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Ergonomics in Anaesthesia

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Abstract. The present research is based on an analysis of the anaesthesia workplaces in the area of operating theatre, which was undertaken in the University Hospital of Zurich. The methodology used includes a status quo analysis and a structured interview with the participated anaesthesia staff. The most significant problems are identified in the arrangement of the equipment which distract the anaesthesiologist from patient care and causes a difficult procedure to connect and reconnect all the cabling for patient input. Therefore a solution was developed to improve the flexibility and integration of monitor and anaesthesia machine. Field-tests with a prototype are now in progress.

1. Introduction

An ergonomic design or redesign of medical workplaces improves the quality of work and therefore the patients safety. The resulting work procedures are more economic and in all, the application of ergonomics gives a positive input to the clinical quality improvement. But in relation to industrial work, the application of ergonomics in hospital settings are rare and Schweres [1] is missing the engagement of physicians for an ergonomic design of their working conditions. In this context, Ahnefeld [2] criticise the lack of ergonomically concepts in developing medical equipment and in designing workplaces in hospitals. In this context, the present research demonstrates an approach to medical workplaces. The work was undertaken by the order of Prof. Pasch, director of the institute of anaesthesiology/University Hospital of Zurich. The reason to start this research was declared by the problematic procedures to connect and reconnect the patient with the anaesthesia equipment. The object of interest was the anaesthesia workplaces in the area of 8 operating theatres.

Administering anaesthesia in this environment of high technology is a risk-loaded process where human or equipment failures have disastrous consequences for the patient health. The continuous surveillance of the triangle patient-equipment-surgery, parallel and fast decision making, requirements of fine motor skills and the management of drugs, liquids and patient data characterises the complex tasks of anaesthetists. Therefore an ergonomic design of the anaesthesia workplace should be regarded as a matter of course. To contrary, the anaesthetist must often perform his tasks in a range of 270 degree in horizontal and 120 degree in vertical plane [3]. Furthermore it’s typical, that the equipment in operating rooms is often randomly placed [4]. The present paper will clarify this situation by an analysis of the status quo of the workplace design. An improved workplace layout was developed and the evaluation of prototype is in progress.

2. Method

The used method can be divided in four steps of actions:

Actions of:

(1) ... Information
(2) ... Involvement
(3) ... Restrictions
(4) ... Presentation

The background of these method is the approach of a non-hospital team of ergonomist to a hospital workplace situation. In accordance to general experiences, improvements proposed by external consults are often problematical accepted by the internal staff. Under this aspect it’s important to involve with step (2) of the method most of the participated staff members into the procedures of research.

Finally the presentations of results in step (4) must reach the involved staff with the aim that the proposed changes are accepted by the subjects as their own ideas. Concerning the quality management of hospitals, the used method have two effects:

a) The improvement of the working conditions causes a better quality of work.
b) The involvement of the participated staff prepares the acceptance of improvements and engage the staff for future demands in their working conditions.

In detail the actions of the used method are:

(1) Actions of information for the external team:
   - Studies of literature.
   - Inspections of the operating room area.
   - Observations of the anaesthesia work process.
   - Discussions with anaesthesiologists.
   - Videofilms of two operations which differs in their complexity.
   - Photo-Documentation of the arrangement of equipment and of certain working postures.

Actions of information for the internal staff:
   The participated staff was informed of the background, the procedure and the aims of the research. This simple action of communication are repeated as much as possible, to reach the staff in a direct, personal way.

(2) Actions of involvement
   A structured interview was carried out with 18 (10 anaesthetists, 8 nurses anaesthetists) of 35 anaesthesia staff members. The interview includes 22 questions to evaluate the technical and working conditions and the organisation of work. The questions are posed in a conversation of approximate 1 hour which each of the anaesthetists. The interview was carried out in an office beside the operating theatres. Data are documented by handwriting notes.

(3) Actions of restrictions.
   Step (1) and mainly step (2) gave a wide spectrum of the different difficulties causes by the anaesthetists working conditions. They are analysed and the most significant points are eliminated to start a first improvement in the workplace design.

(4) Actions of presentation.
   The results of step (3) are first discussed with Prof. Pasch, director of the institute of anaesthesiology. A presentation for the most of the involved anaesthetists was carried out as a part of the periodically staff meeting. In this context, the feasibility of the proposed improvement in the workplace design was discussed. The results of the interview are summarised and published for the participated anaesthesia staff.

