona.	24
4.3	Results from the first mind mapping session.	25
4.4	Poster for visualization of concepts and ideas.	25
4.5	Flowchart of the mind map for the training tool.	26
4.6	The final version of the affinity diagram.	27
4.7	A screen shot of the work space from the Wix platform.	28
5.1	User flow diagram for the exercises.	33
5.2	Template for the setup of the exercise page and different types of cases.	35
5.3	Template for the setup of each case with three sections.	35
5.4	Setup of the cases in desktop view for the multiple choice questions.	37
5.5	Setup of the cases in desktop view for the text question.	37
5.6	Setup of the cases in desktop view for the matching question.	38
5.7	A screen capture of the home page.	39
5.8	A screen capture of other resources.	40
5.9	Two categories of exercises the user can choose from.	41
5.10	A screen capture of the CTG exercise.	41
5.11	The setup of the CTG exercise, extended view.	42
5.12	The layout of the build-in quiz from the Wix platform.	43

5.13	Visual feedback after the questions have been answered.	43
5.14	An explanation to a question from the CTG exercise.	44
5.15	About page for the prototype.	44
5.16	Contact us page for the prototype.	45
B.1	User persona for a midwife.	V
B.2	User persona for a midwifery science student.	VI
C.1	ST Analysis Exercise.	VII
C.2	ST Analysis Exercise Part 1.	VIII
C.3	A set of Figures of the mobile view.	IX
C.4	A set of Figures of the mobile view.	X
D.1	CTG trace for question 1	XI
D.2	CTG trace for question 2	XII
D.3	CTG trace for question 3	XII
D.4	CTG trace for question 4	XIII
D.5	CTG and ST Analysis recording for question 6.	XVI
D.6	Fetal ECG signal for question 7.	XVII
D.7	CTG trace with ST Analysis for question 8	XVII
D.8	CTG trace with ST Analysis for question 11	XVIII

List of Tables

2.1	Results from the three meta-analyses.	9
-----	---	---

1

Introduction

Being born is the greatest challenge in the life of a human being. Unexpected events can happen during childbirth, where the conditions of the fetus can change quickly. Continuous intrapartum fetal monitoring aims to identify fetuses at risk during birth. This method is used based on the understanding how the fetus reacts to stress and oxygen deficiency, before it becomes compromised [1]. Oxygen deficiency is a great risk for the fetus during the delivery process. It can cause neurological damage that has a long-term effect on the baby and the family. In some cases the damage is so severe it can lead to cerebral palsy, autism, seizures or even death, and human cost is obviously irreversible [2]. It is therefore very important to monitor both the condition of the fetus and the mother, with an accurate and real-time overview of their well-being.

The STAN Method is a method developed by a company called Neoventa Medical which is a unique analysis tool for fetal monitoring. It combines ST Analysis and standard Cardiotocography (CTG) and thereby provides more accurate information about the fetus during labour [3]. CTG is the technical means of recording the fetal heart rate (FHR) and the uterine contractions during labour and birth, also called electronic fetal heart rate monitoring (EFM) [4]. ST Analysis informs if the ST segment of the fetal electrocardiography (ECG), electrical activity of the heart, is abnormal. The ECG complex is demonstrated in Figure 1.1. The ST waveform of the fetal ECG provides information of the function of the fetal heart during stress tests [5]. The combination of CTG with ST Analysis can lead to significant reduction in obstetric interventions, reduce rates of fetal blood sampling, and reduce the numbers of infants born with significant metabolic acidosis [6, 7]. Using the STAN Method in the maternity ward enables obstetricians and midwives to analyze the changes in the FHR during labour, in order to institute timely intervention to avoid fetal oxygen deficiency [4]. In fact, results from three meta-analyses show comprehensive improvements with use of the STAN Method [8, 9, 10].

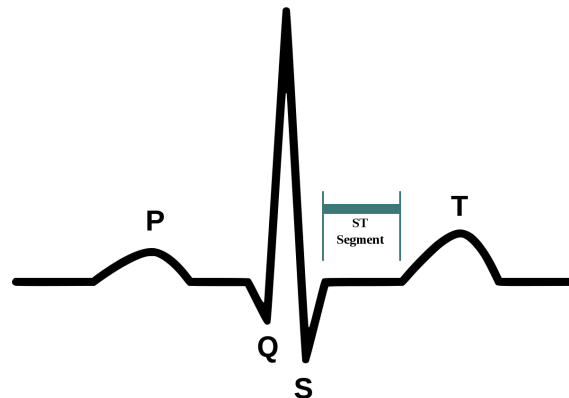


Figure 1.1: Fetal ECG complex marked where the ST segment is located.

With introduction of new technology and methodology, structured efforts on training and re-education are essential in order for a full implementation in clinical practice [1]. Existing guidelines employ visual interpretation of the CTG traces which introduces inter- and intra-observer variability between individuals. Thus, the health care staff needs to be well trained and have appropriate knowledge in understanding different CTG patterns along with interpretation of the physiological reactions of the fetus during labour [4]. It is recommended that all users devote time on both aspects, that there is easy access to training tools, and that these tools are made available to all staff. A structured training model will simplify the implementation of CTG and ST Analysis and also add value and quality to the everyday work in the maternity ward [11]. Some of the key factors in minimizing the threat of risky situations during childbirth are compulsory education and regular training in the interpretation of CTG traces and fetal physiology. Obstetric litigation are increasing in the western world, and the majority of claims related to the intrapartum period happen due to misinterpreted CTG or because inappropriate action was taken when the fetal heart rate was abnormal [12]. The newer methods such as ST Analysis act as adjuncts to CTG traces and can help bring more healthy babies to the world, making vaginal births possible for women and prevent obstetric litigation.

In the past few years, changes have occurred regarding medical education. Changes in the health care along with advances in medicine result in medical educators having less time for teaching. Traditional teaching methods are shifting towards learner centered models where it puts the learner in control of their own learning [11]. This change has led to online learning, eLearning, becoming a part of the conventional medical education. eLearning has been defined in many ways, however, primarily it means the educational use of technology [13].

1.1 Aim & Objectives

The aim of this Master's thesis was to investigate, analyze and propose a design for an interactive web-based training tool, assessing CTG traces with and without ST Analysis, focusing on fetal physiology during labour. The tool was intended for continuous education in the maternity ward as well as in midwifery science programs. In order to achieve the aim of the thesis, a literature review was conducted on CTG, ST Analysis and eLearning initiatives to assess ways of teaching in health care environment. Research was also done on current state-of-art and promising work, i.e. similar projects and what type of solutions were implemented. Potential users of the proposed training tool were interviewed to get a basic understanding of the problem at hand, further input for the design and function of the tool. The thesis also provided a set of guidelines and recommendations on how to implement the design. The recommendations were based on the literature findings, results from interviews and market research. A prototype for a solution that can be further developed into a fully functional training tool was also included.

1.2 Neoventa Medical AB

The focal company of this study is a privately held Swedish company called Neoventa Medical AB (henceforth referred to as Neoventa). It is a medical device company founded in 1997 by Professor KG Rosén. Professor Rosén is a physiologist, pediatrician and a neonatologist. He started developments on medical devices as a way to ensure the use of his knowledge in the field of fetal monitoring. Neoventa's headquarters are located in Gothenburg, Sweden and they have subsidiaries in Paris, France and Boston, USA. The company provides innovative fetal monitoring solutions and services that improve perinatal care. Their expertise is the STAN Method for fetal monitoring which, as mentioned earlier in this chapter, uses the combination of ST Analysis of the fetal ECG and CTG in monitoring during childbirth. It is a system that displays the FHR, the uterine activity and information resulting from a computerized analysis of the ST interval of the fetal ECG. STAN S41 is the latest in a series of products launched for the perinatal health care. The company also has a comprehensive education and training program called Neoventa Academy. It includes customized training, elearning with certification and CTG Master Classes, where they use authentic cases for the training material. Neoventa is a provider of a disposable fetal scalp electrode for internal fetal monitoring. The electrode is called Goldtrace and was the first scalp electrode to be developed specifically for ST Analysis [14]. The authors of this thesis were first introduced to Neoventa in the course Biomedical Instrumentation at Chalmers University of Technology. A company visit was arranged in the course to learn more about fetal monitoring and they made a positive first impression. The authors were immediately curious to know more about the company and knew that this was their area of interest. The interest was still there when they were evaluating what subject to focus on for a master thesis. The main reason why Neoventa was chosen as the focal company for this project is because they are leading in perinatal care, and their vision is to make

each baby's birth into this world as safe as possible.

1.3 Ethical & Sustainability Aspects

Well trained health care staff will provide overall better care and safety for the patient's, and reduce human suffering. Patient safety should be embedded in the training of health care staff, as the providers of neonatal care it should be a top priority. Health care staff have an ethical obligation to train and educate themselves about aspects of the medical care they provide. Not pursuing to improve the situation with additional new or other methods is unethical [15]. Assessing difficult situations can be challenging and different ethical dilemmas can occur. The suggested training solution will help health care staff to assess and address these challenging situations and can be helpful in preventing unforeseen neonatal injuries. Communication and information flow between health care staff will be better under stressful situations and ensure improved effectiveness. By achieving better communication and information flow, there will be an increase of patient safety and well being. An eLearning training solution will lower the paper consumption of hospitals and therefore reduce impact on the environment. This will improve the sustainability of health care.

2

Background

This chapter describes the theoretical background of the STAN Method that combines two methods used during labour, CTG and ST Analysis. In addition, it presents clinical evidence from four different studies that used the STAN Method. Furthermore, it will describe examples of fetal responses that labour ward staff need to be aware of when assessing the CTG and the ST Analysis traces during labour. Different stages of oxygen deficiencies are discussed along with discussion on the fetal responses against oxygen deficiency. The last section presents the concept of eLearning in medical education. The purpose of these four sections is to give the reader an introduction to the methods and its scientific status in relation to this thesis.

2.1 Cardiotocography (CTG)

Cardiotocography (CTG) is a term used to describe continuous monitoring of the fetal heart rate (FHR) and uterine contractions [16]. The method of using CTG to record the FHR can also be called electronic fetal heart rate monitoring (EFM). This method is used during the pregnancy and either continuously or intermittently during labour. It is used to determine the fetal well-being in lowering rates of fetal metabolic acidosis and operative deliveries [4]. Monitoring the fetus dates back to the 18th century when it was used to distinguish between a live and a dead fetus. The more recent technology of electronic fetal monitoring techniques was, however, introduced in the 1950s and 1960s [17, 18]. The continuous monitoring of the fetal reactions was considered to provide an opportunity to identify hypoxia and prevent brain damage. With improvement of the CTG monitors and the labour ward equipment, the CTG technology has become standard [5]. The technique is easy to operate and is measured externally by using a Doppler ultrasound transducer for measuring the FHR and a pressure transducer for measuring the contractions [19]. Another method, the STAN Method, can be used by measuring internally with a fetal scalp electrode. In that case, ST Analysis is used and that type of method will be explained better in the relevant Section, 2.2.

In order to properly interpret the CTG recordings, a number of parameters should be assessed such as the duration and quality of the recording, baseline heart rate, variability, accelerations, decelerations and the recording of contractions. A good signal quality is essential to get accurate interpretation and it is better to spend time improving the signal quality rather than interpreting inaccurate data [5]. The STAN

2. Background

Clinical Guidelines classifications system of CTG that Neoventa uses is originally based on the FIGO classification systems. The classifications described here below are followed by the FIGO guidelines and Figure 2.1 displays the parameters that need to be assessed [16].

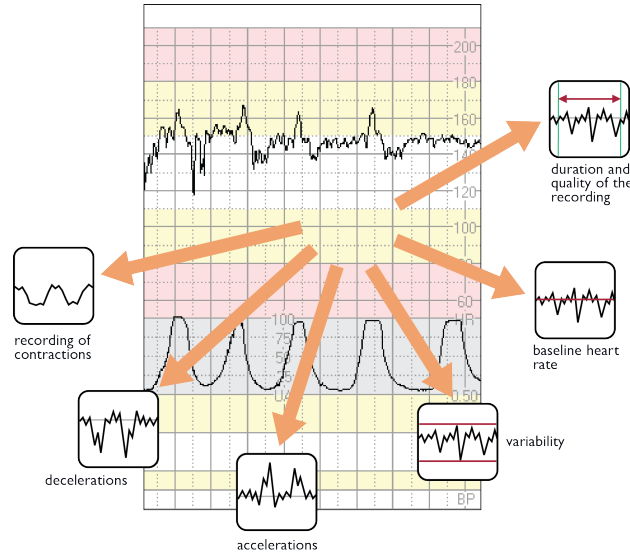


Figure 2.1: The five features evaluated in CTG interpretation, ©Neoventa Medical AB.

Baseline heart rate is defined as the fetal heart rate recorded between contractions over a period of at least 10 minutes. A normal fetal baseline heart rate for a term fetus is defined as 110 to 150 bpm [5].

Variability is the bandwidth of the baseline and refers to the oscillations in the FHR signal. It is therefore evaluated as the average bandwidth amplitude of the signal in one-minute segments and can be defined as normal, reduced and increased variability. A normal variability has a bandwidth amplitude of 5 to 25 bpm [16].

Accelerations occur when there is an increases in FHR above the baseline of more than 15 bpm that lasts for 15 seconds or more. A reactive CTG containing at least two accelerations within a period of 20 minutes is considered reassuring [16].

Decelerations are defined as a drop in the FHR below baseline of more than 15 bpm lasting more than 15 seconds [16]. Decelerations are related to contractions and thereby the development of hypoxia. This type of CTG pattern can be classified as early, late and variable [5].

Contractions are visible as bell-shaped gradual increases in the uterine activity signal. Uterine contractions are so strong that they can compress the fetal head, the umbilical cord and they can cause reduction in the utero-placental circulation. They are important for the progression of labour and while being evaluated, they can contribute to changes in the FHR [16].

2.2 ST Analysis

Initial research of ST Analysis started over 40 years ago, by Professor KG Rosén, where preclinical animal studies were performed on fetal lamb as a model. This knowledge has enabled interpretation of complex reactions that exists during labour [5, 14]. It was, however, around the beginning of the 20th century when the ST Analysis method became an additional source of information that allowed for more accurate identification of the fetal status. The ST Analysis technique has now a widespread use around the world [20]. The technique uses a number of parameters that work together to detect changes in the fetal ECG waveform. It continually analyses, detects and alerts changes that could potentially be related to fetal hypoxia and is used as an adjunct test to the standard CTG monitoring. The change in the ST interval of the fetal ECG assists in detecting any signs of hypoxia and gives valuable information how the fetus is handling the stress of labour [3]. A normal ST waveform, as represented in Figure 2.2, demonstrates a sufficient fetal oxygen supply and the fetus usually displays a rather stable ECG waveform throughout labour. The ST segment is normal when it is horizontal or upward leaning and positive and the T-wave is stable [5].

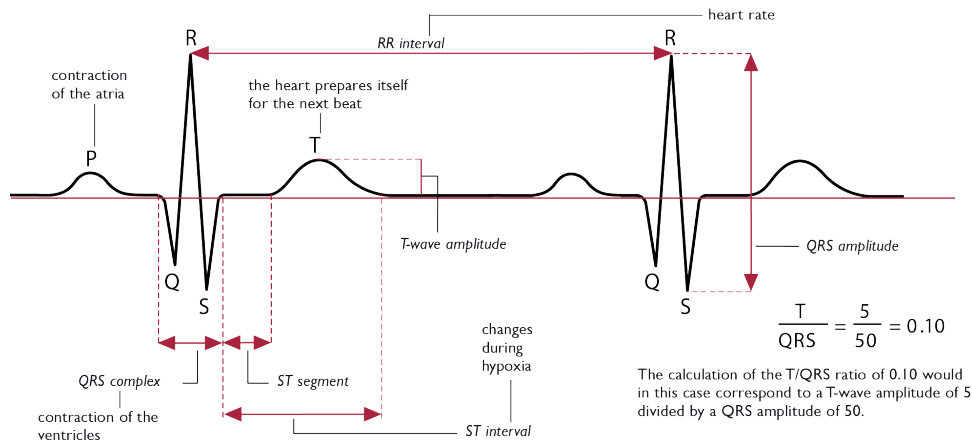


Figure 2.2: Normal ECG complex displayed with explanations, along with an example of how to calculate the T/QRS ratio, ©Neoventa Medical AB.

If the segment is abnormal, it will show a change in amplitude and/or instability, see Figure 2.3. A change of the ST segment and an increase of the T wave amplitude of the fetal ECG can indicate when the fetal heart is responding to hypoxia. A depression of the ST segment indicates when the fetal heart muscle is not fully able to respond or has not had time to respond. This pattern occurs when the fetal heart is exposed to stress and its pumping ability is reduced. In case of an abnormal ST segment, the monitor displays an automatic 'ST Event' alert and required actions are recommended according to clinical guidelines provided by Neoventa. In order to obtain the fetal ECG a spiral electrode is attached directly to the fetus's scalp.

The ST Analysis technique combines measurements of the R-R interval with assessment of changes in the ST interval [5]. During continuous monitoring using CTG,

2. Background

the time between two heart beats is recorded, called the R-R interval, seen in Figure 2.2. When recording the R-R interval, the fetal heart rate can be obtained. However, in order to accurately measure the changes in the ST interval, the ratio between the height of the T-wave and the QRS amplitude is calculated. That provides the T/QRS ratio and an example of that can be seen in Figure 2.2. An important thing to note here is that the fetal heart and the brain are equally sensitive to oxygen deficiency. Therefore, the information related to the heart function provides an indirect indication as to whether the brain is suffering from hypoxia during labour. The technique has been studied thoroughly and its diagnostic value has been confirmed to significantly reduce the number of metabolic acidosis as well as unnecessary interventions such as operative deliveries and fetal blood sampling (FBS) [5].

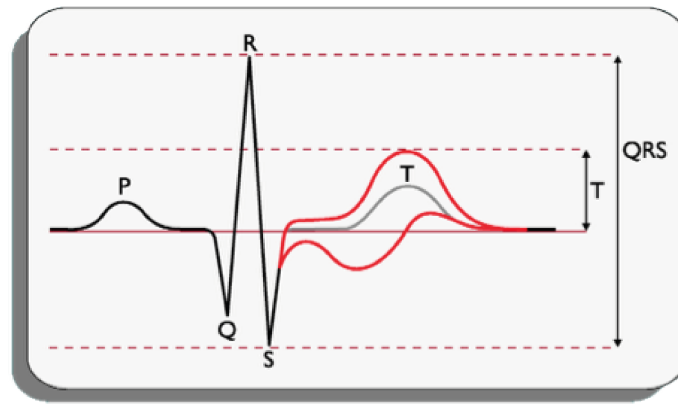


Figure 2.3: The interpretation principle of ST waveform changes, ©Neoventa Medical AB.

2.3 STAN Method

The STAN Methodology, developed by Neoventa, is used for continuous fetal monitoring. The method is a unique analysis tool consisting of a device with the standard CTG functions with ST Analysis as an adjunct to CTG. The combination of ST Analysis and standard CTG parameters can provide more accurate information about the condition of the fetus compared to using CTG alone [7]. The method requires that an electrode is applied to the fetus's scalp to measure the ECG waveform. This central message from the fetus's heart provides continuous monitoring in order to secure the best outcome for both the baby and its mother [3].

2.4 Clinical Evidence of the STAN Method

ST Analysis is one of the most studied fetal monitoring methods where several randomized trials and observational studies have been published showing a broad spectrum of improvements. The first clinical randomized controlled trial was published in 1993 showing a 46% reduction in operative deliveries for 'fetal distress' and a trend to less metabolic acidosis in birth [21]. In a more recent study, published

March 2018, 42,146 deliveries were analyzed over the study period 2001 to 2011. The primary objective of the study was to "evaluate the importance of the learning period on the rates of metabolic acidosis and operative deliveries after implementation of ST Analysis". Cord blood metabolic acidosis, rates of cesarean section, and FBS were the main outcome measures. The prevalence of cord pH decreased from 1.5% to 0.81%, the rate of cesarean deliveries decreased from 17.2% to 14.1% and the rate of FBS went from 1.75% to 0.82%. The authors conclude that they provide evidence that the results improve over time and that there is a learning curve in the introduction of the ST Analysis method [22].

Three meta-analyses (MA), statistical analysis based on multiple randomized controlled trials, have been conducted showing important results with using CTG together with ST Analysis. Olofsson et al. assessed the methodology, execution, and quality of five previously published MA which compared using CTG alone to the combination of CTG and ST Analysis. The author concluded that those five MA contained errors and were not performed properly. The analysis showed that CTG plus ST monitoring can significantly reduce FBS usage, reduction of 36%, total operative delivery rate, reduction of 7% and metabolic acidosis rate, reduction of 39% [8]. Vayssi re et al. conducted a MA on revised data, using five different MA methods. The author concluded that the results were consistent and significant using all five methods. The application of revised and comparable data produced results showing 35% decrease in metabolic acidosis at birth using CTG with the ST Analysis method. The author thinks that the use of the STAN Method for intrapartum surveillance turns out to be a valuable alternative compared to using CTG alone. Also, the author finds the method beneficial since it shows improved results in reducing the incidence of metabolic acidosis as well as better standardized decisions for immediate operative delivery [9]. Blixt et al. performed a MA where the objective was to quantify the effectiveness of using CTG with ST waveform analysis compared to only using CTG. Six randomized trials were included in the MA. The author observed a significant reduction of 36% in the rate of metabolic acidosis. The author also concluded that ST waveform analysis "was not associated with a reduction in operative deliveries". The conclusion of this study was that there is not enough evidence to justify the use of ST waveform analysis in present obstetrics [10]. The results from the three MA have been summarized in Table 2.1.

