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IT for Advanced Life Support in Hospitals.

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Abstract: In this study we have analyzed how IT support can be established for the treatment and documentation of advanced life support (ALS) in a hospital. In close collaboration with clinical researchers, a running prototype of an IT solution to support the clinical decisions in ALS was developed and tried out in a full scale simulation environment. We called this IT solution the CardioData Prototype.

Keywords: Computerised Decision Support, Computerised Documentation, Advanced Life Support. Sociotechnical Design.

Introduction

Cardiac arrest is a hyper acute situation where correct and immediate treatment according to existing guidelines [1] is to be accomplished under a substantial time pressure. This provides two kinds of problems: First keeping clinicians updated with the skills to act correctly when they are in the situation of doing advanced life support and secondly collecting data in the situation for secondary use, so the treatment in the long run can be improved. The incidence of cardiac arrest in hospitals in general range between 1 and 5 events per 1,000 hospital admissions [2]. Reported survival to hospital discharge varies from 0% to 42%, the most common range being between 15% and 20% [2]. There is a need to ensure that the quality of the treatment of patients with a cardiac arrest in hospitals is the best possible [3]; this is reflected in the education of clinical staff at Copenhagen University Hospital Herlev. During training programs conducted in a simulation environment, it is possible to imitate the clinical challenges in resuscitation of a patient suffering from a cardiac arrest and to ensure training to a level of application of the treatment algorithm as described by the European Resuscitation Council (ERC ²). The job of ensuring relevant and necessary documentation during the resuscitation process is another challenge which is related to both legislation and to the collection of data for secondary use in research according to the Utstein Style [4] standard. Our goal for the project was to develop an IT application

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² <http://www.erc.edu/new/>

that could support treatment as well as the documentation during advanced life support (ALS) in hospitals. The needs for decision and documentation support in ALS had previously been investigated as part of a clinical PhD study at Copenhagen University Hospital Herlev where ideas to functionality of an IT system were developed as a paper prototype³.

The clinical setting

The situation that occurs when a patient in a hospital suffers from a cardiac arrest is a hyper acute event. The staff at the hospital is trained to initiate basic life support with airway support on a facial mask and external thoracic compression right away. There is an alarm system in the hospital activating a resuscitation team: a cardiologist, an anaesthetist, an anaesthesia nurse and two hospital porters. One nurse from the department where the incident takes place is allocated to the team as well. All the team members have dedicated roles on the team. The team is not a stable team; the roles in the team are assumed by those on call in the different departments responsible for the specific roles on the team.

The treatment algorithm and clinical research

The treatment algorithm being used is described in the European Resuscitation Council (ERC) Guidelines for Resuscitation 2005 [1]. It is implemented in Denmark by the Danish Resuscitation Council⁴. The treatment algorithm includes standard activities, which must be performed, at time intervals of 2 minutes. Decision points are inserted in the algorithm to ensure that treatments are chosen in accordance with the clinical observations; this means that there are different ways to proceed depending on the clinical situation.

One of the most important developments in relation to the treatment algorithm is named The Utstein Style [4]⁵. This work was conducted in 1997, but is still valid as the basic topic in clinical studies in ALS. The Utstein Style is a consensus among experts on what uniform reporting in resuscitation ought to be, and it gives recommendations for clinical studies in ALS.

Training resuscitation procedures

All staff members in the hospital are trained in initiating basic life support and the resuscitation team members are trained in practising ALS. At Copenhagen University Hospital Herlev the training is conducted at the Danish Institute for Medical Simulation. The training techniques are based on full scale simulation; the only alteration from real life is the fact that the “patient” is a full size electronic doll, connected to a computer. In this simulation setting it is possible to repeat procedures several times, until they are well known, comprehended and applied by all the team members.

³ Unpublished.

⁴ <http://www.genoplivning.dk/>

⁵ Utstein Abbey: Name of the place where the first Utstein Symposium was held at the Norwegian Island of Mosteroy.

1. Methodology

Our methodology was based on participatory design (PD) [5] including observations literature studies, and prototyping.