Table 2.1: Results from the three meta-analyses.

34-39 %	Reduction in neonatal metabolic acidosis
36-41 %	Reduction in fetal scalp blood sampling
7-8 %	Reduction in operative delivery

2.5 Fetal Response During Labour

During labour, it is essential to understand fetal physiology to be able to correctly assess all aspects and findings of the CTG trace [4]. Normal fetal physiology involves

various adaptations. They allow the fetus to achieve a level of oxygen consumption, distribution of fetal blood flow and can be measured in the FHR [23]. At the same time, it is critical to keep in mind that every fetus reacts differently to the same kind of mechanical or hypoxic stress [4].

There are three phases of fetal oxygen deficiency during labour, see Figure 2.4. The first phase of oxygen deficiency is hypoxemia, which means a decrease in the amount of oxygen in the arterial blood alone. The fetal response to hypoxemia are more effective uptake of oxygen, reduced activity, decrease in growth rate and maintaining energy balance. The fetus can handle this situation for days or even weeks. Hypoxia is the second phase of oxygen deficiency. During hypoxia, oxygen saturation decreases further, which affects the peripheral tissues. The fetus response to hypoxia can be a surge of stress hormones, redistribution of the fetal blood flow, tissue anaerobic metabolism and maintaining energy balance. The fetus can handle this situation for several hours. Asphyxia is the third and last phase of oxygen deficiency that affects the high priority organs, and causes a high risk of organ failure. During asphyxia, there is anaerobic metabolism in the central organs, the fetus reacts with maximum alarm reactions and the heart and brain fail to function. In case of asphyxia, there has to be immediate delivery because the fetus can only handle this phase for several minutes [5].

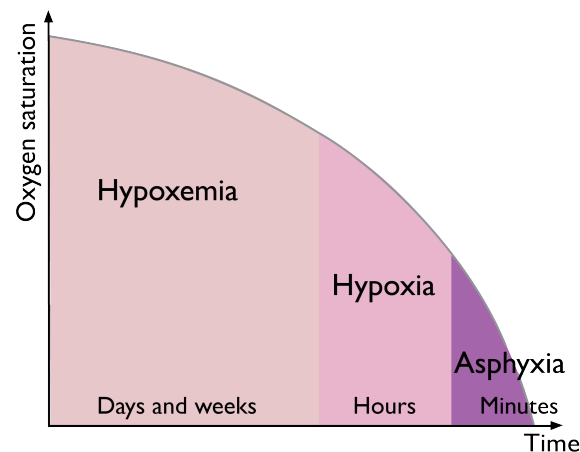


Figure 2.4: Three phases of fetal response to oxygen deficiency, ©Neoventa Medical AB.

2.6 eLearning in Medical Education

eLearning, also called web-based learning or online learning, has been defined in many different ways. In its broadest sense, eLearning is learning through the internet. A very basic definition of eLearning is that it is "the use of internet technologies to deliver a broad array of solutions that enhance knowledge and performance" [24]. The definition adopted for this research is "an interactive activity based on a web-based technological tool for the purpose of training, and improving knowledge and performance in health care" [25]. The central users implied by eLearning, eLearners,

are any individuals that intend some learning activities online, henceforth referred to as the user. Understanding this role is crucial to a fruitful implementation and design of an eLearning tool [11]. The definition of good eLearning is that it should be tailored to the particular profession and the user. It also needs to be interactive, captivating and be accessible for the user [26].

Students usually find work more interesting with engagement and interaction during their education. Through active learning and engaging students, it can improve knowledge gain, the work becomes more interesting and the students therefore put more effort into it. Active learning is a learner centered method in teaching where the focus is set on the individual, compared to the whole group or class. One definition says that it is "anything that involves students in doing things and thinking about the things they are doing" [27]. Passive learning, on the other hand, occurs when students prepare for lectures at home or outside of the classroom. It requires students to attend lectures and the teacher being the main provider of content. Nowadays, teachers in medical schools lack the pedagogical training. Instead, they teach as they were taught when they were students. Usually, they manage lecture driven teaching methods with limited engagements and interaction despite the fact that the field of medicine is constantly changing and evolving. Active learning can combine observing and engagement with reflective exercises where students perform certain activities. In that way, active learning is different from passive learning but it is important that the role of passive learning can not be lessened [27].

Studies related to knowledge gain have shown that using web-based learning in medical, nursing, and dental literature is equivalent to using traditional methods. It has also been shown, both in medical and non medical literature, that students are very content with eLearning. When comparing eLearning to traditional learning, students have rated eLearning as easy to use and accessible. Their satisfaction rate regarding eLearning increases with interactivity and user friendly graphical interface design. However, it is important to note that they do not see eLearning as a replacement of teachers but instead as a complement to it. The integration of eLearning into midwifery science and re-training in hospital environment can change the way adults learn in medical education. On one hand, instead of going to class and listening to a teacher, students can come to class to discuss, work and collaborate in groups. In that case, the teacher becomes a facilitator of learning instead of almost only providing students with material. On the other hand, in re-training, the students can use eLearning on their own, whenever they want and control their studies as it offers great flexibility regarding time and place [11].

3

Previous work

The amount of eLearning material available has increased throughout the years, thanks to the growth of educational technologies and the internet. Within medical education, digital libraries have been created along with high-quality and share-able eLearning material. This chapter will cover current and previous work in the field of eLearning material in neonatal care. The majority is programs made by Neoventa, and one was found through online research.

3.1 CTG-utbildning

CTG-utbildning is an interactive program for education, training, and evaluation of the users knowledge of CTG and fetal monitoring only available in Swedish. The aim of the program is to prevent birth injuries and fetal death, by ensuring skills and knowledge in the assessment of CTG traces for obstetric professionals. The program offers exercises and reading material, a certification test as well as information on Swedish guidelines on CTG interpretation. The certification and guidelines can be found on the home page. The training section of the program consists of different chapters with material that can be followed in the order they were intended or in the order the users's choice. The chapters contain different categories and educational programs. There are ten chapters with various subjects that are related to fetal physiology, monitoring, CTG, and case studies. Figure 3.1 shows the library of reading material and training material that is available on the CTG utbildningen web-page, www.ctgutbildning.se. At the end of each chapter, there is a knowledge test where the user can test its acquired understanding of the material. The practice test is made up of multiple choice questions. It varies if the questions have only one correct answer or if they can have multiple correct answers. The last chapter of the training section is where the user can train CTG traces interactively. It consist of four different kinds of cases with different amount of exercises each: 12 exercise cases, 6 study cases, 24 typical cases, and 38 classification cases. These cases are presented in different format depending on the purpose of the training.

The certification test is a CTG knowledge test and is divided into two parts, theoretical and CTG interpretation. The theoretical part of the test contains multiple choice questions, where the questions can have several correct answers. The CTG interpretation part contains five different cases with identical multiple choice questions. In order to pass the test, the user has to get at least 70% correct out of 100% and the test takes approximately 45-60 minutes to finish.

3. Previous work

Fostrets fysiologi	Basal hjärtfrekvens	Värkregistrering	Fetala faktorer
Gasutbyte foster/mamma	Takykardi	Kontraktionernas effekt på cirkulationen i placenta	Korioamnionit
Fostercirkulation	Bradykardi	Testa dina kunskaper	Fetal blödning och anemi
Fosterhinner och fostervatten	Kortvarig nedgång i basalhjärtfrekvensen		Tryck mot ögonbullen
Navelsträngen	Överstimulering och bradykardi		Autonoma nervsystemet
Gasutbytet i placenta	Testa dina kunskaper	Klassificering av CTG	Sovnmönster
Cellens ämnesomsättning		Normalt CTG	Hypoxi
Autonoma nervsystemet	Variabilitet och accelerationer	Avvikande CTG	Fosterförelser
Fosterförelser	Accelerationer	Patologiskt CTG	Prematuritet
Kontraktioner	Normal variabilitet	Testa dina kunskaper	Fosterhjärtarytmi
Hypoxiutveckling	Nedsatt variabilitet		Åtgärder vid fosterpåverkan
Syra-bas balansen	Upphövd variabilitet	Maternella faktorer	Testa dina kunskaper
Testa dina kunskaper	Ökad variabilitet – saltatoriskt mönster	Feber	
	Sinusoidalt mönster	Smärtlindring	Träna CTG interaktivt
Metoder för övervakning	Pseudo-sinusoidalt mönster	Maternella blödningar	Övningsfall
Övervakning under förlossning	Testa dina kunskaper	Läkemedelpåverkan	Typfall
Övervakning med CTG	Decelerationer	Överstimulering med oxytocin	Instrueringsfall
Längd och kvalitet på CTG-registrering	Uniforma tidiga decelerationer	Vena cava-syndrom	Klassificeringsfall
Bedömningsgrunder för CTG	Uniforma sena decelerationer	Smärtpåverkan	
Risikbedömning	Variabla decelerationer	Bad och dusch under förlossning	
Skalpblodprov	Kombinerade decelerationer	Testa dina kunskaper	
Testa dina kunskaper	Testa dina kunskaper		

Figure 3.1: A screen capture of all the different exercises offered by CTG-utbildningen.

3.2 Neoventa Academy

Neoventa Academy is a web-based education program offered by Neoventa. It covers basic physiology, CTG physiology, CTG interpretation, fetal ECG physiology, fetal ECG interpretation, and assessment of the child where the material is can be used all over the world. The literature material is available in fourteen different languages. The program offers doctors and midwives both practical and theoretical education based on authentic cases. It offers a broad range of learning opportunities in the form of printed training materials, eLearning with certification and STAN Cases along with other non web-based activities. STAN Cases and eLearning with certification will be discussed further in the following two sections considering the relation to this research.

3.2.1 STAN Cases

STAN Cases is an online interactive case library. It is created by Neoventa and provides additional learning opportunities, training, and education for the intended user. The STAN Cases are to engage the user in a real life cases, similar to a case it will face when working in the maternity ward. They are available at no cost so that the users can practice and train their skills by identifying different patterns of standard CTG with and without ST Analysis recordings. The library contains 24 CTG case recordings without ST Analysis and 24 CTG case recordings that include ST Analysis where all are real life authentic cases. Included in each case is a clinical background, outcome information and expert comments. Due to privacy reasons, all personally identifiable data has been removed from the recordings. All cases can be scrolled through at the users own pace where the summary is always present on the left side of the recording. The benefit with an online case library like this is that it is easy to access where the user can train at his or her own pace and re-train when there is time. Figure 3.2 displays the front page of the STAN Cases web-page, www.stancases.com.

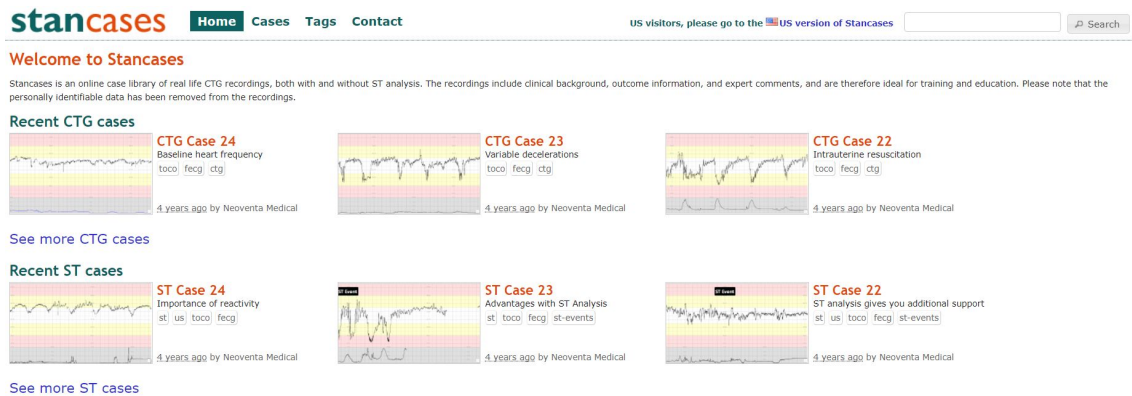


Figure 3.2: A screen capture from stancases.com.

3.2.2 eLearning with Certification

eLearning with certification is a program that offers educational content built on Neoventa's printed training material. It is an interactive program for education and training in CTG and ST Analysis interpretation. It has been divided into three separate parts: Fetal Monitoring with CTG, Fetal Monitoring with ST Analysis and a certification test. Each chapter is further divided into several sub-chapters where the material is based on authentic and real life cases, reading material, and self tests. As an aid to the reading material and to illustrate it, the sub-chapters contain photographs, animated images and interactive images that move when clicked on. In some chapters there are scrollable recordings showing CTG traces and ST Events. The material can be read in sequence or in the order of the reader's choice. At the end of each chapter there are study questions along with answers in a PDF format, which can be downloaded directly from the site. The Fetal Monitoring with CTG part holds a case library of 36 authentic CTG recordings along with patient history. The Fetal Monitoring with ST Analysis part has a case library of 25 authentic ST Analysis recordings also along with patient history. The cases enable the user to practice and get a deeper understanding of CTG and ST Analysis interpretation. When the user feels well prepared, and has read the material and answered the study questions, he or she can take the certification test. The certification test is a knowledge control test that starts with a selection of 25 multiple choice questions and five short CTG recordings along with questions. The grading system for the test has a maximum of 50 points, and the user is required to pass the test with a minimum of 85%. If the test is not passed the first time, the user can try again. Although a new set of questions and recordings is presented for every new attempt. The test takes approximately 20 minutes to finish. Figure 3.3 shows the front page of the Fetal monitoring with CTG part of the eLearning training program, www.neoventaeducation.com.

3. Previous work

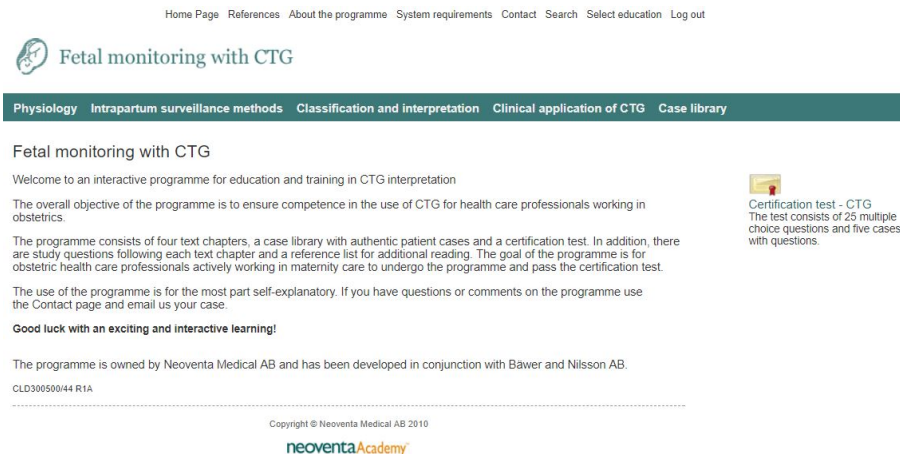


Figure 3.3: A screen capture from neoventaeducation.com.

3.3 Electrical Fetal Monitoring

A project called eLearning for Healthcare (eLfh) was developed by the Health Education England (HEE) Programme to support patient care by providing accessible eLearning to educate and train health care staff. This is a comprehensive project and has over 10 thousand eLearning sessions within 150 programs with a wide range of subjects. Electrical Fetal Monitoring (eFM) was developed for the eLfh project and is an online training program. It aims to teach and assess the users in all aspects of intrapartum fetal monitoring. The intended users for this program are health care staff in the maternity ward and midwives in training. There are administrative restrictions where access to the program is limited to the hospital staff in United Kingdom.

When entering the training program the user is presented with a section called 'My eLearning'. This section contains the training sessions where the user can choose the desired training topics. The training session is divided into four parts. The first part is interactive, knowledge based tutorial section with different topics regarding background, care in labour, CTG, etc. The second part is the assessment part. It tests the what the users' understanding and what they have acquired from the learning session. The third part is the case studies. This part contains real life cases from the years 2011 to 2017. They can provide the users with valuable knowledge and allow them to practise and interpret an actual FHR recording. Furthermore, the user can learn to manage practical maternity ward setting and knowledge that is not available from other resources. There are two types of cases and they are divided into 'Test' and 'Learning' study cases. The Test cases are divided into one hour segments and this trace hour will carry points for the exercises. These points can be earned from the online courses and upon completion, a certification is available. In order to pass the course and get a certification, a score of 80% or higher is required. The Learning cases allow the user to have more flexibility to explore certain segments of the trace throughout the case study. This part is a great addition for further discussions, for study groups, and meetings in the labour ward. Skills

and knowledge can be tested by analyzing case studies with CTG traces, using interactive exercises. The score outcome is provided at the end of each session, giving the user feedback on the performance. The fourth part is access to an extensive eLibrary, with clinical guidelines and related articles from medical journals. Figure 3.4 presents the different options to choose when the user has entered his or her account, www.e-lfh.org.uk/programmes/electronic-fetal-monitoring/.

'My Account' contains an electronic activity record of all sessions the user has registered for. The record shows the title, date and time of access, the score in percentages and outcome for all the sessions the user has accessed for a specific time frame and displayed in ascending or descending date order. This gives a visual overview of the progress, status of the session, and can be displayed in a web-based format of a CVS file for Excel or a PDF file [28].

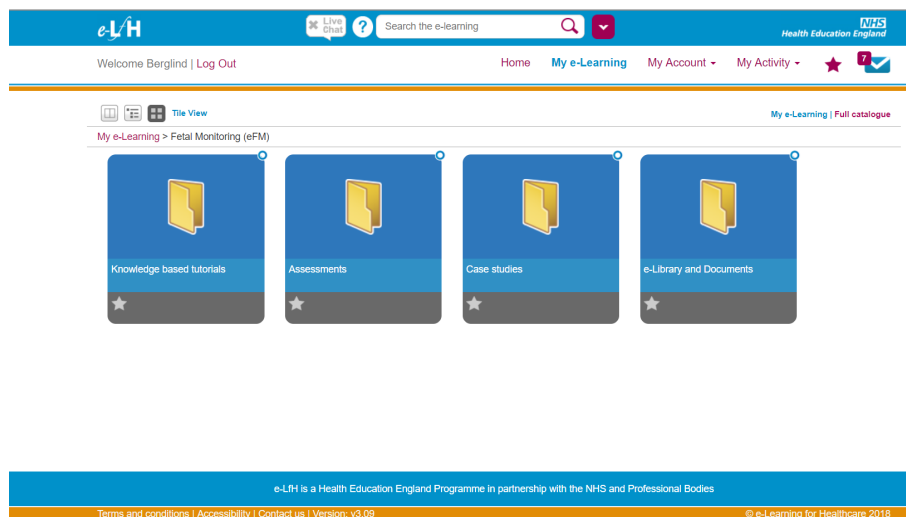


Figure 3.4: A screen capture from a eLearning eFM session.

3.4 Previous STAN Trainer

The STAN Trainer is an exercise tool for assessing CTG curves with ST Analysis. It is an application built in 1998 and was used as a learning tool for the Swedish STAN study [7]. All functions are in Swedish and it needs to be installed to run on a desktop or a laptop computer. The application offers two alternatives, the Trainer and the Editor. The trainer is built of, through the user interface, a CTG recording that scrolls automatically and stops on regular intervals. The user can, however, turn the automatic scrolling off. When the CTG recording stops, the user is presented with a question where he or she is asked to judge the curve. Each case is presented with the same set of questions. The editor is where the user can import cases, study them and practice. There are no question presented in the editor, but what the editor has in addition to the trainer is that it acts as a repository for comments on each case. It is possible to add the comments either in a log section on the right side, see Figure 3.5, or as a black box on the recording. If the user finds

3. Previous work

that something looks abnormal on the trace, a comment can be added as a black box and in that way reference a place on the CTG trace. The box will then stay in that particular place of the users choice. The Trainer is not being used at the moment and has not been used for many years for the reason that it is outdated and has some features that act as a hurdle for the user and its experience with the trainer.

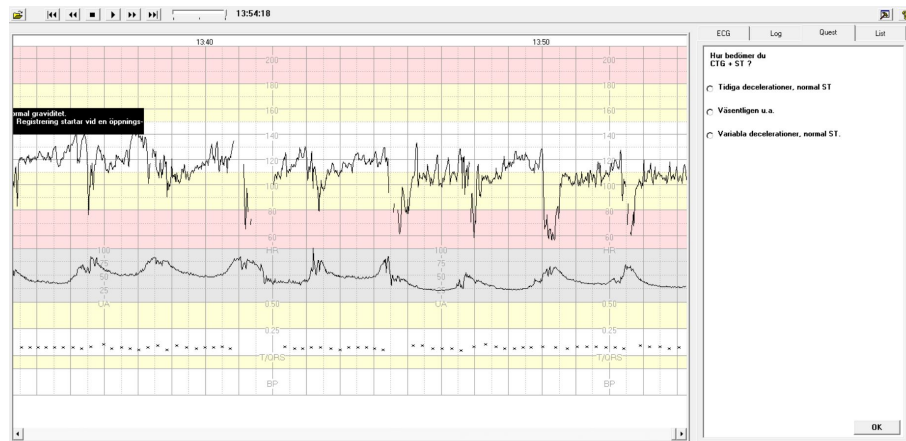


Figure 3.5: A screen capture of the old version of the STAN Trainer.

4

Methods

Designing an interactive product concerns creating user experience to enhance, support and develop the way people work and communicate. The process requires development of a desirable product that will be easy and effective to use. It should be challenging and motivating, and leave the users with an enjoyable, useful and engaging experience. In order to design such a product, several things needed to be evaluated beforehand. The following chapter will describe the process of the methodology used toward a design of an interactive training tool. To clarify how the thesis was carried out, a problem solving cycle approach was followed. Firstly, the chapter addresses the background research strategies and choice of data gathering for understanding the problem at hand. The problem was then defined and goals for a solution were established. Interviews were conducted in order to gain a better insight and understanding of the problem. Secondly, brainstorming session were held where ideas and solutions were generated by using mind maps. Results from the interviews were analyzed and used as an aid for choosing an designing the solution. In order to chose a solution, the Affinity Diagram method was used and from then on the designing and prototyping started. Finally, usability testing and the prototype evaluation were methods explained. The final two steps of the problem solving cycle, should be to implement the solution and review the results, they were however not a part of this research [29]. The problem solving cycle can be seen in Figure 4.1.

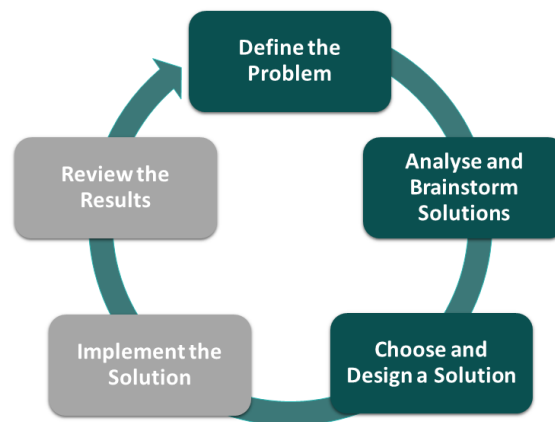


Figure 4.1: The five-step problem solving cycle that was followed.

4.1 Define the Problem

During the project work, the steps of the problem solving cycle were constantly being revised. The process went back and forth, when working towards a solution and to justify the choices that were made. Initial steps were to fill in the blanks by gaining a greater understanding of the nature of the problem. The first step in this process was to research the theory and background behind the content of the web-based training tool. Sources on the four sections discussed in Chapter 2 were crucial in order to understand the topic and helped narrow down the issue at hand. The literature study was carried out by reviewing both unpublished and published articles while gathering key findings and quotations. In addition to the background research, the field of eLearning in health care needed to be studied as well as how to optimize the user experience. The product idea was then defined through open discussion between the authors and supervisors at Neoventa. Next step was to search for similar product on the market. The research provided vital information regarding the desired characteristics of the training tool and identified design ideas. It provided a deeper understanding of what the user requires and how the tool could be tailored to the intended user. This part of the research was also included to understand the market of eLearning tools, get inspiration and creative new ideas for the product. The process of defining and researching a product is closely connected due to the fact that is essential to know the context in which a product exists before defining it [30]. The final step of the problem definition was to carry out interviews with possible users. In addition to user interviews, the authors attended a two day event held by Neoventa, called CTG Master Class henceforth referred to as master class. Additional user interviews were carried out during the event. The information and knowledge gained during the event gave an even better understanding of the problem. The interviews and the master class will be discussed further in the following section.

4.1.1 Interviews

The most common method of data collection in health care research is to conduct interviews [31]. Thus, for this research, interviews were used as a qualitative research strategy. Also, interviews were the most appropriate alternative due to the fact that little was already known about the topic of the thesis work. This target group of the interviewees would be the primary users of this training tool since it is intended for personnel working in the labour ward. It is worth noting that the interviewee's identity will be kept confidential throughout the thesis. The aim was to use the feedback from the interviewees to build a foundation of knowledge about the users, their background education and re-education, as well as the status of continuous education at their workplace and current education status at midwifery science program. Before conducting the interviews and looking into what information was aimed to retrieve, a set of interview goals were identified. The goals were, first and foremost, to identify if there was an interest for a tool like this and observe if midwifery students, midwives and obstetricians were willing to use it. Secondly, to get ideas from possible users and to get their opinion on what type of information

they want to include in the tool. Additionally, the aim was to look at where they would use it, in combination with preferred type of electronic device they would like to use the exercises. The last goal was to discover their profession and background. The purpose of the last goal was to observe what type of continuous education they get at their workplace, and to get to know their experience from their studies. The interviews were all semi-structured where they combined features of structured and unstructured interviews. Both closed-ended and open-ended questions were used and they can be seen below. The semi-structured interviews consisted of several key questions that allowed both the interviewers and the interviewees to diverge in order to pursue an idea or response in more detail. This type of method is popular in health care setting whereas it can provide guidance on what to talk about without being too restricted. The method is also helpful regarding elaboration of important information to the topic at hand that may not have occurred to the interviewers [31].

Questions asked during the master class:

1. How is the training today at your workplace and is there anything you would like to add or change regarding this training?
2. How often do you have organized re-education sessions where you work?
3. Can you think of anything that would make the re-training at your workplace more interesting and exciting?
4. Have you used Neoventa Academy?
 - (a) If Yes: How did you like it? How often do you use it? Is there some aspects that you like or dislike about it?
 - (b) If No: It is a web-based education system with case studies, and interactive educational program with certification.
5. If you were to use an application like we propose, where do you like to perform these exercises? Would you want to use a computer, tablet, smart phone or all?

Questions asked during interviews through the internet with midwifery students:

1. How was your experience of the midwifery education regarding CTG interpretation and topics related to that subject? For example, the lectures, what was the main focus etc.
2. Can you give ideas on ways to improve the way of teaching?
3. If a training tool such as this one would exist, would you make time to use it?
4. If you were to use a tool such as this one, where would you use it?
5. If you were to use a tool such as this one, on what type of device would you use it? Desktop computer, tablet, smart phone or all?
6. Finally, if there is anything you would like to add or if you have any ideas for a tool such as this one, feel free to share them.

Questions asked during interviews through the internet with midwives and professors at the University of Iceland:

1. How does the staff at the labour ward in Iceland maintain their knowledge on interpreting CTG traces?
2. How is the implementation of the new CTG system going, and have you stopped reading CTG traces on paper?
3. How is the training for the new system going?
4. Can the staff at the labour ward access reading material and cases studies electronically to recall at their own pace?
5. Will the staff receive a certification of participation if they take part in lectures, training days etc.?
6. Is there more emphasis placed pattern recognition or fetal physiology?
7. Do you think midwives and students could benefit from an exercise system such as the STAN Trainer?

A total of twenty five people were interviewed through eighteen interviews. There were more people contacted for the purpose of being possible interviewees, however not all replied or wanted to be interviewed. For this work there were twenty five interviewees available. The aim was to get a comprehensive group of interviewees from different countries to explore their views, experiences, needs and beliefs on the topic of CTG and ST Analysis. Five interviews were conducted through the internet while nineteen were conducted face to face during the master class and one was a scheduled interview. The interviews conducted through the internet were all through asynchronous communication, in other words through email or instant messaging. The reason for performing interviews through the internet was due to geographical distance [32]. These five interviewees were Icelandic midwives, midwifery students and professors in the midwifery science program in Iceland. The face to face interviews conducted during the master class were performed during 10 to 15 minutes breaks which resulted in a tight time limit for each interview. The interviews were both conducted through individual and group discussion. Before conducting the interviews, a basic script with a short introduction and the questions, adapted by supervisors, were developed for guidance and in order to cover the same topic with each interview. After each interview was conducted the answers were written down as notes and later transferred to a computer. These nineteen interviewees were from Sweden, Finland, Norway, Denmark and Ukraine. The scheduled interview was with a professor at the department of Biomedical Engineering at Chalmers University of Technology. The purpose of this interview was to get an insight into the method of active learning. From attending the master class and conducting the interviews, a basic understanding of needs and requirements was gained which is a vital part of any web-based design.

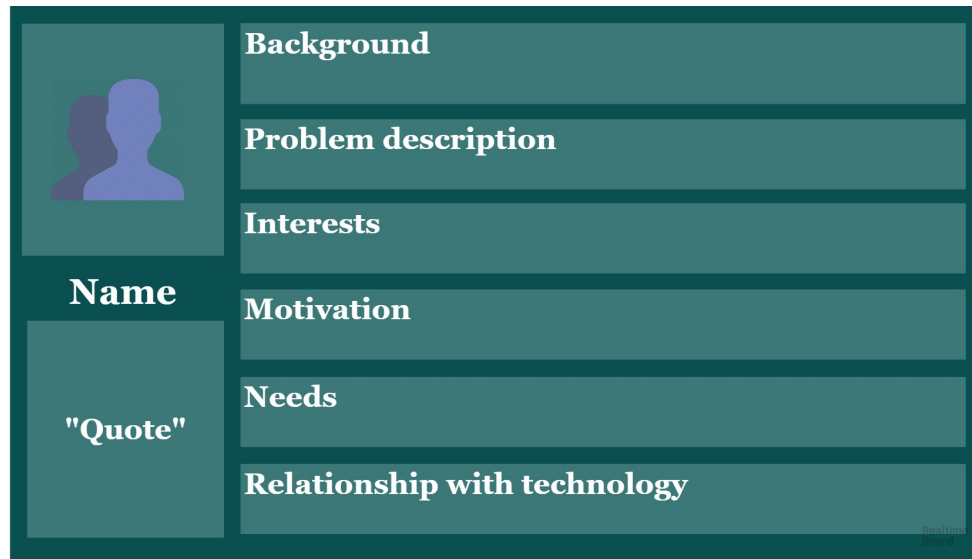
4.2 Analyze & Brainstorm Solutions

After conducting the interviews, the next thing to consider was how to analyze the interview data. The focus was to analyze the results to gain an overall impression from the feedback, use it to identify patterns and generate ideas for a solution. The

interviews contained mostly qualitative data where the data was represented by themes, patterns and stories. One of the advantages of using this method, was that it allowed the interviewers to understand the different experiences of the potential users. Also, this was an opportunity for the interviewees to share their experiences in their own words. As was mentioned in Chapter 4.1.1, the interviewee's answers, from the master class, were all written down as unstructured notes. The answers from the online interviews were more structured but needed to be categorized. The initial step in the analysis was, therefore, to organize the data, structure and transcribe into understandable texts. The texts were then summarized with guidance from the interview questions, that contained the key points that emerged from the interviews. This created a framework that allowed for labeling the data. When summarizing the data, recurrent themes were identified right away which gave a fundamental understanding of the training tool [32]. It is worth mentioning that the themes were not influenced by the authors views. However, the questions might have influenced the interviewee's answers, but that is highly doubtful. The themes and patterns noticed through the summaries were later used as an aid in decision making related to the design process and were incorporated into the Result and Discussion, see Chapters 5 and 6. Summaries from the interviews are available in the Appendix A. The qualitative analysis produced results that answered questions regarding the user and its goals. The results helped in defining user characteristics that were not clearly available through the market research. These characteristics were then used to build two personas that were used throughout the design process from initial brainstorming sessions to the prototyping. The persona, initial and repetitive design steps will be discussed further in the following two sections.

4.2.1 User Personas

In order to bring user profiles to life, they are often transformed into several user personas. Personas are a vivid description of a typical user that will use the product under development [32]. The interviews were used to create two user personas for this thesis. One is focused for midwives in re-training and another is focused on midwifery students training for their future work at the labour ward. Creating the personas was an important step in order to understand the mindset of the potential users. The personas help to focus product decisions by adding a layer of realistic consideration when crucial and decisive decisions were made. However, the two personas were not a representation of all the possible users but focused more on the major needs of the most important user groups [30]. Personas do not describe real people and usually one persona represent a typical user based on data collected in interviews [32]. Each persona has been characterized with a set of goals related to the training tool. As well as goals, the personas included a name, photo, description of job responsibilities and included illustrative information about the persona such as the user's skills and personal details. A template for the personas can be seen in Figure 4.2 and the two personas that were created can be found in Appendix B. To create the personas, a platform called <https://realtimeboard.com> was used. It is an online canvas and whiteboard platform that allows for ideation, to visualize, and share ideas.



 Name "Quote"	Background
	Problem description
	Interests
	Motivation
	Needs
	Relationship with technology

Figure 4.2: A template for a rich description of a persona.

4.2.2 Mind Mapping

The initial steps in the design process consisted of brainstorming sessions. Mind maps were made in order to come up with ideas for the product. The product ideas iterated throughout different phases in the process. With each iteration, new relationships between concepts were discovered [30]. In total of three iterations were accomplished for the mind mapping method. The method is a multicoloured and image-centered diagram that allows for using imagination in order to explore associations between concepts. It represents visualization of ideas where spontaneous thinking is required. A central topic is established that has sub-topic branches. The advantages of mind mapping are its unconstrained structure and it promotes creative thinking, and encourages brainstorming [33, 34].

During the brainstorming sessions, the aimed was to gather as many ideas as possible from both authors to store in one place. The focus was on quantity, not quality. The ideas were focused on the function of the web-page, the content, and type of exercises for the training tool with the STAN Trainer as the central idea. Also, prototyping platforms were brainstormed and in what form the training tool could be, for example, an application, a web-site and so forth. The authors worked separately on collecting ideas in the beginning of the session in order to generate as diverse ideas as possible from different perspectives. When the ideation phase was done, the authors gathered their ideas and had an open discussion. Next, images and handwritten ideas were attached to a poster for visualization, forming a colorful and image rich mind map useful for getting started [35]. Figure 4.3 shows the result from the first session.

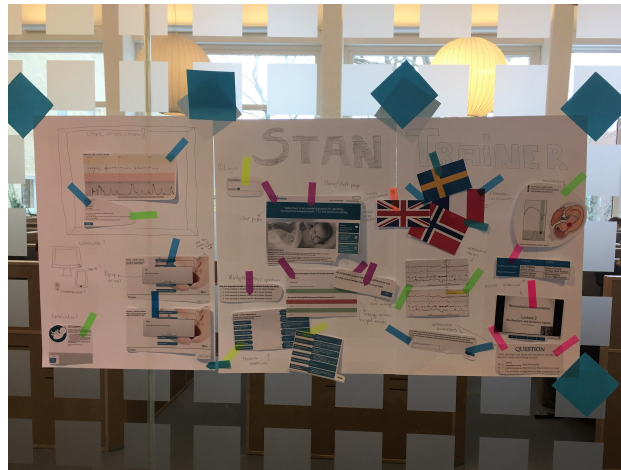


Figure 4.3: Results from the first mind mapping session.

Next session focused on putting all ideas in order and forming them into a more organized mind map. A method of attaching images and ideas on a poster was also used for this session. The mapping was helpful in a way to visually illustrate the relationship between the concepts and ideas in a more structured way. The concepts were linked together with arrows to show the flow of the web-page function. The main topic of the map was the home page and the branches spreading from it were the ideas broken down into specific topics. Figure 4.4 shows the result from the second session.

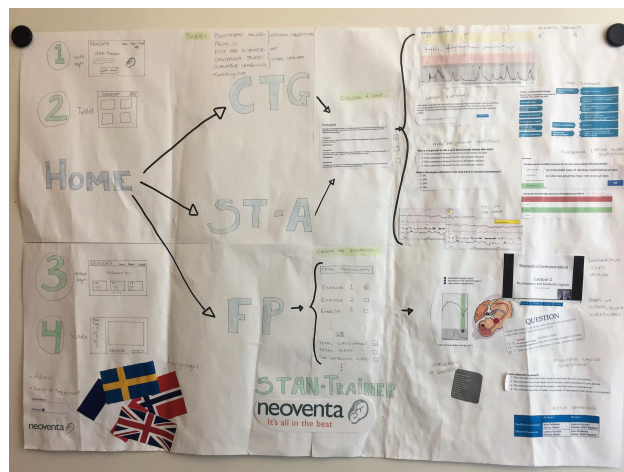


Figure 4.4: Poster for visualization of concepts and ideas.

The third iteration was to convert the mind map to a digital version of a flowchart. Now, the map was implemented as a hierarchy where the smaller set of key concepts and propositions were made more prominent. This was done to acquire a more organized and detailed structure. Figure 4.5 show the result from the third session. It could be said that this iteration looked more like a concept map but a concept map is a top-down diagram showing the relationships between concepts in a structured and organized way [34]. Mock-ups and initial stages of the prototyping were created

at this stage as a parallel process. It is safe to say, at this stage of the process, that the idea had reached a low-fidelity prototype.

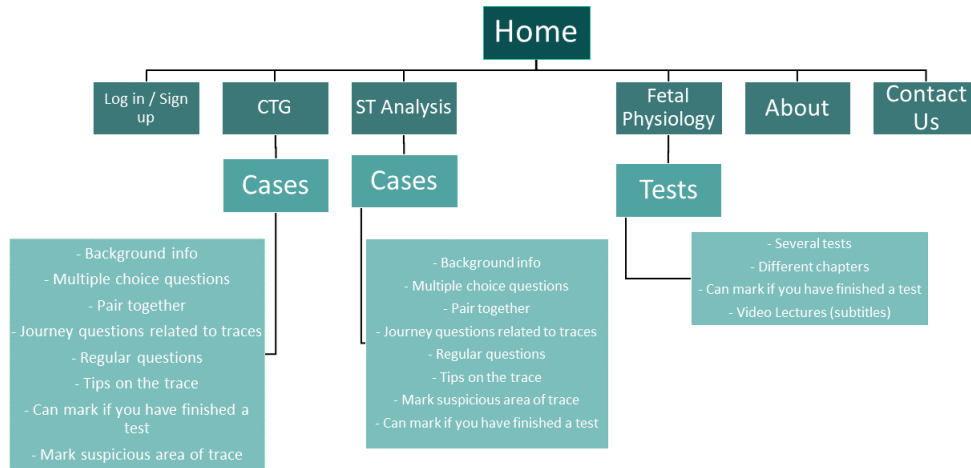


Figure 4.5: Flowchart of the mind map for the training tool.

4.3 Choose & Design a Solution

Large amount of data had been collected from the literature study, data gathering, and brainstorming sessions. For choosing a solution and getting a better grasp of the whole idea, an affinity diagram was used. This method is widely used as a generalized brainstorming technique or "idea-generating" methodology to gather qualitative data [36]. Affinity diagrams are usually made out of large set of ideas to group together similar and related ideas. It was an effective technique after the brainstorming sessions in order to organize all the ideas. The diagram process organizes ideas in several steps. First step is to document ideas on cards or notes with a marking pen. The notes are randomly spread on a large work surface so all notes are visible to everyone involved. Next step is to look for a relation among all the ideas in some way. This step is repeated until all notes are grouped. The last step is to discuss the shape of the chart that has been created. A heading for each group is selected and evaluation of the result from the affinity diagram take place [37].

A session was held where the previously mentioned steps were followed. Post-it notes were used to map out the user needs, the main functions of the web-page and other factors related to the design. This method helped with understanding and choosing the final functions that later resulted in the final version of the design. It assisted in completing the concept of the training tool from earlier research processes and provided an important visual representation. The final affinity diagram is illustrated in Figure 4.6. At this point, a clear understanding of the personas, the training tool and the whole concept was established. Therefore, the next step was to start designing the guidelines and the prototype. The guidelines were gener-

ated through iterative ideation sessions. No specific method was used but more of brainstorming and using whiteboards to collect ideas and later narrowing down to the final guidelines. An important thing to note here is that the design is not just how it looks but how it works. A good product functionality usually starts with an understanding of the potential users [30].

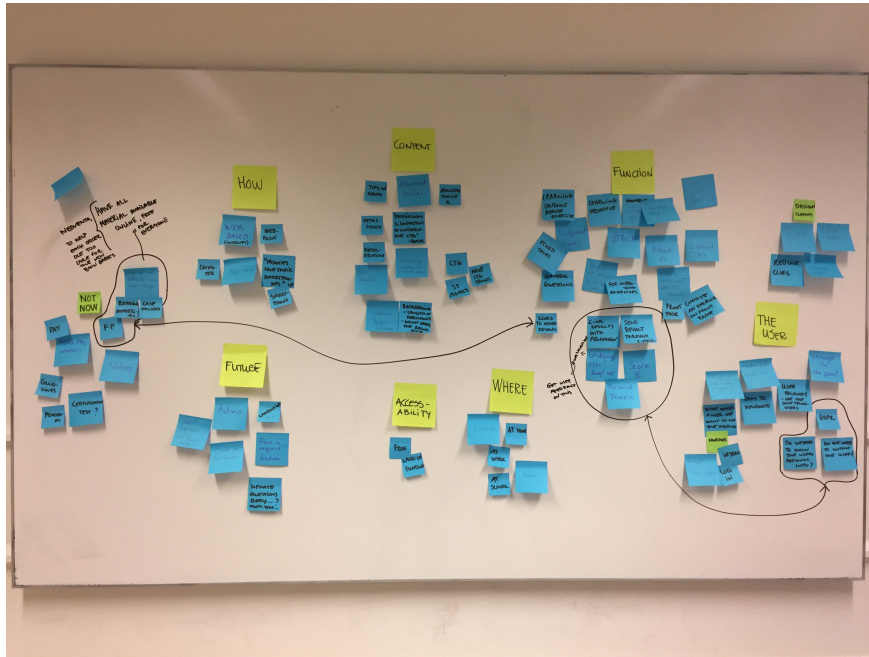


Figure 4.6: The final version of the affinity diagram.