1.1. Data collection

Based on literature studies we analyzed the external requirements such as the legal demands and the research and development needs related to treatment and documentation of cardiac arrests in hospitals. Based on observation studies in simulation settings, group interviews, and a questionnaire to team leaders we analyzed the internal requirements from the resuscitation teams. The observation studies based on PD were conducted at the Danish Institute for Medical Simulation⁶. The team members we observed were participants in a training program. The simulation setting allowed us to get an impression of the clinical work. Due to ethical issues it was not possible to follow the usual methods in PD, where it is almost obligatory to make observation studies in real life settings. Patients suffering from a cardiac arrest are not able to give their informed consent to our presence at the resuscitation scene as they are unconscious.

1.2. Data processing

The literature study made it possible for us to set up in theory an ideal resuscitation scenario, and afterwards to compare it with our observations from the simulated scenarios. Hereby it was possible for us to identify where the challenges were for the team to follow the treatment algorithm and to do appropriate detailed documentation. Thus we got a supposition on how IT could support the team. In our data processing we used the method Diagnostic Maps [6] to organize our findings. We described the challenges, the possible causative agents, the consequences for the resuscitation team performing ALS, and came up with new ideas for solutions. This method gave us an overview that made it possible to concentrate on ideas to support the team with an IT solution.

1.3. Findings

Our major findings in the observation studies were concentrated on lack of registration of the total time from the collapse of the patient to end of treatment and time intervals according to the treatment algorithm. This was in accordance with the findings in the group interviews and in the questionnaire to team leaders. In our literature studies [3, 4, 7] and interviews we found that in general it was difficult to achieve documentation on an adequate level for clinical use as well as for secondary use (i.e. research).

In the development of the CardioData Prototype our focus was on the match between hardware, software and the working situation. We developed and tested the CardioData Prototype in an iterative process with clinicians from the hospitals resuscitation teams. The tests were conducted in the simulated scenario and based on

⁶<http://www.herlevhospital.dk/menu/Afdelinger/Dansk+Institut+for+Medicinsk+Simulation/In+English>

our analysis of findings and the existing paper prototype. We came up with an Ultra Mobile PC with touch screen, a dedicated simple user interface, so the artifact could be easy to interact with during the stress full working condition while performing ALS.

2. Analysis

The major problems in ALS treatment are difficulties in forming a general view of the situation during the resuscitation, the time management and the ability to follow the treatment algorithm strictly. The most important findings were concentrated on lack of registration of time and time intervals, caused by the very acute and stressful working situation. The consequences of this are primarily the risk of a less effective treatment of the patient as the algorithm is not followed strictly. As a secondary consequence it will be difficult to collect data for research and quality improvement. We found that some of the time registration challenges and the need for a clinical overview obviously could be solved with an IT solution. We also found it possible to support decisions concerning ALS treatment.

In the ALS setting there will always be a defibrillator. There are many different brands, but most of them support the time management and to some extent other functions for example data collection. But the user interface is often too complex in a resuscitation setting. Support functions like conversion to child dosages are not integrated in defibrillators; neither is the ability to exhibit a treatment summary while still performing ALS. Ideas of using some kind of voice or sound response to support the team was analysed, but our observation studies and interviews showed a very complex environment of noises and the clinicians were not interested in bringing more noise into the resuscitation scene.

3. Results

The CardioData Prototype supports time intervals defined by the treatment algorithms, chest compression rates and ventilation procedures. By default it supports treatment of adults, but it is possible to choose a user interface that can support resuscitation of children of various weight intervals. It supports documentation of defibrillation, as well as collection of data and re-evaluation of the patient during ALS. It also supports documentation of various medications and intubation of the patient. When the resuscitation is terminated, it is possible to send the collected data to a database, for example the local electronic health record. The functionalities behind the user interface of the CardioData Prototype are listed in table 1. These were the features of ALS that we found meaningful to support with IT.