In order to demonstrate an idea of the guidelines, a high-fidelity prototype was created. Prototypes can generally answer questions and support designers in selecting between alternatives. The purpose of creating a prototype was to test out technical feasibility's of the idea, to perform testing and evaluation. The advantage of building this prototype is that it demonstrates almost complete functionality and interactivity of the training tool. It was user-driven and can illustrate the look and feel of the final product. The prototype was therefore able to clarify how users interact with the web-page [32]. For designing the prototype, an online prototyping platform was used. It is a cloud-based development platform, called Wix and the web-pages address is wix.com. It provides a web-page building platform for anyone to create their web-page where it offers users drag and drop options. It keeps the technical coding process behind the scenes so people without programming experience can also create a web-page. The platform has HTML5 capabilities, over 500 templates to chose from, built in apps, for free. Figure 4.7 illustrates the work space of the Wix platform. The reason for choosing this platform was mainly due to the reason that it offers the possibility to design reactive web-page for desktop computer, a laptop computer and smart phones. In that case, it adapts to all views. This prototype allowed users to test the product and give feedback regarding the feel, function and the experience with it. A small set of usability feedback was collected during the last phase of the thesis work and will be discussed further in the following section.

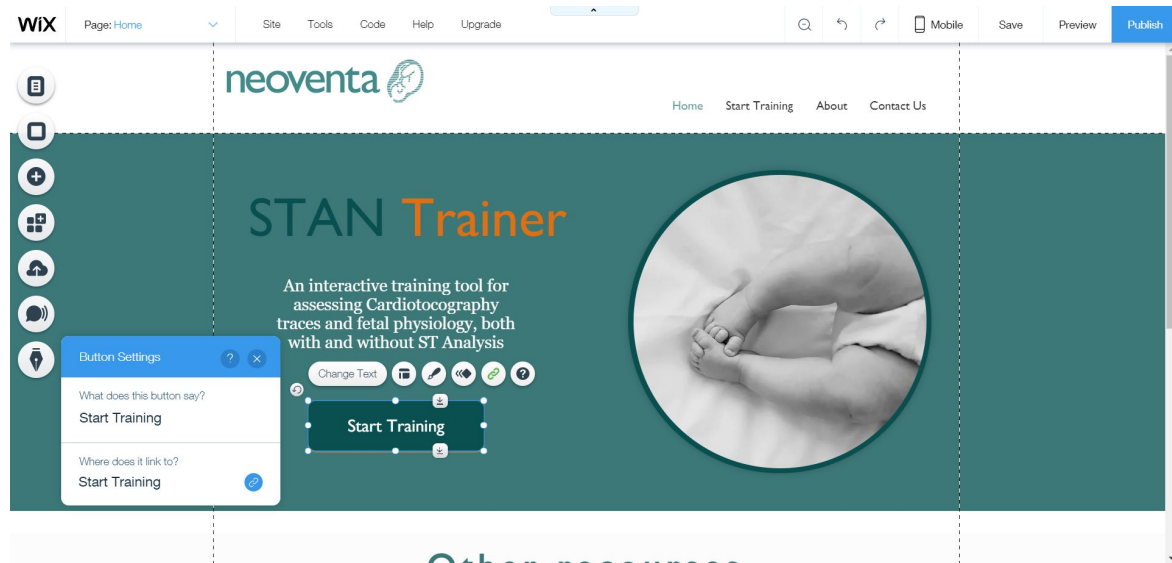


Figure 4.7: A screen shot of the work space from the Wix platform.

4.3.1 Usability Testing

Usability testing was included in this project in order to answer the question "Can people use this design?". This type of test provides insight into how users interact with the web-page to notice if it is usable or not. The importance of usability testing considers the fact that if a web-page is difficult to use, people will not use it. Issues regarding the web-page are not always noticed by the designers and can then be recognized through this type of testing. It is not always possible to go on sight to perform an observational usability testing. In addition, usability testing done in person does not always have to be more useful than other methods. Therefore, a method of remote usability testing was performed. Remote usability testing uses online software to test the user behaviour. The user works with the web-page from a different physical location than the facilitator, for example in another country. Communication can be managed through telephone or online communication throughout the test seeing that feedback and verbal feedback is important to understand problems regarding the usability [38]. The advantages of using this method compared to other usability testing methods is that it provides access to a larger group of potential testers, cuts travel time, and can substantially reduce the cost related to usability testing. The testing for this project was done through online instant messaging and an application called *Facetime* that allows for telephone communication. The users were asked a series of questions regarding the overall design, usability, navigation, and user flow of the web-page. The questions can be seen below. The users tested the prototype while either verbally expressing comments or writing them down comments along with observations they encountered while performing the exercises and browsing through the web-page on a computer or a smart phone. The feedback was gathered and incorporated into the prototype and will be discussed in the Discussion, see Chapter 6.

Questions asked regarding usability testing:

1. What do you think of the over all design and look of the prototype?
2. How easy was it to find the exercises? Did you need more navigation to find them?
3. What did you think of the flow of the training tool?
4. Did you use a computer, smart phone and/or tablet?
5. Do you have any other comments about the prototype?

5

Results

The result of this thesis is divided into three sections, non-functional and functional requirements, and a high-fidelity prototype of the STAN Trainer. The non-functional requirements provide navigation and design guidelines that address the user experience. In addition, two user personas are discussed and how they influenced the design process. The functional requirements address ideas on how the STAN Trainer can be implemented and developed. The results were inspired by the literature findings, the market research, results from the interviews, guidelines from the internet and the authors own suggestions. The high-fidelity prototype presents an idea how the authors have visualized how the STAN Trainer can look and function. With both the functional and the non-functional requirements, the authors want to inspire developers to implement an engaging, efficient, simple, and an appealing training tool to get the users interested to learn and incorporate the tool in their everyday professional continuous education. Current tools do not address the exact same topic as the STAN Trainer. Therefore, the objective is to provide recommendations on how the training tool can offer the most optimal user experience and training possible. The aim is also to provide new and effective exercises that guarantee that the users will never forget what they just learned.

5.1 Non-Functional Requirements

When it came to designing the STAN Trainer, it was important to focus the attention on optimizing the usability and the user experience. While the look and feel of the training tool was important, the users are not aiming to evaluate the nice design but instead to improve their skills and perform exercises. The users have a limited amount of time to spare on something else than their studies or professional responsibilities. Therefore, it was crucial to focus on having the design simple and efficient. What was also important when it came to designing a training tool such as this one, was visual hierarchy. The way that the web-page is structured is important for simplicity as well as navigability. The users are of all ages and have a wide range of experience, some are students and other have several years of experience working in the delivery ward. Thus, it was essential to focus on having the web-page tailored and easy navigable for these users. Some users are not used to using technology and therefore they should be able to move around the web-page easily as possible. The feedback from the interviews were used for the design as well as guidelines found on the internet [39, 40, 41].

The simplicity of the STAN Trainer came from not using too many colors. Also, by not using unnecessary graphics that could be distracting, or other elements that served no purpose. The color pallet and typography of the web-page should be according to Graphical Guidelines of Neoventa. This was utilized to maintain consistency and the visual identity of the company. When designing the navigation for the training tool, the most important elements should appear first when the web-page is opened. The home page should be structure in a way so that the training tool could be accessed from the left side. This is because users scan web-pages from left to right. Also, buttons or actions that direct the user towards an action should be in a dark color to draw their attention. According to the user interviews, the users want to have the training tool available for desktop or laptop computers, tablets and smart phones. Therefore, the training tool will be available as a reactive web-page so that it supports all these electronic devices. Also, it eliminates the need to download an application or a software program which can act as a negative user experience. In addition, results from *StatCounter Global Stats* found that mobile and tablet devices accounted for 51.3% of internet usage worldwide in October 2016 compared to 48.7% by desktop or laptop computers. These results support the reason why the the web-page should be available for all three types of electronic devices, desktop or laptop computers, tablets and smart phones [42].

A user flow diagram was created to make the design process more effective and efficient. This process aimed to have the user flow with as little complexity as possible. It allowed for better understanding of the design process and was valuable when trying to understand how the user would interact with the training tool. The user flow diagram was made up of three components, squares, diamonds and arrows. Squares represent different screens, such as the home page or the exercises pages. Diamonds represent different decisions, such as tapping a button or scrolling up and down, and arrows are used to link screens and decisions together. When the user enters the web-page, the home page would be the first thing that the users should see. From the home page there are a number of actions that the user can perform, such as start the training or look through other resources. When the button for starting the training is pressed, the user is directed to the exercises page and can choose between either CTG exercises or ST Analysis exercises. After the user has chosen an exercise, a button is pressed to start the exercise. A back button is always present, in case the user has started the training and wants to go back to the previous page. A home button is also always present that brings the user to the home page. The user flow diagram can be seen in Figure 5.1 and was used in the design of the STAN Trainer prototype.

During the design process, two user personas were used to keep the perspective of the intended user. The two personas created were a midwife and a midwifery student. They gave a good overview of the different needs and behavior of the two groups that the personas represented. The interviews with midwives were focused on analyzing their motivation and needs. The midwives were interested in abnormal cases that they do not come across everyday in the labour ward. The reason why they want abnormal cases is to be well prepared for when they occur. They were

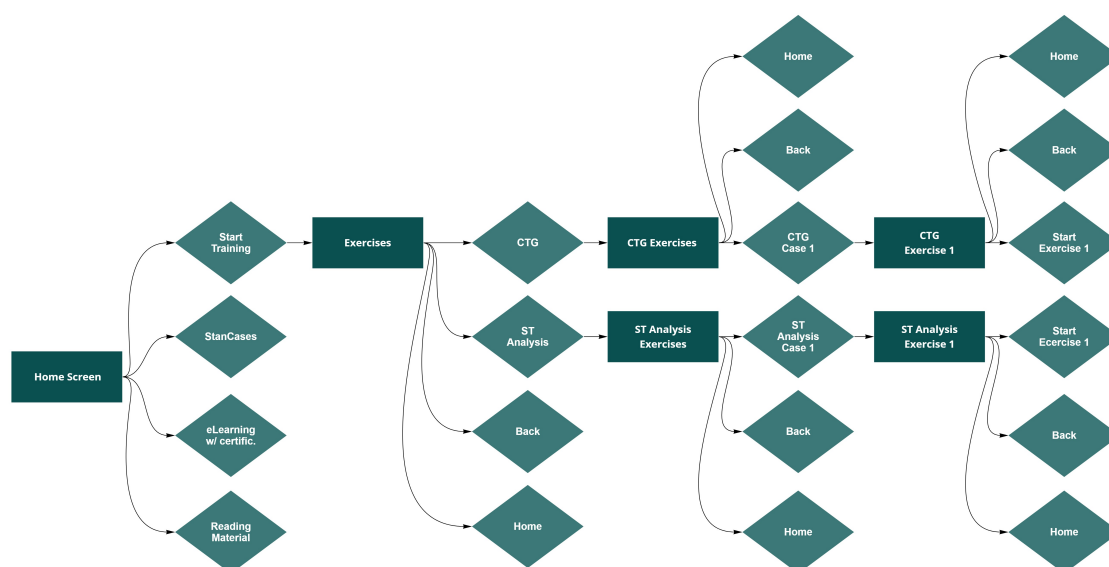


Figure 5.1: User flow diagram for the exercises.

keen on trying new ways of retraining and willing to learn if the training tool was simple and straight forward. However, they were not as comfortable with technology as the the students. Based on the interviews with the midwifery student, the students were eager to try new ways of training and wanted to be better prepared for the labour ward. They mentioned that during lectures, it would be beneficial to implement more interactive exercises. Sometimes, it can be hard to stay focused when the teacher speaks and explains for several hours at a time. Additionally, research has even showed that the average attention span of a medical student is 15 to 20 minutes at the beginning of class [43].

According to the interviews, the midwifery students would use the STAN Trainer either at work, alone or with colleagues on a desktop or laptop computer, at home using their tablet or smart phone. They would look through it in their free time or during shifts when there is spare time. A crucial condition that needed to be met was that the training tool had to be user friendly. The personas, interviews and market research were of great help when trying to meet that condition and were used extensively in the design of the STAN Trainer. The personas that were created can be seen in Appendix B.

5.2 Functional Requirements

The functional requirements address guidelines for how the STAN Trainer can be implemented and developed. The guidelines encourage active learning in the form of applied interactive exercises and discussions with peers and colleagues, both for continuous education and for the midwifery science program. This way of learning

encourages users engagement and encourages them to explore attitudes and value while motivating them to enhance their skills and knowledge. The authors believe that with these active learning strategies, the STAN Trainer can engage users in critical thinking, encourage collaboration and discussion when interpreting cases. According to an interview with a professor from Chalmers University, students become more active with implementation of active learning and they improve their learning. Thus, the guidelines have been developed with that in mind. The functional requirements contain exercise guidelines and recommendations for the training tool. The topic will be discussed in more details in the section below.

5.2.1 Exercise Guidelines & Recommendations

The STAN Trainer will contain exercises, cases, quizzes and questions. The exercise pages should be categorized into two parts, CTG related exercises and ST Analysis related exercises. These exercises will contain different cases. The cases should also be categorized in two parts, predefined cases and random cases. The predefined cases should be categorized into different topics of interest where the users can enhance their skills related to a specific event. If the users prefer to test their knowledge, they have the option to select a random case where the topic of interest is not known in advance. Thus, the users do not have knowledge of the outcome of the case prior to performing the quiz. Each case is diverse, therefore, there should be different questions for each case. In addition, the main focus of the questions would not rest on only pattern recognition but also focus on fetal physiology. Each case should be arranged in a layout with three sections. The first section is a scrollable recording and the second section is the summary/clinical background. These two sections should always be present throughout the quiz. The third section and the only part that will change are the questions. The questions should be of three different types, multiple choice questions, match correct statements, and fill in multiple blanks of a text related to the case. These type of question were chosen so that future launch of the product will be easy to implement. Templates for the cases and the exercises can be seen in Figures 5.2 and 5.3.

The reason for setup of the templates is according to interviews, usability testing, discussion with supervisors and through market research. According to interviews, it is important to have the summary/clinical background visible throughout the assessment of the case. The recording of the CTG and ST Analysis cases should be scrollable so that the user can view the whole trace. Also, the user should be able to scroll through the recording at its own pace. According to the master class a CTG trace should not be segmented, instead the whole recording needs to be visible. The trace should be viewed as a story and valuable parts can be overseen if presented in segments. Nothing should block the recording at any time during the exercise. The users should be able to go back and forth between questions at their own pace. One question should be present at a time, in that case, the user does not have to scroll up and down to view the questions together with the graph. From usability testing, the importance of feedback was realized. There should be feedback after each question so the users know if they answered the question correct or not. Also, an explanation

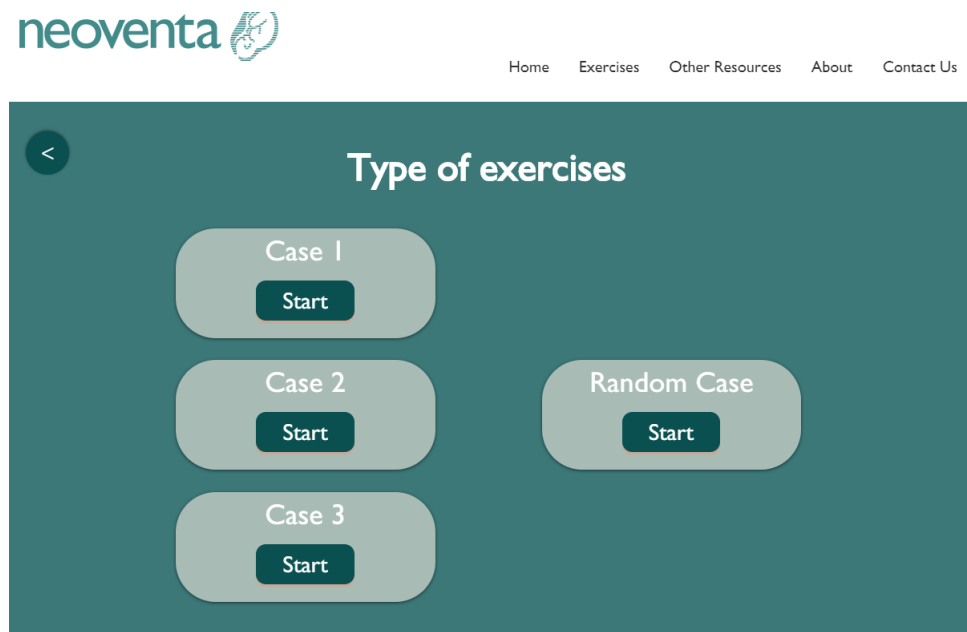


Figure 5.2: Template for the setup of the exercise page and different types of cases.

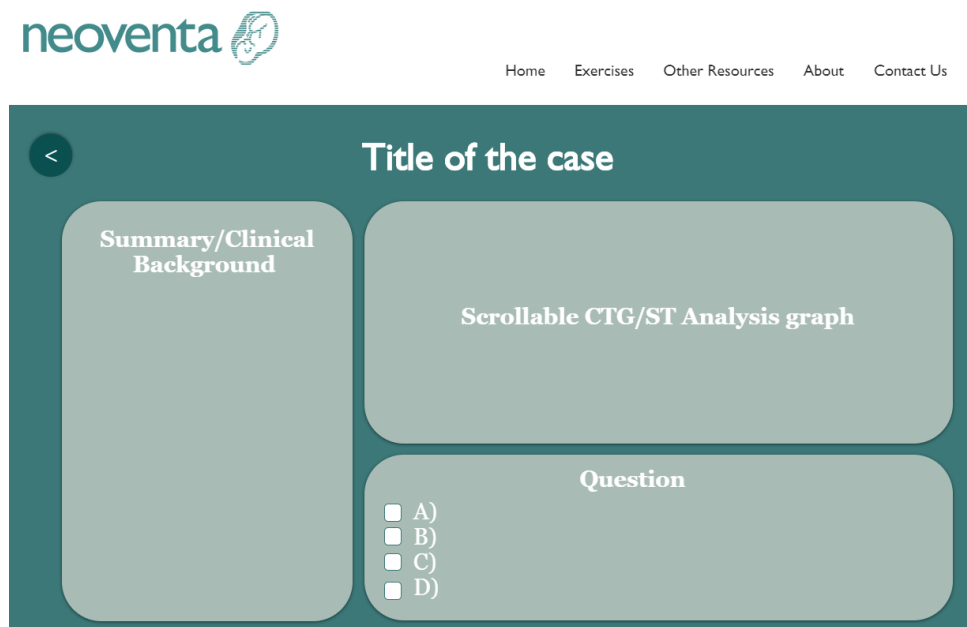
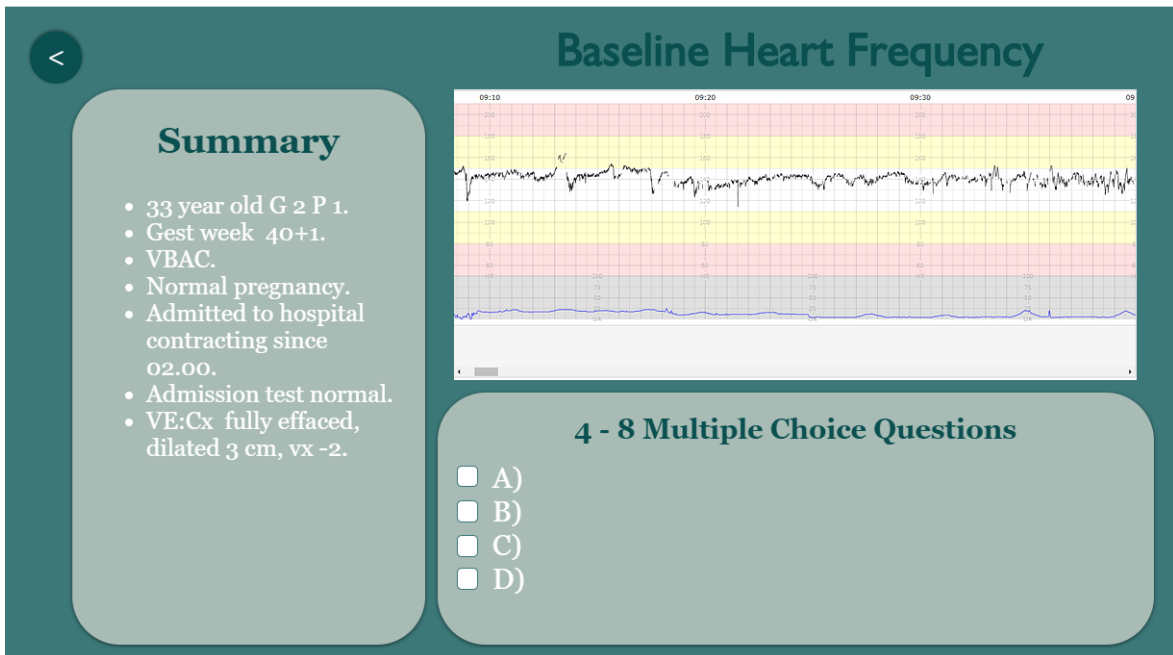


Figure 5.3: Template for the setup of each case with three sections.

to the correct answer should appear, before the users are presented with the next question and they should be able to control when they want to proceed to the next question. The exercises can be performed individually, in a group of colleagues or with fellow students. Ideas for the layout, type of questions and interaction exercises for the STAN Trainer have been summarized and are the following:

- CTG exercises & ST Analysis exercises
 - CTG categories:
 1. Basic physiology
 2. CTG physiology
 3. CTG interpretation
 - ST Analysis categories:
 1. Fetal ECG physiology
 2. Fetal ECG interpretation
- Each exercise includes:
 - 4 – 8 multiple choice questions
 - Interactive exercise to match statements
 - Interactive exercise to fill in blanks of a short text

In order to clarify what was listed above, the questions should be categorized into two parts: CTG related questions and ST Analysis related questions. The questions should address the listed topics with regard to give the user a comprehensive approach to interpret the recordings in the desired way. The questions should be composed by an expert in labour and delivery care along with extensive knowledge of ST Analysis. Each case should start with 4 to 8 multiple choice questions. The reason why there is not a fixed number to the amount of questions is because every case is different and differs in length and complexity. An example of a question could be to refer to a specific time or event in the recording and ask what action to take, call a physician, continue or take action. More questions can be viewed in the Appendix D. After the multiple choice questions, an interactive question should appear next where the user has to match statements related to the type of case. These type of questions do not have to be present in every case, but is recommended in order to invite diversity. This can optimize the user experience and can be fruitful for the users to get them engaged in the exercises. The quiz should end with a question where the users are presented with a short text and have to fill in the blanks where there are some key statements missing. Next to the text there are several words that could possibly fit the text and the users need to figure out which word would fit correctly. The user has to drag and drop those words in to the correct place in the text. In total, one quiz should contain between 6 to 10 interactive questions. Below, in Figures 5.4, 5.5 and 5.6, are examples of how a case can look.

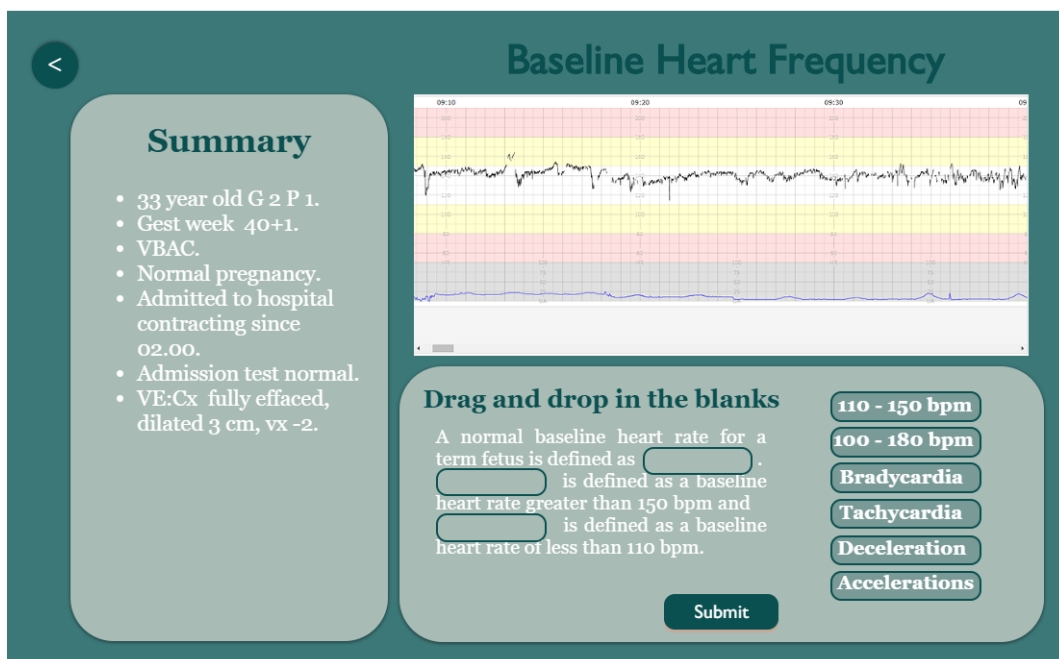


The screenshot shows a desktop interface for a case titled "Baseline Heart Frequency". On the left, a "Summary" box contains the following text:

- 33 year old G 2 P 1.
- Gest week 40+1.
- VBAC.
- Normal pregnancy.
- Admitted to hospital contracting since 02.00.
- Admission test normal.
- VE:Cx fully effaced, dilated 3 cm, vx -2.

To the right of the summary is a fetal heart rate monitor (FHR) trace showing a baseline heart rate around 140 bpm. Below the FHR trace is a section titled "4 - 8 Multiple Choice Questions" with four radio button options labeled A), B), C), and D).

Figure 5.4: Setup of the cases in desktop view for the multiple choice questions.



The screenshot shows a desktop interface for a case titled "Baseline Heart Frequency". On the left, a "Summary" box contains the same text as in Figure 5.4. To the right of the summary is a fetal heart rate monitor (FHR) trace showing a baseline heart rate around 140 bpm. Below the FHR trace is a section titled "Drag and drop in the blanks" with the following text:

A normal baseline heart rate for a term fetus is defined as _____.
_____ is defined as a baseline heart rate greater than 150 bpm and
_____ is defined as a baseline heart rate of less than 110 bpm.

Below this text is a "Submit" button. To the right of the text are five buttons for dragging and dropping: "110 - 150 bpm", "100 - 180 bpm", "Bradycardia", "Tachycardia", and "Accelerations".

Figure 5.5: Setup of the cases in desktop view for the text question.

neovolta

Home Exercises Other Resources About Contact Us

Baseline Heart Frequency

Summary

- 33 year old G 2 P 1.
- Gest week 40+1.
- VBAC.
- Normal pregnancy.
- Admitted to hospital contracting since 02.00.
- Admission test normal.
- VE:Cx fully effaced, dilated 3 cm, vx -2.

Match the correct statements

Tachycardia	<input type="text"/>	Is a sign of an active adaptation with an increase in sympathetic activity or metabolic activity from a temperature rise.
Bradycardia	<input type="text"/>	Is generated from an increase in parasympathetic and fetal adaptation to reduced cord blood flow.
Baseline FHR	<input type="text"/>	Is sometimes referred to as the balance of the autonomic nervous system.
Variability	<input type="text"/>	Is maintained by the interaction between the sympathetic and the parasympathetic systems.

Submit

Figure 5.6: Setup of the cases in desktop view for the matching question.

Additionally, the mobile view will be different from the desktop or laptop view. The users will have to scroll up and down through the case to see the question and the graph. This is necessary as a result of the smaller screen size of the smartphone. Another important function that would be appreciated to include, according to the usability testing, is to enlarge portions of the recordings. This effect would have to be available for both desktop or laptop view and mobile view. For the desktop or laptop view the recording could be enlarged if the mouse pointer would hover over the desired parts of the trace. To get the original size of the recording the mouse pointer would be redirected away from the recording and it's original size would be restored. This function would only affect the view of the recording not the summary/clinical background or the questions. However, to enlarge a portion of the recording for the mobile view the user needs to double tap the desired portion or zoom with two fingers going in the opposite direction. To get the original size of the recording, the user needs to double tap the recording again or drag the fingers in towards each other.

5.3 High-Fidelity Prototype

A high-fidelity prototype of an interactive STAN Trainer was implemented where it's suitability can be explored. The web-pages address or URL is www.berglindf22.wixsite.com/stantrainer. The prototype was created in a platform called Wix that generates reactive web pages functioning in desktop or laptop computers, and smart phones. Even though it reacts to these two types of devices, it functions well on tablets as well. It can operate on both Android and iOS devices seeing that this is a reactive web page. In order to produce these results, it was crucial to understand the requirements for this type of training tool. The interviews and the master class were of great help regarding that. The prototype aims to help future developers to further iterate the design and eventually create a fully functional STAN Trainer training tool for the midwifery science program, and for re-education in the labour ward. The prototype was divided into five parts: the home page, called *Home*, the exercises, called *Start Training*, *Other Resources*, *About*, and *Contact Us*. It has been noted, in several places of the web-page, that this is a prototype made by two students, and that this is not a fully functioning training tool presented by Neoventa. Figures for the mobile view are illustrated in Appendix C. The ST Analysis exercises have almost an identical setup and look as the CTG exercises, therefore, they can also be viewed in the Appendix C.1



Figure 5.7: A screen capture of the home page.

5.3.1 Home Page

When the user enters the web-page, the aim was to provide an easy interface that minimizes distractions. In addition, the aim was to have a clear purpose of the web-page. This is above-the-fold content, that is the part first visible when the users enter the page. The left side is a combination of a headline, the sub-headline, and the primary call-to-action. The headline purpose is to answer the question "What is this?", and the sub-headline helps the user realize "How can this help me?" which

includes a short text that provides clarity about the purpose of the web-page. The primary call-to-action is the button that says "Start Training". It guides the user to what step to take next, working as a direction indicator. The "Start Training" button was in dark color to draw the users attention. At the top right part of the home page is the navigation bar where the user can choose the option to go back to the home page. The exercises option is the same as the call-to-action button "Start Training". The purpose of that option is so that the user can change exercises without going back to the home page. The result is therefore a clear, simple and clean home page that can be seen in Figure 5.7.

To meet the users wishes, according to results from the user interviews, other resources were included in the training tool. However, since that was not the main focus of the STAN Trainer it was decided to address that function with the option of other resources. With this option, the users can easily access a broad range of resources to get more thorough knowledge and in-depth understanding on the topic of CTG and ST Analysis. Three different resources were inserted below-the-fold, see Figure 5.8. To access these resources the user has to scroll down to see the content or click a button on the navigation bar in the top right corner on the home page. The resources are previously discussed topics, stancases.com and elearning with certification, as well as reading material offered by Neoventa. The button works as an anchor which is an invisible position marker. By clicking the button the user is directed to the section of the home page where the resources can be found. This feature was included to improve navigation and to enhance user experience.

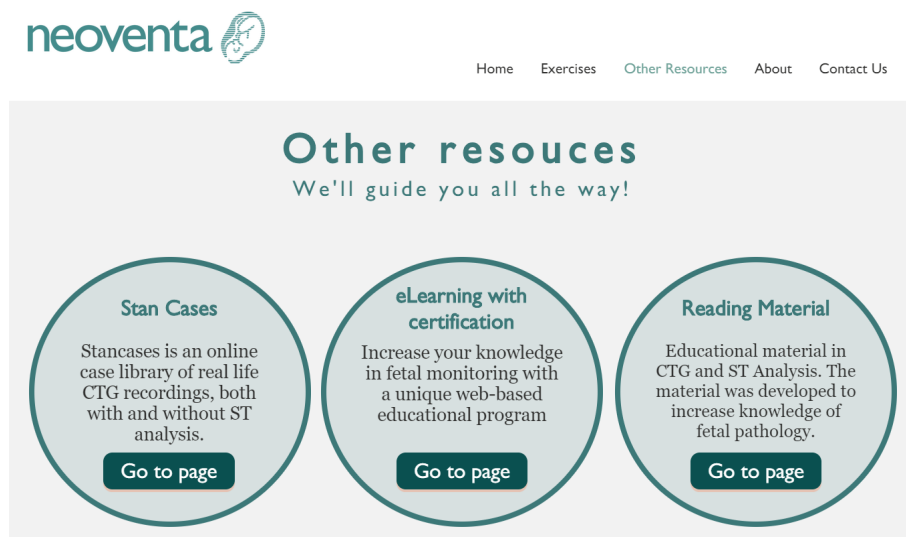


Figure 5.8: A screen capture of other resources.

5.3.2 Exercises

The exercises for the prototype were designed to be simple and easy to perform. In order to start the exercises, the user has to click the "Start Training" button or choose the "Exercises" option in the navigation bar on the top of the web-page. The exercise page presents the user with two choices, either CTG cases or ST Analysis

cases. The two choices are an online library of cases related to the previously mentioned subjects with an emphasis on the fetal response and pattern recognition, see Figure 5.9.

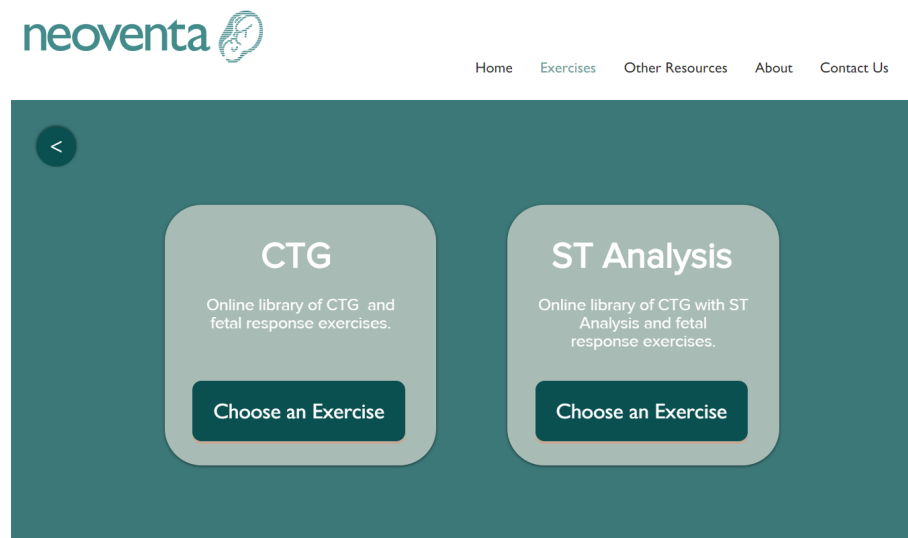


Figure 5.9: Two categories of exercises the user can choose from.

One quiz is present for each topic, with only multiple choice questions. As can be seen in Figure 5.10, a message explains that this is only a prototype. The quiz was designed with a built-in app provided by Wix. Therefore, the authors were not left with much space for designing the quiz itself. However, it was easy and quick to create which allowed the authors to perform usability testing and get valuable comments on the design. The questions were composed by one of the supervisors of this Master's thesis, a STAN-specialist midwife.

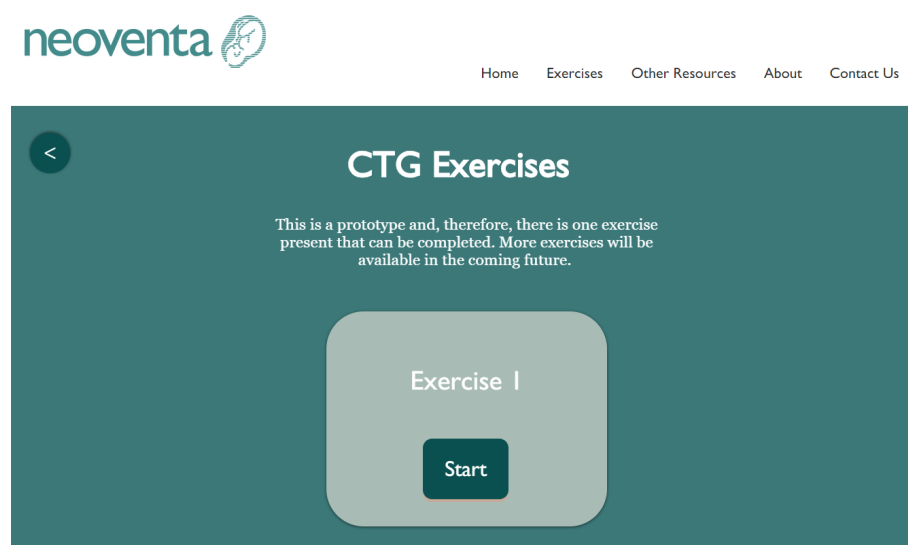


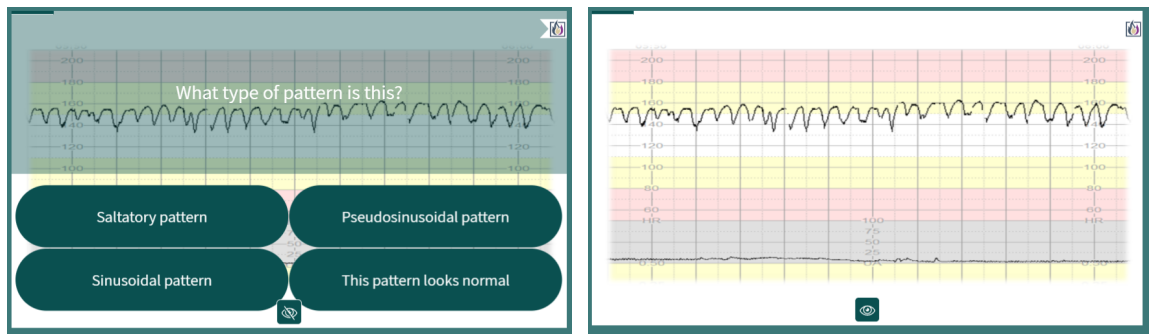
Figure 5.10: A screen capture of the CTG exercise.

When the user has chosen a case, the learning objectives are the first thing that are presented. Including a learning objective at the beginning of each exercise is important to focus the user's attention on what he or she should know and learned by the end of the exercise. They should be realistic and achievable. Immediately after the learning objective, there are instructions and explanations regarding the quiz. To start the quiz, the user then needs to scroll down. References related to the questions are situated below the quiz, see Figure 5.11.



Figure 5.11: The setup of the CTG exercise, extended view.

In that way, the user can see the whole image and interpret the recording. To have the question visible again, the user has to press the eye symbol again. Figures 5.12(a) and 5.12(b) demonstrate the format of the questions, first with the question visible and then with the background image visible. Results from the usability testing showed that it was confusing for the user to press the eye symbol in order to see the image. Therefore, the exercise guidelines have mentioned that the graph should always be present and nothing should block it at any time during the exercise.



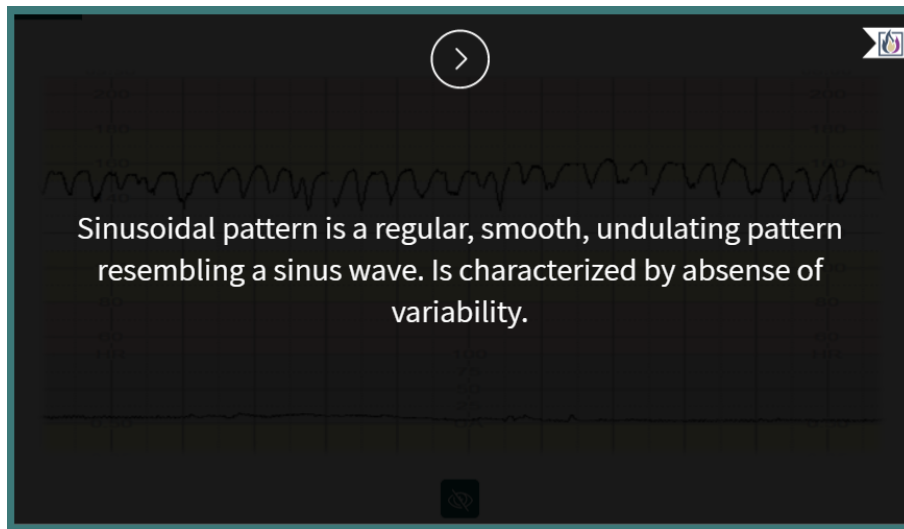



Figure 5.14: An explanation to a question from the CTG exercise.

5.3.3 Other Functions

To inform the users on the STAN Trainer, its function and history, they can read a short summary in "About". The users can also approach the company's contact information under "Contact Us". If they have any questions or recommendations regarding the function, design etc. they are encouraged to contact the company. The two functions are displayed in Figures 5.15 and 5.16. Final function to be explained is, if the Neoventa logo is clicked, the user will be redirected to the home page.



Figure 5.15: About page for the prototype.

neoventa 

Home Exercises Other Resources About Contact Us

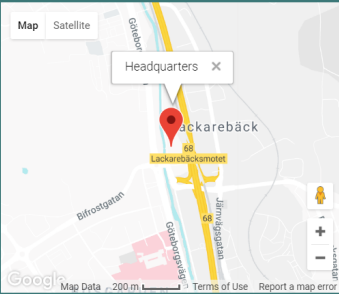
Contact us

Thank you for your interest in the STAN Trainer. If you wish to be contacted by us, please enter and submit your request below.

Email * Name *

Subject

Message



Neoventa Medical
Norra Ågatan 32
431 35 Mölndal, Sweden
Phone: +46(0)31 758 32 00
Fax: +46(0)31 758 32 99

Figure 5.16: Contact us page for the prototype.

6

Discussion

One of the objectives of this thesis was to investigate and analyze the need for a training tool such as the STAN Trainer. Initial research, interviews with potential users, and the attendance during the master class were of great help and gave the authors valuable understanding of the problem, knowledge, ideas and feedback. During a step wise approach to the solution it was relatively early in the process where the authors understood that the main problem was to interpret CTG patterns. The problem is identifying specific hypoxia-related patterns and, consequently, large amounts of deliveries result in unnecessary interventions in an attempt to prevent intrapartum hypoxia. Additionally, investigation initiated by the Swedish Board of Health and Welfare, showed that adverse outcomes of cases were related to misinterpretations of the CTG traces. These outcomes were caused by staff not reacting to abnormal CTG patterns and/or incorrect use of the STAN Method due to lack of proper training [15]. In the coming future, focus will be on intensive training on fetal physiology and mandatory competency testing in order for the labour ward staff to be able to interpret and use the STAN Method in a correct way. Edwin Chandrachud, the lead consultant for the Labour Ward and an Honorary Senior Lecturer at St. George's University Hospital in London, also the lecturer during the master class, confirms that training on fetal physiology has contributed to the lowest emergency cesarean section rate at St. George's. This can be concluded in the fact that there is a great need and interest for a training tool such as the STAN Trainer, for both labour ward staff as well as students planning to work in the labour ward. The purpose of the tool should be to provide well prepared midwives and obstetricians right after they finish their studies, also to have well trained personnel in the labour ward.