The tests we performed, using the CardioData Prototype in the simulation training session was very successful. The clinicians found the functionalities useful and supportive for both decision making and documentation. The primary challenge is to find the right person on the team to control the CardioData Prototype. Sociotechnical design including design of work practice is an important issue. We tested it both with the two hospital porters and with the team leader (the Cardiologist) and it seem to be the hospital porters who maintain the best overview of the situation and by controlling

the CardioData Prototype they are able to keep track of time and to support the work of the rest of the team.

Table 1: Functionalities in the CardioData Prototype

Start and restart	It is possible to restart the CardioData Prototype, if the same patient gets another incident of cardiac arrest
Algorithm for adults	Default setting in the user interface
Algorithms for children	Options to choose treatments within weight intervals for every 5 kilograms
The total time	The total time from the CardioData Prototype is turned on is registered
The cardiac rhythm, defibrillation and time intervals (2 minutes)	The result of the observation can be documented as shockable- or non-shockable cardiac rhythm. The amount of Joule to be delivered is indicated on the button. A clock counts down 2 minutes from the last rhythm observation registered and supports the treatment algorithm.
Cardiopulmonary Resuscitation	Before intubation of the patient: "30:2" - this refers to 30 thoracic compressions alternating with 2 ventilations After intubation it changes to continually thoracic compression and ventilation The ventilation rate and the compression rate is visualised with icons The icon changes rate according to whether the patient is intubated or not. The time of intubation can be documented
Medication administered	Adrenalin 1 mg, Atropine 3 mg, Amiodaron 300 mg Other medication administered If "child" is chosen, the dosages shown on the buttons are following the weight intervals
Summary	Spontaneous circulation. The button is activated when a spontaneous circulation is achieved, and it terminates the total clock. Summary or termination. The button is activated if the team needs a treatment summary during the resuscitation. A new window is opened and shows a list of the treatment with an exact time log. When the resuscitation is terminated, it is possible to send the collected data to a database

4. Discussion

The primary strength of the CardioData Prototype is the support of the documented relevant functionality and doing so through a simple user interface. The functionalities in the CardioData Prototype are developed to support primarily decision making for the team leader, but also to keep track of time and time intervals under stressful working conditions. The collected data can secondarily be used for research.

The main challenge in the prototyping process was to design a user interface that is simple and intuitive, as it is to be used in a life critical setting by persons who perform ALS infrequently and under urgent conditions. It is also a challenge to support resuscitation teams that are put together ad hoc. Due to this, only the functionalities we

found most important are displayed in the user interface in order to keep it simple; we refrained for example from medications that are rarely used.

The CardioData Prototype is still an early prototype and it is not yet being used in a real life setting. At the moment it is being tested as a device to ensure the quality of training at the Danish Institute for Medical Simulation. The primary results are very promising and the instructors and clinicians are very satisfied with the use of the CardioData Prototype in this setting. The CardioData Prototype makes it easier to give feedback on the test scenarios for resuscitation; this includes observation and comparison of the thoracic compression rate and the ventilation rate. In the training situation it is the instructor who controls the CardioData Prototype. Optimizing the user interface design is still an issue, as well as the challenge of how to optimize the use of the CardioData Prototype and the relation to the other technical devices apparent in the situation. It is a disadvantage to the CardioData Prototype that it is not yet connected to the monitoring of time in the defibrillator; that would give a possibility to connect clinical events to the cardiac rhythm "on-line". More tests and sociotechnical design needs to be performed to clarify who in the resuscitation team should control the CardioData Prototype. It is still considered whether other user interfaces could support the team work in a better way, for example by projecting the user interface on a wall or screen, so it is visible for everyone on the team.

5. Conclusion

We developed and afterwards tested the CardioData Prototype as close to reality as possible at the Danish Institute for Medical Simulation. The test persons were real clinicians with experience in Advanced Life Support. The clinicians' evaluation was positive. We find it important to continue the development and testing of the CardioData Prototype so it can be developed for use in a clinical setting. We found the modified PD method very useful in the development process. Our work contributes to the research in the field of how to optimize the resuscitation paradigm as well as it contributes to studying clinical work in a hyper acute setting in a simulation environment. Further development is necessary, thus the collaboration is continued to ensure this.

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