6.1 Interviews

During the interviews conducted in the master class, the status of continuous education was investigated. The personnel were presented with questions regarding continuous education in fetal monitoring. There are both pros and cons with the method used during these interviews. Open ended question introduce discussion between the interviewee and the interviewer that can bring out information the interviewer had not thought of. They can also introduce discussion where the interviewees go off topic and talk about something not related to the question asked. In that case, the interviewers had to direct the conversation on the right path. This resulted in a tight time limit for each interview. Interesting things were, however,

noticed during the interviews. Firstly, only a few knew of Neoventa Academy and no one was using a training tool such as the STAN Trainer on a regular basis. They are working with fetal monitoring every day but may not be dealing with abnormal cases regularly. Therefore, there is a possibility that the staff is not prepared well enough to deal with those abnormal cases when they occur. Another interesting thing noted during the master class was the difference in interest between interviewees regarding the topic of interpreting CTG traces. Moreover, the difference in the reason why they were there was diverse. Some of the interviewees came there in a group of two to approximately ten, while others came alone. Two midwives from Sweden came because two weeks prior to the master class they had lost a baby during delivery and they suspected that the reason was related to misinterpretation of the CTG trace. A common thing noticed through all interviews was that the labour ward personnel get re-training either once a year, every second year, or not at all. The staff hold meetings either every week or every other week (depends on the hospital) where the personnel review cases that happened during last shifts. This way they can review abnormal cases together and discuss actions etc. Also, when the interviewees were asked if ST Analysis was currently used at the hospital, all except one said they had stopped using ST Analysis. However, several interviewees mentioned that they would want to get this technology back to the labour ward because, according to them, it is one of the best method available today.

Interviews with the midwifery students and the professors from Iceland also gave valuable insight into the importance of having a training tool easily available for students. In Iceland, the midwifery science program lasts for two years. The students attend a lecture in CTG interpretation twice in the first year for two hours each time. In the second year, the students review what they did the year before and together they view CTG traces. Through practical training, the students get to train their CTG interpretation. However, as was mentioned above, they are not presented with abnormal cases every day. Therefore, according to interviews, they would like to have access to different cases to practice. The students do not get access to many traces to review during their studies. Instead they get access to the teachers slides who has added a fixed amount of traces, along with access to cases through their practical training. An interesting thing noticed through the interviews was that the tool could easily be used both as an individual as well in a group. If used in a group, it could be used to create valuable discussion between colleagues.

A new system was recently installed in the labour ward in Iceland, less than a year ago. It offers the personnel to view traces digitally but before that every recording was printed on paper. The recordings are still being printed on paper, although it is only for security reasons and will not be done for much longer. There is no training tool available for the new system at the moment. This is relatively unsustainable and uncommon, at least in Scandinavia.

6.2 The STAN Trainer

The process of the STAN Trainer went through several iterations, as can be seen looking at the mind maps in Chapter 4. From the very start it was known that the STAN Trainer would not be classified as a medical device. It is not a software that is directly used in medical practice and the users need to apply their own interpretation to the diagnosis and treatment process.

The users choose exercises to perform that address different topics regarding CTG and ST Analysis. The exercises are designed so that they enhance users skills and knowledge. The design of the exercises is set up in a way so that the user can choose a specific case or test their knowledge on a random case. This offers training exercises for users at different competence level. This setup of design can be explained in a way how engineers might develop systems. A system is developed and tested on fixed data. To see if the system works, it is tested on random data. In this case, the user acts as the model.

One thing discussed during the process was CTG guidelines. Countries and hospitals use different guidelines regarding interpretation of CTG. For example, Neoventa has one type of guidelines, Sweden uses different guidelines and Iceland uses the third type of guidelines. With this in mind, the aim was to have the questions in the STAN Trainer as general as possible. The goal was to find similarities between the most common guidelines and have that in mind when composing the exercises and questions for the STAN Trainer. Also, to emphasize more on fetal physiology interpretation of traces.

When making the prototype, the authors realized that the Wix platform had some limitations. Breadcrumbs was one of the desired function that Wix did not offer. It is a navigation function that reveals the user's location in the web-page. Using breadcrumbs can allow users to reduce unnecessary clicks, help them understand the layout of the web-page and helps to retrace the users steps from the home page to the page they are currently viewing. According to the usability testing, the users would go all the way to the home page when changing exercises. The authors believe that with using this option, it can make the user experience and simplicity of the trainer better. Other limitations that were realized through usability testing were related to the quiz itself. The quiz was made through a recommended Wix app and all functions were fixed, which gave no room for creativity or manual fixing. Regarding the viewing of the image and the questions, it was not obvious to the users that they had to press an eye symbol to view the whole image. Even though there was a text explaining what the users should do, they had to get guidance how to view the image. It was hard to press the eye symbol in the mobile view and the text was relatively small. A good way to enlarge the text is to tilt the phone. In that way the questions get bigger and the image as well. Additionally, the way of presenting feedback was a limitation. The platform used to create the quiz only allowed a fixed amount of characters for the questions, the answers, explanations etc. Also, the feedback at the end of the quiz would have been designed with more

detailed feedback on each question, if the platform had allowed that. A process line is present at the top of the quiz and is not easily detected by users. It should be visible in order for the user to aware of how many questions are left. Finally, according to the usability testing, other resources should be better explained. A simple text at the top explaining its purpose can do the trick. Over all, the testers mostly commented on the function of the quiz. Therefore, the authors conclude that the prototype was easy, simple and user friendly.

6.3 Other Functions

The trainer could have been designed in many different ways. There are, however, always pros and cons with every design. At first, the authors thought of including a log-in feature. In that way, the users could track their process and benefit from other features that the log-in feature has to offer. Also, by collecting data and statistics from the quizzes, the administrators can analyze the data and use the results for improvements. Despite these benefits, things always become much more complicated as soon as the user is asked to put in personal information. The General Data Protection Regulation (GDPR) comes into effect the 25th of May 2018, and will have a extensive impact on web-page design. There should be a clear reason why the web-page and its supervisors need personal information from the users. A fraction of the things that need to be taken into account regarding web development are the following:

1. It needs to be transparent what the user information will be used for when administration receives it, and how long it will be retained on the web-page as well as by the office system.
2. With more users, the data needs to be stored somewhere. There needs to be a good understanding and documentation records of the data that is being held.
3. There needs to be gained consent for the data and there needs to be a well defined policy on how long the data will be retained in order to be sure that it is not kept for too long.
4. Last but not least, correct legal arrangements for holding all that data need to be in place, and not to mention the reason why this data is needed in the first place.

The main purpose of the GDPR is to protect peoples information and data. To limit its exposure to new rules and regulations it was decided not to collect this type of data and exclude this feature. Mainly due to the reason that this information was not needed for the training tool. This feature would only introduce complications to the whole process of developing the training tool. The log-in feature was also considered to be an obstacle for the users since they would have to go through the process of putting in information and so on before starting the exercises. Another feature that could have been a part of the design is to have the tool as an application. It was also considered to be an obstacle for the users and their experience since they would have to download it. One of the main goals with the STAN Trainer was that the user should be able to go to the web-page and start right away. That is also

one of the reasons why it will be available at no cost. Resources on this subject were found through online research, especially from a blog called the Hallam blog [44, 45].

7

Conclusion

This final chapter presents the conclusions that can be drawn from this Master's thesis by returning to its aim and objective stated in the Section 1.1. The aim of the current research was to investigate, analyze and propose a design for an interactive web-based training tool, assessing CTG traces with and without ST Analysis, focusing on fetal physiology. Due to an initially loosely defined project, a problem solving cycle approach was used to solve the issue at hand. After a thorough market research, interviews with potential users, attending a two day master class, and brainstorming sessions with supervisors, a solution was designed. The thesis resulted in a high-fidelity prototype of the STAN Trainer. Also, a set of guidelines and recommendations were also produced for further development of the training tool. The guidelines included non-functional and functional requirements for the STAN Trainer, that will eventually be implemented by developers into a fully functional training tool.

In accordance with the results, there is a great need for a training tool such as this one and it is important and ethical to share knowledge and skills regarding this topic. The main reason is, after all, to bring healthy babies to this world. Much can be learned by improving interpretation and understanding of how the fetus reacts to the stress of labour. The risk of a child being injured during birth will be significantly reduced through this learning process. Labour ward staff using the fetal monitoring methods today face the challenge of information interpretation. Visual analysis is needed in order to manage complex situations. With the help of a training tool like this one, it is possible to decrease unnecessary operative deliveries and avoid other complications during birth.

7.1 Suggestions for Future Development

This product needs further development, and would be a fruitful area of future work. If the training tool was to be developed further and later launched, the next step would be to get user feedback from midwives, also to get an expert in labour and delivery care with extensive knowledge of ST Analysis to compose questions for the quizzes. Finally, the training tool should be developed and implemented the proposed design of the STAN Trainer. Neoventa's vision is that in the future their material and knowledge will made accessible to all. The STAN Trainer should and will be available at no cost.

During the design process, some features were excluded from the guidelines, but could be included in the future development. As discussed in Section 6.3, the STAN Trainer could have been design with a log-in feature. By including a log-in feature, the users have an option to trace their progress and monitor their activity. Thereby, the user gets a more personal experience. Additionally, a multi-language option could be added to the training tool. This would allow the users to train in their own language and use terms they are comfortable with. Videos with interactive questions could also be included. This would allow for a more learner centered teaching and could generate more time for discussion between peers.

The suggested implementation for the STAN Trainer aims at being accessible, efficient, simple, and appealing for the intended users. The authors hope that with the introduction of this training tool, the users can devote more time on training and that it can add value and quality to the everyday work in the maternity ward. Finally, the proposed training solution will, without a doubt, help labour ward personnel and midwifery students to assess and address challenging situations as well as be helpful in preventing unforeseen neonatal injuries.

Bibliography

- [1] K. G. Rosén, “Fetal electrocardiogram waveform analysis in labour,” *Current Opinion in Obstetrics and Gynecology*, vol. 17, no. 2, pp. 147–150, 2005.
- [2] E. Heintz, T.-H. Brodtkorb, N. Nelson, and L.-Å. Levin, “The long-term cost-effectiveness of fetal monitoring during labour: a comparison of cardiotocography complemented with st analysis versus cardiotocography alone,” *BJOG: An International Journal of Obstetrics & Gynaecology*, vol. 115, no. 13, pp. 1676–1687, 2008.
- [3] N. Medical, “Stan method - introduction.” <http://www.neoventa.com>, 2013. [Online; accessed 14-February-2018].
- [4] A. Pinas and E. Chandraharan, “Continuous cardiotocography during labour: Analysis, classification and management,” *Best practice & research Clinical obstetrics & gynaecology*, vol. 30, pp. 33–47, 2016.
- [5] A. M. KG Rosén, “The green book of neoventa part i – the physiology of fetal surveillance.” Neoventa Medical AB, Norra Ågatan 32, 431 35 Mölndal, May 2014.
- [6] I. Amer-Wåhlin, I. Kjellmer, K. Maršál, P. Olofsson, and K. G. Rosén, “Swedish randomized controlled trial of cardiotocography only versus cardiotocography plus st analysis of fetal electrocardiogram revisited: analysis of data according to standard versus modified intention-to-treat principle,” *Acta obstetricia et gynecologica Scandinavica*, vol. 90, no. 9, pp. 990–996, 2011.
- [7] I. Amer-Wåhlin and K. Maršál, “St analysis of fetal electrocardiography in labor,” in *Seminars in Fetal and Neonatal Medicine*, vol. 16, pp. 29–35, Elsevier, 2011.
- [8] P. Olofsson, D. Ayres-de Campos, J. Kessler, B. Tendal, B. M. Yli, and L. Devoe, “A critical appraisal of the evidence for using cardiotocography plus ecg st interval analysis for fetal surveillance in labor. part ii: the meta-analyses,” *Acta obstetricia et gynecologica Scandinavica*, vol. 93, no. 6, pp. 571–586, 2014.
- [9] C. Vayssière, V. Ehlinger, L. Paret, and C. Arnaud, “Is stan monitoring associated with a significant decrease in metabolic acidosis at birth compared with cardiotocography alone? review of the three meta-analyses that included the recent us trial,” *Acta obstetricia et gynecologica Scandinavica*, vol. 95, no. 10, pp. 1190–1191, 2016.
- [10] E. Blix, K. G. Brurberg, E. Reiherth, L. M. Reinart, and P. Øian, “St waveform analysis versus cardiotocography alone for intrapartum fetal monitoring: a systematic review and meta-analysis of randomized trials,” *Acta obstetricia et gynecologica Scandinavica*, vol. 95, no. 1, pp. 16–27, 2016.

- [11] J. G. Ruiz, M. J. Mintzer, and R. M. Leipzig, "The impact of e-learning in medical education," *Academic medicine*, vol. 81, no. 3, pp. 207–212, 2006.
- [12] B. Williams and S. Arulkumaran, "Cardiotocography and medicolegal issues," *Best Practice & Research Clinical Obstetrics & Gynaecology*, vol. 18, no. 3, pp. 457–466, 2004.
- [13] R. Ellaway and K. Masters, "Amee guide 32: e-learning in medical education part 1: Learning, teaching and assessment," *Medical teacher*, vol. 30, no. 5, pp. 455–473, 2008.
- [14] N. Medical. <http://www.neoventa.com>, 2013. [Online; accessed 26-February-2018].
- [15] I. Amer-Wahlin and S. Dekker, "Fetal monitoring—a risky business for the unborn and for clinicians," *BJOG: An International Journal of Obstetrics & Gynaecology*, vol. 115, no. 8, pp. 935–937, 2008.
- [16] D. Ayres-de Campos, C. Y. Spong, and E. Chandrachar, "Figo consensus guidelines on intrapartum fetal monitoring: Cardiotocography," *International Journal of Gynecology & Obstetrics*, vol. 131, no. 1, pp. 13–24, 2015.
- [17] R. K. Freeman, T. J. Garite, M. P. Nageotte, and L. A. Miller, *Fetal heart rate monitoring*. Lippincott Williams C Wilkins, 2012.
- [18] D. Gibb and S. Arulkumaran, *Fetal Monitoring in Practice E-Book*. Elsevier Health Sciences, 2017.
- [19] Z. Alfirevic, D. Devane, G. Gyte, *et al.*, "Continuous cardiotocography (ctg) as a form of electronic fetal monitoring (efm) for fetal assessment during labour," *Cochrane Database Syst Rev*, vol. 3, no. 3, 2006.
- [20] I. Amer-Wahlin, S. Arulkumaran, H. Hagberg, K. Maršál, and G. Visser, "Fetal electrocardiogram: St waveform analysis in intrapartum surveillance," *BJOG: An International Journal of Obstetrics & Gynaecology*, vol. 114, no. 10, pp. 1191–1193, 2007.
- [21] J. Westgate, M. Harris, J. S. Curnow, and K. R. Greene, "Plymouth randomized trial of cardiotocogram only versus st waveform plus cardiotocogram for intrapartum monitoring in 2400 cases," *American Journal of Obstetrics & Gynecology*, vol. 169, no. 5, pp. 1151–1160, 1993.
- [22] S. Timonen and K. Holmberg, "The importance of the learning process in st analysis interpretation and its impact in improving clinical and neonatal outcomes," *American Journal of Obstetrics & Gynecology*, 2018.
- [23] C. B. Martin, "Normal fetal physiology and behavior, and adaptive responses with hypoxemia," *In Seminars in perinatology*, vol. 32, no. 4, pp. 239–242, 2008.
- [24] C. Romm-Livermore, "E-learning, traditional education, and the corporatizing of higher education," *Journal of Information Technology Case and Application Research*, vol. 16, no. 1, pp. 3–8, 2014.
- [25] M. Nichols, "A theory for elearning," *Educational technology & society*, vol. 6, no. 2, pp. 1–10, 2003.
- [26] M. Mayes, *Mayes' Midwifery*. Elsevier, 15th ed., June 2017.
- [27] B. Graffam, "Active learning in medical education: strategies for beginning implementation," *Medical teacher*, vol. 29, no. 1, pp. 38–42, 2007.

-
- [28] e-learning for Healthcare, “Electrical fetal monitoring programme.” <https://www.e-lfh.org.uk/programmes/electronic-fetal-monitoring/>. [Online; accessed 2-Mars-2018].
 - [29] A. Tarvin, “The five steps of problem solving.” <https://www.humorthatworks.com/learning/5-steps-of-problem-solving/>, 2013. [Online; accessed 14-February-2018].
 - [30] C. Bank and J. Cao, “The guide to ux design process and documentation.” <https://www.uxpin.com/studio/ebooks/guide-to-ux-design-process-and-documentation/>. [Online; accessed 9-April-2018].
 - [31] P. Gill, K. Stewart, E. Treasure, and B. Chadwick, “Methods of data collection in qualitative research: interviews and focus groups,” *British dental journal*, vol. 204, no. 6, p. 291, 2008.
 - [32] Y. Rogers, H. Sharp, and J. Preece, *Interaction design: beyond human-computer interaction*. John Wiley & Sons, 2011.
 - [33] M. Davies, “Concept mapping, mind mapping and argument mapping: what are the differences and do they matter?,” *Higher education*, vol. 62, no. 3, pp. 279–301, 2011.
 - [34] M. J. Eppler, “A comparison between concept maps, mind maps, conceptual diagrams, and visual metaphors as complementary tools for knowledge construction and sharing,” *Information visualization*, vol. 5, no. 3, pp. 202–210, 2006.
 - [35] C. Wilson, *Brainstorming and beyond: a user-centered design method*. Newnes, 2013.
 - [36] R. Scupin, “The kj method: A technique for analyzing data derived from japanese ethnology,” *Human organization*, vol. 56, no. 2, pp. 233–237, 1997.
 - [37] N. R., “Affinity diagram.” <http://asq.org/learn-about-quality/idea-creation-tools/overview/affinity.html>, 2004. [Online; accessed 09-May-2018].
 - [38] J. Gardner, “Remote web site usability testing-benefits over traditional methods,” *International Journal of Public Information Systems*, vol. 3, no. 2, 2007.
 - [39] J. Johnson, “10 rock solid website layout examples.” <https://designshack.net/articles/layouts/10-rock-solid-website-layout-examples/>. [Online; accessed 16-April-2018].
 - [40] C. Wong, “5 awesome home page design layouts you can copy today.” <https://www.websitebuilderexpert.com/awesome-home-page-design-layouts/>, 2018. [Online; accessed 16-April-2018].
 - [41] H. Pun, “15 timeless rules for creating intuitive web apps (with examples).” <https://www.designforfounders.com/web-app-ux/>, 2016. [Online; accessed 18-April-2018].
 - [42] StatCounter, “Mobile and tablet internet usage exceeds desktop for first time worldwide.” <http://gs.statcounter.com/press/mobile-and-tablet-internet-usage-exceeds-desktop-for-first-time-worldwide>, 2016. [Online; accessed 14-May-2018].
 - [43] J. E. McLaughlin, M. T. Roth, D. M. Glatt, N. Gharkholonarehe, C. A. Davidson, L. M. Griffin, D. A. Esserman, and R. J. Mumper, “The flipped classroom:

- a course redesign to foster learning and engagement in a health professions school,” *Academic Medicine*, vol. 89, no. 2, pp. 236–243, 2014.
- [44] S. H. MBE, “How to make your website gdpr compliant.” <https://www.hallaminternet.com/how-to-make-your-website-gdpr-compliant/>, 2017. [Online; accessed 20-April-2018].
- [45] T. Hallam, “Gdpr – the challenges and opportunities for marketers.” <https://www.hallaminternet.com/gdpr-challenges-and-opportunities-for-marketers/>, 2017. [Online; accessed 20-April-2018].

A

Interviews

This appendix contains interview summaries with twenty five people through eighteen interviews. These interviewees were from different countries and the aim was to get a comprehensive group to explore their perspectives, experiences, and needs on the topic of CTG and ST Analysis. There are four summaries. Firstly, an interview summary from the interview with five Icelandic midwives and midwifery students. Secondly, a summary from the interview with midwives and professors in the midwifery science program in Iceland. Thirdly, interviews that were conducted during the master class. Finally, a summary from the interview with a professor at the department of Biomedical Engineering at Chalmers University of Technology

A.1 Summary from Interviews with Three Midwives and Midwifery Students from Iceland

Question: To begin with, we would like to know how was your experience of the midwifery education regarding CTG interpretation and topics related to that subject? For example, the lectures, what was the main focus etc. Can you give ideas on ways to improve the way of teaching?

Summary: The teaching is all in a traditional lecture form where the teacher holds lectures and discussions, and provides the students with education material. During lectures they review basic topics regarding CTG interpretation, such as what is normal and abnormal, accelerations, decelerations, what could be causing abnormal cases etc. They look at CTG recordings that the teacher has provided and displays on slides during lectures. The students only get access to these recordings and no additional cases. During practical training, the students get additional training in CTG interpretation. Two students out of three mentioned that they would have wanted more time with the teacher for studying interpretation of CTG recordings. They also mentioned that they would have wanted to have access to interactive exercises along with attending lectures. According to all of them, they mentioned that it can get tiring to sit and listen to the teacher talk for several hours and it would make the teaching more fruitful to include interactive exercises. They mention the importance of getting hands-on training in interpretation of CTG, both to see at what level of knowledge they are and interactive training can be of help with remembering and learning this topic. When asked for ideas on ways to improve the way of teaching, they mentioned more discussion lectures where they work in groups

while interpreting CTG recordings and they mention the importance of having background and clinical information included while performing CTG interpretation.

Question: If a training tool such as this one would exist, would you make time to use it?

Summary: All three interviewees responded positively when asked if they would be willing to use a training tool such as the STAN Trainer. They mention that it would have been good to have it during their studies as well now when working in the labour ward. They explain that while studying to become a midwife, they want to be well prepared before they start working as midwives. They want to be familiar with the as many type of cases that they will be handling when they start working. They also discuss the importance of continuous education and that it is important to keep training. They are not dealing with abnormal and complicated cases daily, therefore, this type of training tool would be a good addition to their practice. One mentions that "it is very important to know how to react to an abnormal recording when you have the mother in labour in front of you". Also mentioned is that this tool is especially good for midwives working in rural areas where obstetricians are not as easily available.

Question: If you were to use a tool such as this one, where would you use it? If you were to use a tool such as this one, in what type of device would you use it? Desktop computer, tablet, smart phone or all?

Summary: They would use this tool during work hours, at home and/or during school hours. If at work, they would use the tool in a desktop computer when there is time. This would be a perfect time to use the STAN Trainer alone or in a discussion with colleagues. If at home, they would use the trainer after or before work to review recordings similar to the ones they are dealing with at that time or to enhance a case they are not perfectly comfortable with or not clear on. They would want to be able to use a tablet or their smart phone when at home. At school they would want to be able to use the trainer on a laptop, tablet or their smart phone.

Question: If there is anything you would like to add or if you have any ideas for a tool such as this one, feel free to share them with us.

Summary: They mention that the mother's summary and clinical history has to follow each case for the exercises. That part is very important when it comes to interpret the CTG recording. They would like to perform exercises which emphasize different decelerations, which ones are harmless and not and when they become harmful for the fetus. They would also want to have an educational section in the trainer. They think it is important to recognize and know the fetal physiology behind the abnormal cases. They would like to have case studies where they can study the procedures used for each case and the outcome. The educational material they would want to have in the trainer can be found in the reading material provided by Neoventa as well as in other options in Neoventa Academy. Over all they are

very excited about this idea and hope this trainer will be released in the coming future so they can try it out and start training.

A.2 Summary from Interviews during the CTG Master Class

We took interviews with twenty people from different countries, midwives and doctors, who were all attending master class for the first time, except for one midwife. They get re-training in the form of lectures or they get reading material and have to take a knowledge test, every year or every other year. If they get reading material, they have to do read it in their own time. It is not common for the labour ward staff to attend a event like master class due to lack of funding and time. Regarding funding and time, two mentioned that it would benefit them greatly to be able to get training through the internet because they live in a rural area, (good to mention Iceland here as well). One out of twenty interviewers works at a hospital that has ST Analysis. She explained that they have the opportunity to get retraining for the method every 4 months but don't have to attend if they do not feel like they have to. A doctor from the labour ward holds the retraining for ST Analysis. Some explain that they used to have an organized retraining sessions in order to have everyone speak the same „language“ and evaluate the CTG in the same way, but they do not have that option anymore due to reasons (did not say). Most of them mentioned that every shift, department,labour ward reviews CTG traces together either every day or every week. One hospital has a box where anyone can leave a note to request if they want to review a specific case from the week before.

One midwife explained that usually when a newly graduated midwife starts working in the labour ward she does not have as much experience as the „older“ midwives so they get mentored by them. The midwifery students need to meet a certain amount of deliveries before they can graduate as a midwife and in that case they get their experience through „real life cases“ instead of practicing and doing interactive exercises with old CTG traces. This is both good and bad, good because they get experience how everything works during labour but bad because they feel unprepared and it's not everyday that they deal with abnormal traces. In that case the „younger“ midwives don't feel prepared enough and think that a tool where they can practice and do exercises would benefit them greatly. The midwives therefore want to be prepared before something serious happens. That brings us to one interview with 2 midwives. They decided to attend the master class because 2 weeks before they lost a baby. They explained that a possible and the most likely reason is due to CTG misinterpretation. They also explained that it happened in the middle of the night and according to the lecturer, Edwin Chandraharan, that is a time when the human is not at it's sharpest related to reflexes and interpretation of complex patterns.

ST Analysis is no longer used in Sweden, since one year ago, and all interviewers from Sweden mentioned that it was a great loss. They would want to get the technology back to their workplace because, according to physician, it is the best method

out there today.

All were very interested in the tool we are working on and would welcome a new and more modern type of exercises for CTG and fetal physiology interpretation, because this technique can easily save unnecessary interventions and untimely neonatal deaths.

A.3 Summary from Interviews with Midwives & Professors at the Midwifery Science Program at University of Iceland

The same person handles the retraining of the health care staff at the delivery ward and the training of the midwifery science program at the University of Iceland. Retraining for the staff is done once a year where there are lectures and practical exercises. Each year there is a different topic of discussion. The training of the students is limited, and they get four hours of CTG training in the two years. The material that is accessible the health care professionals is a scanned chapter from the PROMPT participant manual based on the NICE guidelines. Also, the staff are provided with FIGO articles and hospitals procedure manual. Today, the CTG traces are printed on to CTG recording paper and only a few admins can access the traces at the hospital. However, it is only a matter of time until the traces will only be digital. The recordings are on paper because the midwives are afraid that the wrong recording will be attached to the patient's file. The new digital system at the labour ward is a tremendous addition to be able to review and discuss the issues without going into the patient's room. Old cases are reviewed with a doctor three days a week before the shift starts. There were no exercises or training to practice before the system was inaugurated. Two years ago there was a CTG expert that came and taught a seminar about interpreting CTG traces. The interviewees thought the training tool would be useful and would be a great addition to the training for the labour ward. Also, for the education of new midwives and physicians.

A.4 Summary from an Interview with a Professor at Chalmers University of Technology

Video lectures are a good alternative to get users to be more active and they participate when there are discussions. The video lectures and active learning will be used more to for teaching. It takes a long time to make video lectures but with good preparation this part can be implemented. In the long run, using video lectures can lower the work load for teachers.

B

Personas

This appendix presents the two personas that were created to keep the perspective of the intended users. The personas were a midwife and a midwifery science student. Each persona includes a name, photo, description of job responsibilities and included illustrative information about the persona such as the user's skills and personal details. Also, a quotation from the interviewees gives the persona a layer of realistic consideration.

B.1 Midwife Persona

	<p>Background Anna Maria Nilsson, 52 years old. Married with three grown children and two grandchildren. She has been a nurse for 10 years and a midwife for 6 years. She is the owner of a health care clinic for families expecting children. Her main aspiration in life is to see her company thrive and deliver healthier babies. She is stressed at work and does not have much spare time to retrain in reading CTG traces.</p>
<p>Anna Maria Nilsson</p> <p><i>"I am very interested and hope this training tool will be released soon. When can I try it out and practice?"</i></p>	<p>Problem description Anna Maria feels like she needs to get retraining in interpreting CTG traces. She does not work with patient care everyday and needs to sharpen her knowledge that she does not feel confident with. She also likes to know state-of-the-art technology and knowledge for her clinic.</p>
	<p>Interests She likes to ski and stay active. She likes to spend time with her family and friends. She thinks it is important to attend classes and seminars to sharpen her knowledge such as the CTG Master Class.</p>
	<p>Motivation When Anna Maria became a midwife she loved helping families and delivering babies. She would like to make the journey for her clients as safe as possible. Each life matters and every minute counts. She wants to be able to provide her clients with optimal fetal monitoring by understanding the CTG traces both with and without ST analysis.</p>
	<p>Needs Unforeseen events may happen during labour and Anna Maria would like to be prepared for them. She would like to be prepared for abnormal cases and practice interpretation of all kinds of traces. In addition, she would like to lower the cost of retraining her staff and have a simple, accessible training tool.</p>
	<p>Relationship with technology She recently got a smart phone and is still getting used to the technology. She is keen on trying new things but is sceptic on trying new applications due to complexity and that it takes too much time. At her clinic and at the labour ward she has to use a computer. Her experience with computers is limited and tries to spend minimal amount of time using it.</p>

Figure B.1: User persona for a midwife.

B.2 Midwifery Student Persona



**Bergrún
Diðriksdóttir**

"It's important for me to be well prepared for the delivery ward when I graduate as a midwife!"

Background
Bergrún Diðriksdóttir, 30 years old. Single mother of two, one child and toddler. She has been a nurse for 2 years and is a first year midwifery science student in Iceland. She decided to become a midwife after experiencing first hand how dedicated and courageous midwives are at their job. Her main aspiration in life is to become the best midwife she can be. She feels like she does not have a good school-home balance, and is often stressed out.

Problem description
She want to spend more time on demanding and hands-on exercises, instead of only listening and observing how the teacher interprets CTG traces. She would like to have access to more case studies to be prepared for classes and abnormal cases at work. Because of her busy schedule, she needs an accessible and convenient training tool that is adapted to her needs.

Interests
Bergrún is from a small town and had to move to the capital to get her education. She would like to move back to her hometown with her children. She likes to spend most of her free time with her children and family. She likes hiking and going to cafes with her friends from school.

Motivation
Her biggest motivation in life is to be a good mother to her two children and be a good role model for them. She likes to be prepared and stay ahead of things both in her personal and professional life. She wants to be a great midwife and an asset to the delivery ward team.

Needs
Unforeseen events may happen during labour and Bergrún would like to be prepared for them. The students go over cases together. However Bergrún would like to have access to a training tool and complete the interpretation of traces in her own time. She wants a tool that is flexible and user friendly due to limit of time.

Relationship with technology
She loves her smartphone and is active on social media. She also has a tablet at home and likes to bring it with her to school and use it when she has time to spare. At work, she mostly uses the computer and has to share it with other midwifery students. She is comfortable using computers at work and likes to spend more time on reading different traces.

Figure B.2: User persona for a midwifery science student.

C

Screen Captures

This appendix contains screen captures of the STAN Trainer both from a desktop/laptop computer view that would only be a repetition of material that had already be presented, and a mobile view.

C.1 Results - ST Analysis

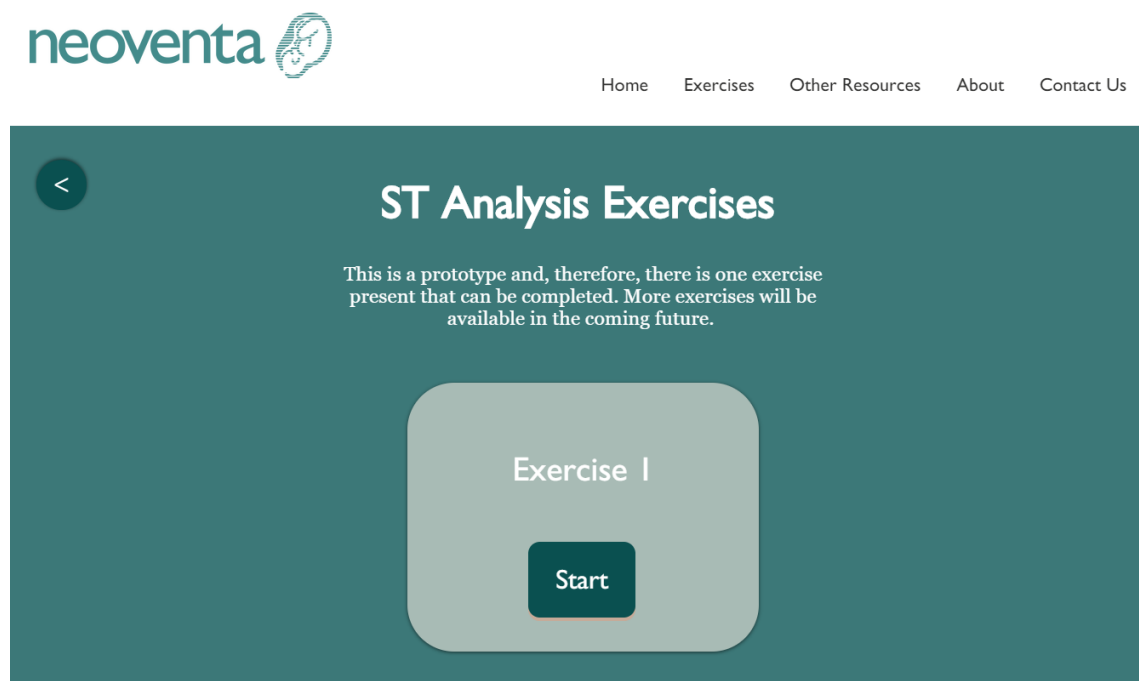


Figure C.1: ST Analysis Exercise.

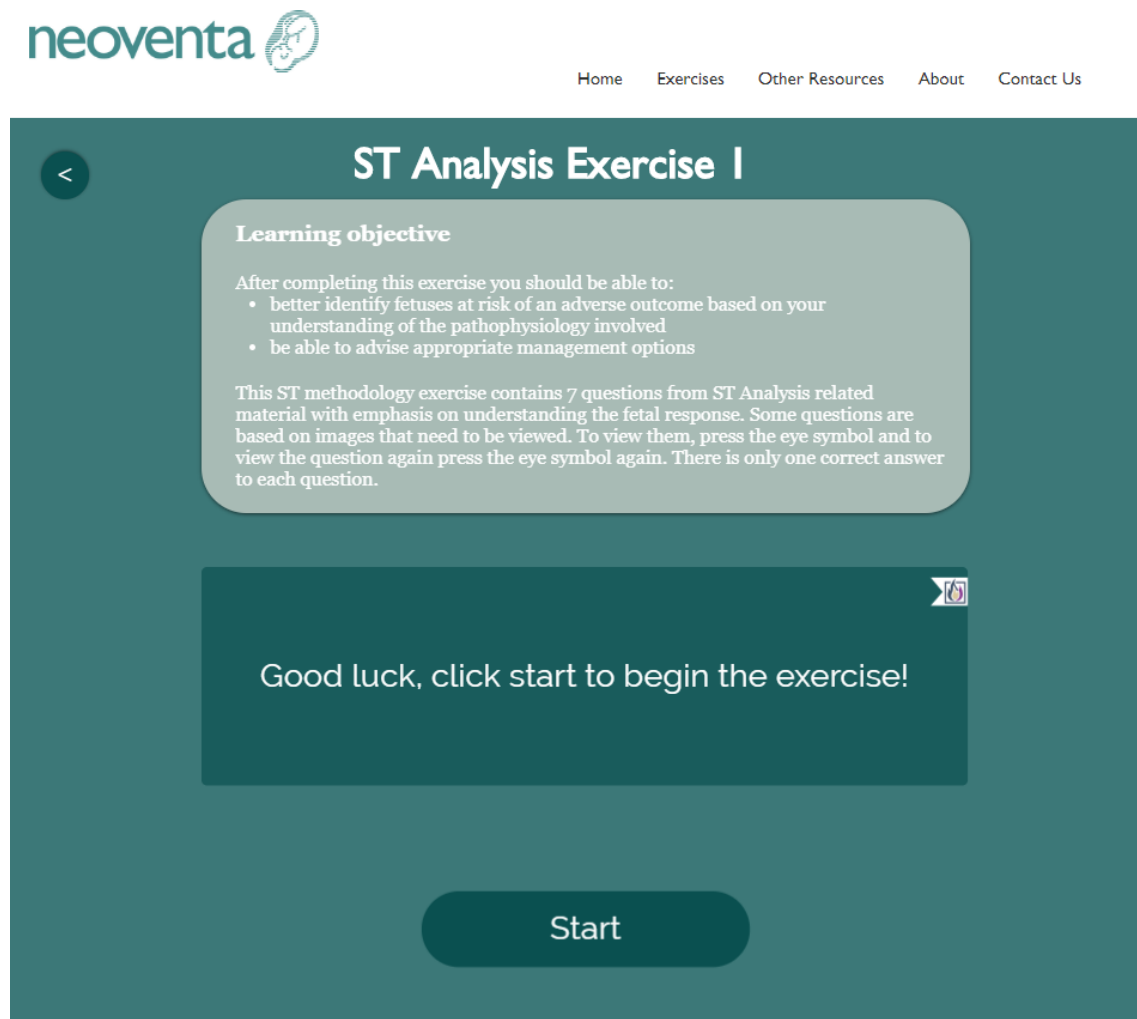


Figure C.2: ST Analysis Exercise Part 1.

C.1.1 Mobile Prototype View

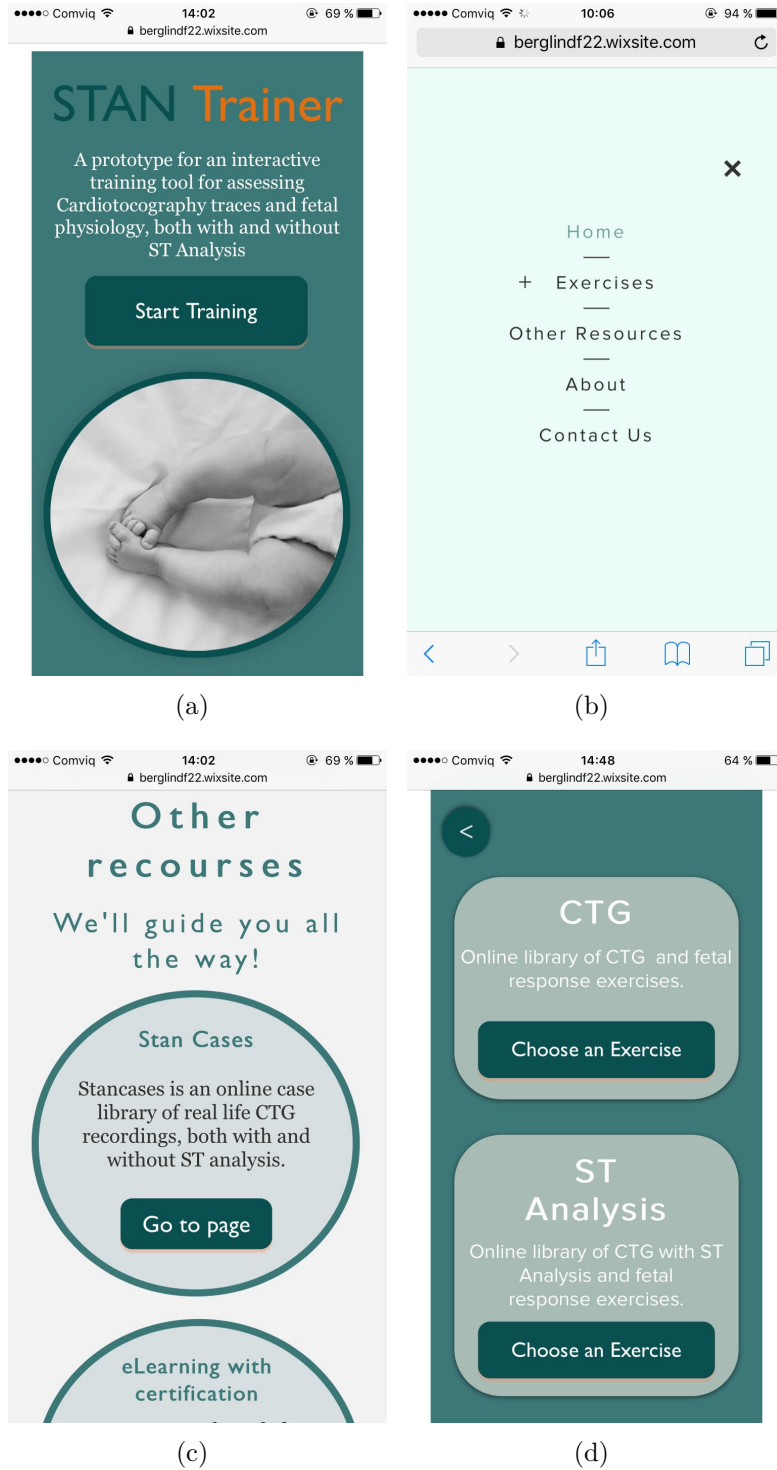


Figure C.3: A set of figures of the mobile view: (a) Mobile view of the home page.; (b) Mobile view of the navigation bar.; (c) Mobile view of the other resources section.; and (a) Mobile view of the exercise categories.;

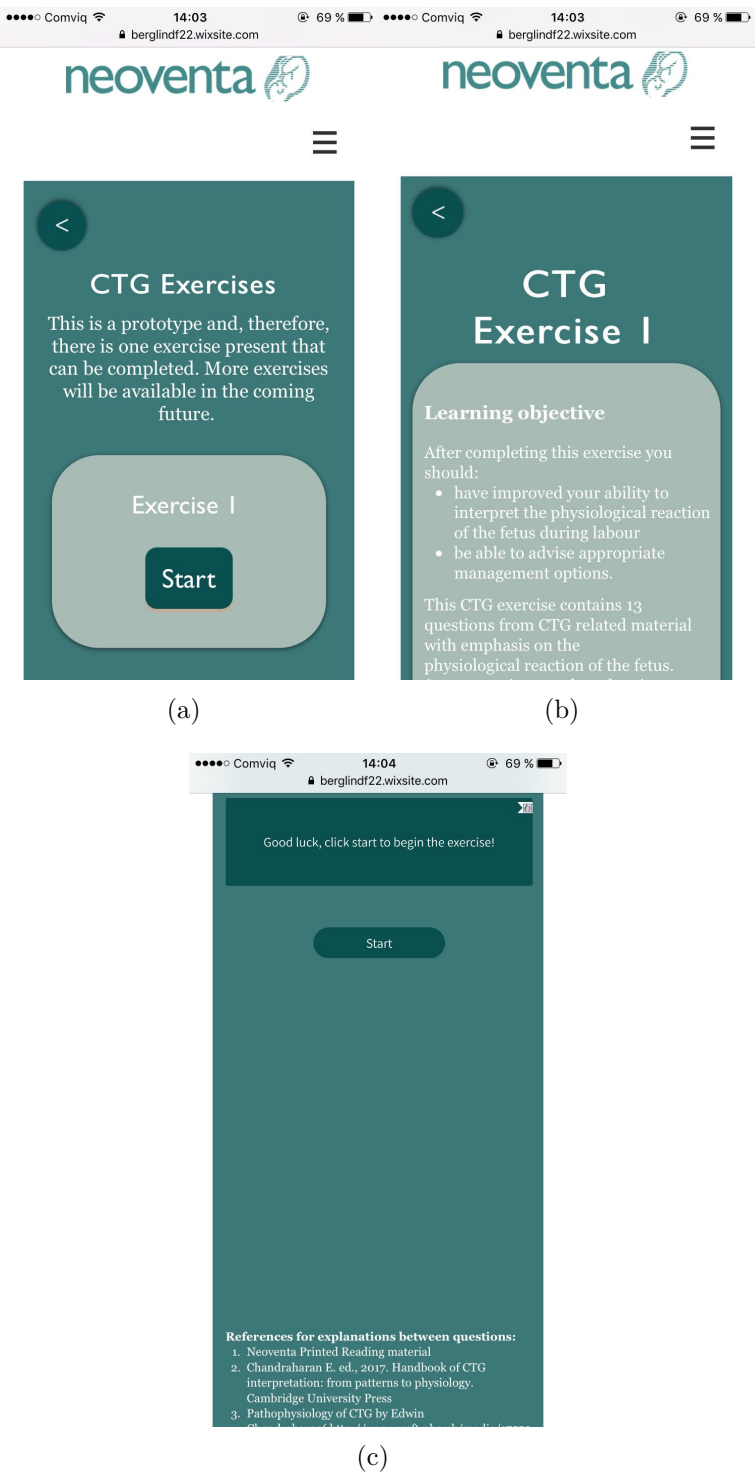


Figure C.4: A set of figures of the mobile view: (a) Mobile view of the exercise categories.; (b) Mobile view of the CTG exercise showing the learning objective.;and (c) Mobile view of the CTG exercise showing the start of the quiz.

D

Multiple Choice Questions

This appendix presents questions that were included in the STAN Trainer prototype plus additional questions that were too long to be included in the two quizzes, CTG and ST Analysis. These questions were composed by a STAN-specialist midwife. The answers highlighted in green are correct.

D.1 Questions for CTG Trace Exercises

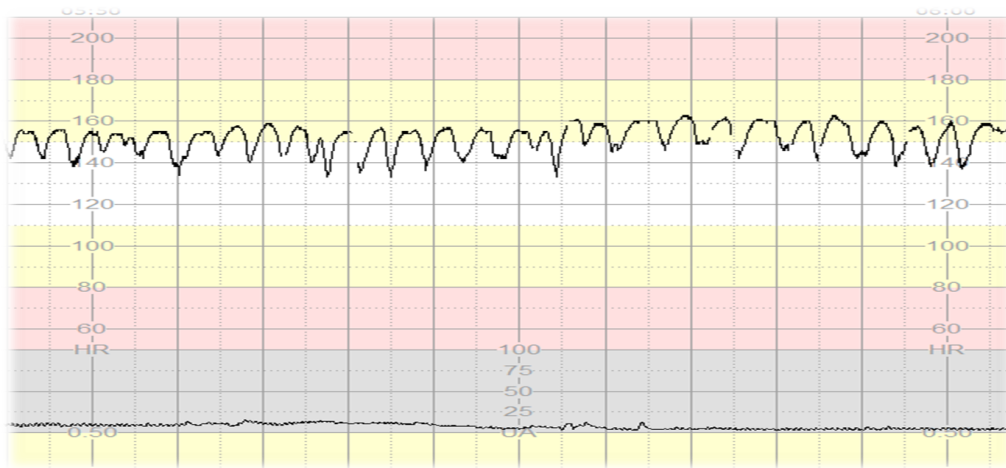


Figure D.1: CTG trace for question 1

Q1. What type of pattern is this (see Figure D.1)?

- a) Saltatory pattern
- b) Pseudosinusoidal pattern
- c) **Sinusoidal pattern**
- d) This pattern looks normal

Explanation: Sinusoidal pattern is a regular, smooth, undulating pattern resembling a sinus wave. Is characterized by absence of variability.

D. Multiple Choice Questions

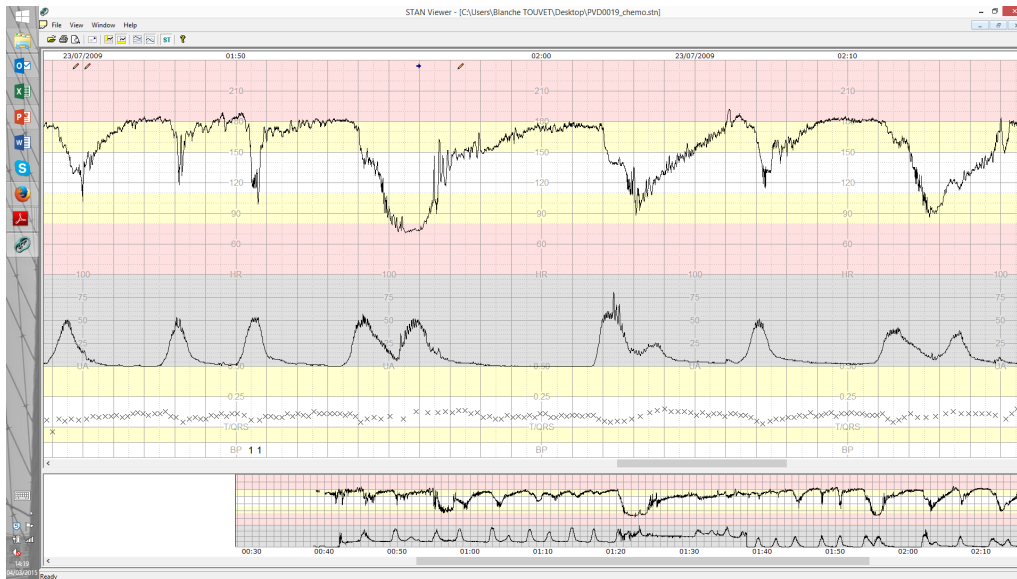


Figure D.2: CTG trace for question 2

Q2. What kind of deceleration do you see in Figure D.2?

- a) Early deceleration
- b) Variable deceleration / V-shaped/ baroreceptor-mediated response
- c) Late deceleration/chemoreceptor-mediated response
- d) This pattern looks normal

Explanation:

Late decelerations are characterized by a uniform pattern. There is a time lag between the onset and peak of the contraction and the onset and peak of deceleration. A slow recovery to baseline FHR reflects a chemoreceptor-mediated response.

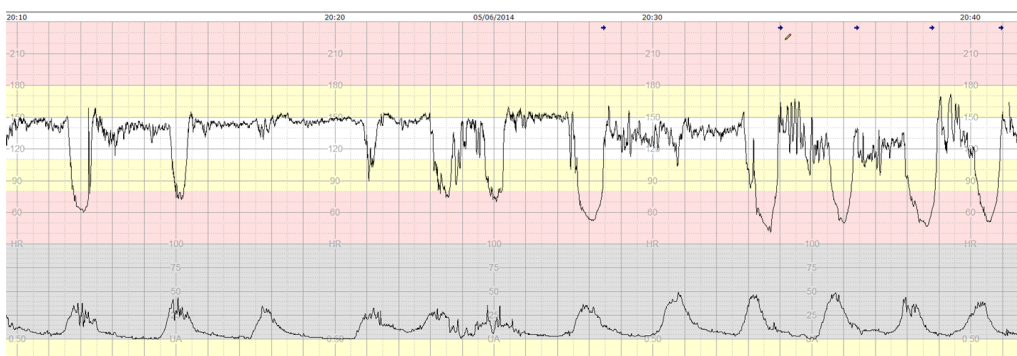


Figure D.3: CTG trace for question 3

Q3. What kind of deceleration do you see in Figure D.3?

- a) Early deceleration
- b) Variable deceleration / V-shaped/ baroreceptor-mediated response
- c) Late deceleration/chemoreceptor-mediated response
- d) This pattern looks normal

Explanation:

Variable deceleration exhibits a rapid drop, good variability within the deceleration, rapid recovery to the baseline, varying size, shape and relationship to uterine contractions. A rapid fall and an instantaneous recovery to the original baseline reflects a baroreceptor-mediated response.

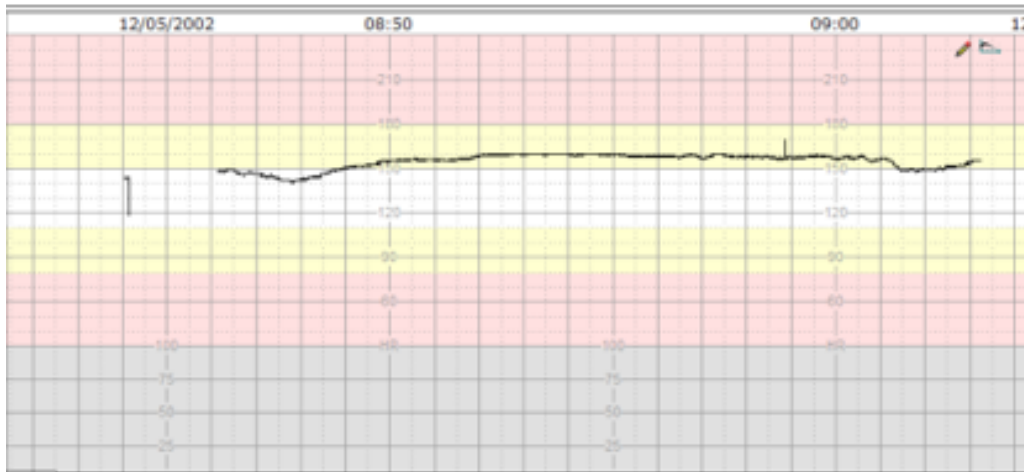


Figure D.4: CTG trace for question 4

Q4. What kind of variability do you see in Figure D.4?

- a) Normal >5bpm
- b) Sinusoidal
- c) Saltatory
- d) **Pre-terminal**

Explanation:

Prolonged bradycardia as well as total loss of variability and reactivity, with or without shallow decelerations are often termed 'pre-terminal' and requires immediate delivery.

Q5. What are the basic components used for normal aerobic cellular metabolism?

- a) Fat and oxygen
- b) Oxygen and glycogen
- c) **Oxygen and glucose**
- d) Carbon dioxide and water

Explanation:

The normal cellular metabolism utilises predominantly oxygen and glucose. This is labelled as aerobic, oxygen-dependent metabolism.

Q6. What action can the fetus use against oxygen deficiency?

- a) Increase extraction of oxygen from the blood
- b) Reduce fetal activity and fetal growth rate

D. Multiple Choice Questions

- c) A surge of stress hormones and an increase in cardiac output
- d) All of the above

Explanation:

Fetal defence mechanisms against oxygen deficiency are: more effective oxygen distribution, reduced fetal activity and growth, release of stress hormones, redistribution of the blood flow, and anaerobic metabolism.

Q7. The fetus may react with a prolonged deceleration with the mother lying on her back. Why?

- a) Activation of the sympathetic system
- b) Decrease in placental blood flow
- c) Spasm of the uterine arteries
- d) Inadequate maternal breathing when the mother is on her back

Explanation:

If the mother is lying on her back the fetus may react to prolonged deceleration with decrease in placenta blood flow.

Q8. What is the cause of early decelerations?

- a) Hypoxic episodes during contractions
- b) Decreased placental blood flow during contractions
- c) Maternal fever
- d) Increased pressure on the fetal head during contractions

Explanation:

Early decelerations are reflex-triggered (by the parasympathetic system) reduction in fetal heart rate being caused by vagal reactions due to fetal head compression.

Q9. What characterises variable decelerations?

- a) Uniform appearance
- b) Rounded appearance
- c) A rapid loss of beats
- d) A marked loss of beats

Explanation:

Variable decelerations are characterized by an abrupt and distinct drop in the heart rate followed by a fast recovery.

Q10. Which portion of the cardiac cycle is used to calculate the fetal heart rate (FHR)?

- a) The P-R interval
- b) The S-T interval
- c) The P-P interval
- d) The R-R interval

Explanation:

The portion of the cardiac cycle that is used to calculate the FHR is the R-R interval.

Q11. Identify the most common cause of rapid shifts in fetal heart rate (FHR)?

- a) Fetal hypoxia

- b) Reductions in placental blood flow
- c) **Fetal movements**
- d) Maternal fever

Explanation:

A common cause for rapid shifts in FHR are fetal movements.

Q12. What is lactate?

- a) **A waste product of anaerobic metabolism**
- b) The oxygen deficit in the blood
- c) A basic metabolite
- d) The most important energy source for the fetus

Explanation:

During anaerobic metabolism, blood glucose and stored glycogen are utilized, and the energy is to cover basal activity. The waste product of this process is lactate acid.

Q13. Which waste products are produced during normal, aerobic metabolism?

- a) Glycogen and lactate
- b) Lactate and water
- c) Hydrogen and bicarbonate ions
- d) **Carbon dioxide and water**

Explanation:

During aerobic metabolism, the energy that is produced it is utilized during activity and growth. It is important to note that that carbon dioxide and water are the waste products of that need to be removed from the cell by blood flow.

D.2 Questions for CTG trace with ST Analysis Exercises

Q1. Which component of the fetal ECG changes as a result of anaerobic myocardial metabolism?

- a) **The S-T interval**
- b) The Q-R interval
- c) The P-Q interval
- d) The P-P interval

Q2. Why is it important for the system to establish a T/QRS baseline when the fetus is in a stable condition?

- a) The T/QRS baseline is used to compare any changes in the FHR over time and alert when changes are significant
- b) **The T/QRS baseline is used to compare any changes in the ST interval over time and alert when changes are significant**
- c) The T/QRS baseline is used to compare any changes in the contraction pattern over time and alert when changes are significant

D. Multiple Choice Questions

d) It is not important

Q3. The CTG is abnormal and two Biphasic ST Events, one minute apart are displayed. What is the recommended management?

- a) Expectant management and continued observation regardless of Biphasic Events
- b) Closer observation and intervention after a third Biphasic Event
- c) **Obstetric intervention regardless of whether more Biphasic ST Events occur**
- d) None of the above

Q4. ST Analysis is indicated as an adjunct to standard CTG monitoring when there is an increased risk for the fetus to develop what?

- a) **Metabolic acidosis**
- b) Hypertone uterus
- c) Bradycardia
- d) Aerobic metabolism

Q5. When a ST Event occurs during a normal CTG tracing it may be related to...

- a) Severe hypoxia and immediate delivery is warranted
- b) A mistake by the monitor and should be ignored
- c) Preterm labour and immaturity of the fetal myocardium
- d) **A physiological reaction to an arousal response (a sudden move or kick)**

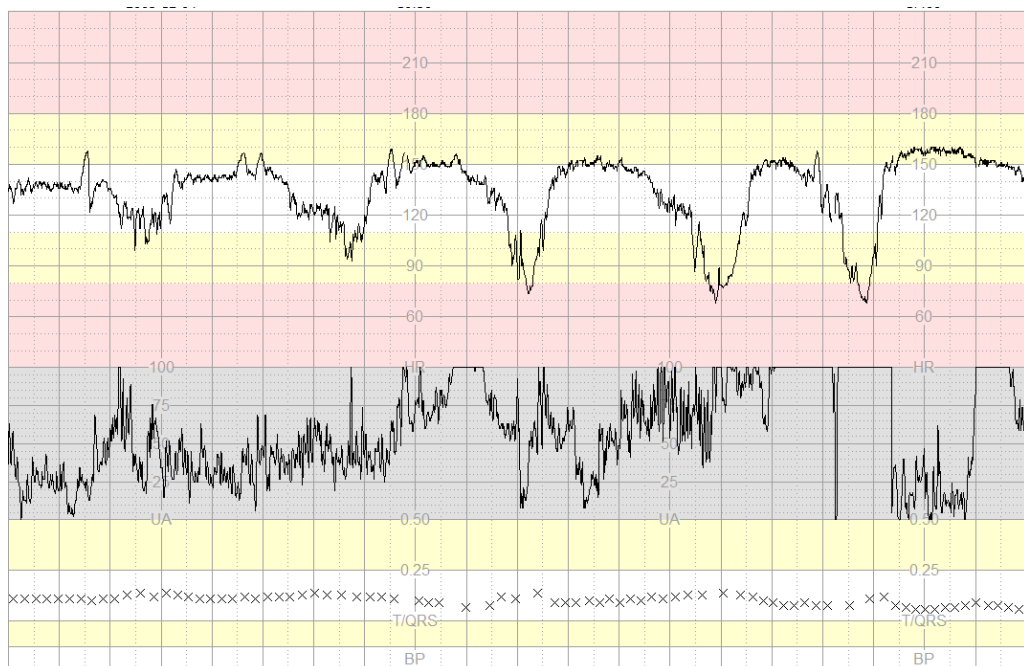


Figure D.5: CTG and ST Analysis recording for question 6.

Q6. In the example above, the STAN recording started several hours ago. At start the CTG was normal. During the last hour the CTG has become abnormal. There are no significant ST changes. What does this signify?

- a) The fetus is suffering from severe asphyxia and does not have the ability to respond with ST changes
- b) The fetus still has a maintained energy balance in its heart and is therefore in control of the situation
- c) The fetus is incapable of responding and FBS is required to obtain adequate information
- d) Poor signal quality



Figure D.6: Fetal ECG signal for question 7.

Q7. What does this ECG signal indicate in Figure D.6?

- a) All is normal
- b) Breech position
- c) Cardiac malformation
- d) Poor signal quality

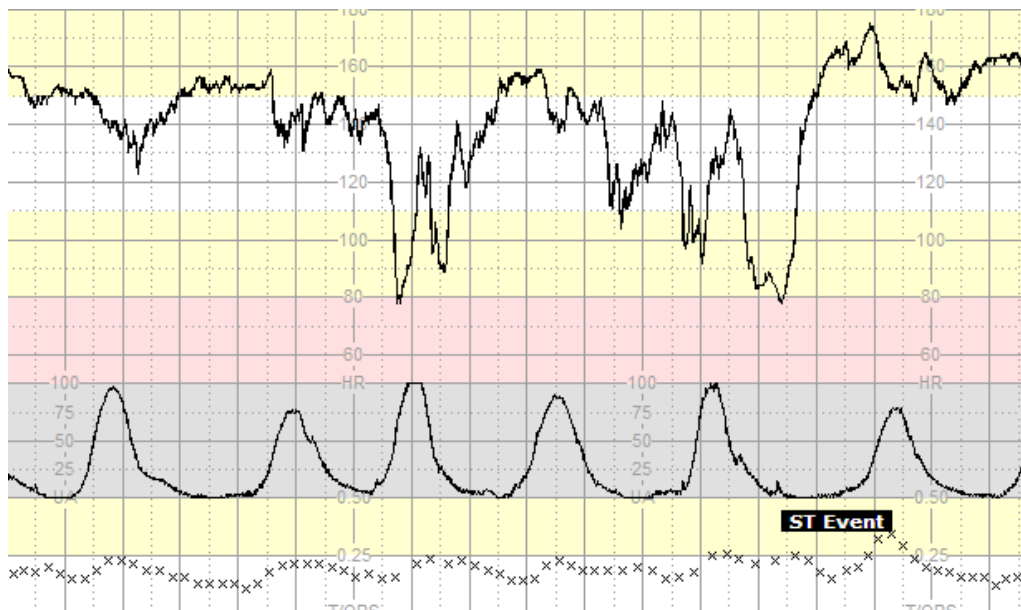


Figure D.7: CTG trace with ST Analysis for question 8

Q8. In Figure D.7 above, the recording illustrates an Episodic T/QRS Event, what does this signify?

- a) The fetal heart is exposed to hypoxia, but cannot or had not had the time to defend itself
- b) The fetal heart is exposed to long-lasting hypoxia and reacts with anaerobic

- c) The fetal heart is exposed to short-lasting hypoxia and reacts with anaerobic metabolism

Q9. Why should a STAN recording start as soon as possible and no later than during the end of the first stage of labour?

- a) No reason at all, it could start any time
b) The STAN Method is based on the ability to record changes in fetal oxygenation. Thus, it is important to start recording before the fetus has utilized all its resources

Q10. What is the T/QRS ratio?

- a) The ratio between the height of the T wave and the amplitude of the QRS complex
b) The ratio between the height of the P wave and the amplitude of the QRS complex
c) A calculation of the RR interval in the ECG complex
d) The ratio between the height of the R wave and the amplitude of the QRS complex



Figure D.8: CTG trace with ST Analysis for question 11

Q11. Is it advisable to initiate ST Analysis in Figure D.8?

- a) No, there is reduced variability
b) No, CTG shows no cycles
c) Yes, CTG shows a stable baseline and normal variability
d) I don't know