Because of his importance for the approach, step (2) has explain more in detail:
The meaning of the examined ‘structured interview’ is to realise a situation of conversation between the ergonomist and the anaesthetist. It was the idea to avoid concrete questions with expected classified answers
as they appear in typical questionnaires. To contrary, most of the questions gave the anaesthetist just a ‘kick’ to communicate his opinions, judgements, analysis of problems, possible improvements, etc.. Although the interview was carried out in an office beside the operating theatres, a set of material was used to illustrate the working conditions. This set contains photos of equipment and work processes and ground plans of equipment arrangements. In all, a structured interview as described above is very helpful to understand the working procedures and the attitude of the physicians. The disadvantage is the great number of answers which are difficult for a classification and for statistical analysis.

3. Results

The interviewed anaesthetists and anaesthesia nurses have a range of experience in anaesthesia from 2 weeks to 15 years. The data of the interview are used in this chapter to evaluate the status quo and to design a prototype to improve the anaesthesia workstation. Therefor the most significant problems are identified in the arrangement of equipment and concerning to this in the procedure to connect and reconnect all the attachments between the patient and the equipment.

3.1 Status quo

The analysed area includes three types of anaesthesia workplaces:

a) the operating room
b) the room for the procedure of preparation/Intubation
c) the room for the procedure of Extubation

Figure 1 presents the status quo of the equipment arrangement with the components of the anaesthesia respirator and the monitor of the patient’s vital physiological signs. A standard position of the operating table is presupposed. The position of the anesthesist is marked by a circle.

![Figure 1: Arrangement of Patient(P), Respirator(R) and Monitor(M) in the anaesthesia workplaces.](image-url)
a) operating room
The monitor of all of the patients vital physiological signs has a position diagonal behind the anaesthetist. The monitor is mounted on a flexible carrier under the ceiling but a beam for media-support traverses the ceiling and prevents a placement of the monitor in the anaesthetists field of vision. Figure 2 illustrates the constellation of monitor and respirator in the operating room.

![Figure 2: Constellation of patient, anaesthesia-respirator and high-mounted monitor.](image)

Therefor the anaesthetist has to employ a range of 130 degree in horizontal plane. In addition of this the monitor’s position blocks a passage in the operation room and must be mounted on a top of approximately 190 cm. This causes a range of 120 degree in the vertical plane for the anaesthetists employment’s. The high-mounted monitor causes furthermore difficult working postures for less tall anaesthetists to connect the cabling or to use the monitor keypad. Video- and photo documents of 2 operations with different requirements of monitoring clarifies the resulting body movements of the anaesthetist: forward and toward on a line, directed to the patient, combined by a rotation of head and posture. Dick [3] describes this movements of the anaesthetist as typical for the anaesthesia workplace. Special operations requires that the patient’s head position is far away from the anaesthesia workplace. In such cases the used cables are to short to connect the patient with the high-mounted monitor and the monitor is pulled down. As named in the interview anaesthetist often knocked their heads at this pull-downed monitor.

The monitoring of patients vital physiological signs requires at least one cable for each vital function and in average 5 cables are in use. In the status quo of operating room arrangement, other equipment, especially the anaesthesia-respirator are positioned between patient and monitor. Video- and photo documents pointed out, that the procedure of ‘patient-monitor’ attachment, done by an assistant conflicts at the same time with the attachment: ‘patient-respirator’ which is performed by the anaesthetist. This accords to the data of interview and most of the statements to this context are the problematic procedure with disordered cables and co-ordination difficulties between anaesthetist and assistant. 15 of 18 anaesthetists stumbled at least onetime over disordered patient-machine attachments.

b) room of Preparation/Intubation

The anaesthesia-respirator stands behind the patient-directed anaesthetist. This position in the corner of the room was justified in the interview by the limit of space and the support of gazes at this point. Most of the interviewed anaesthetists have criticised this position, which distract them from patient and monitor.
c) room of Extubation

The situation is similarly to b), the process of extubation requires less functions of the anaesthesia-respirator and therefor the used respirator is usually a small type.

3.2 Design of the prototype

The status quo analysis presented three anaesthesia workplaces in the area of the operating theatres. The arrangement of important components as monitor and respirator are not unique in these workplaces and the status quo of arrangement causes a number of ergonomic problems. To improve the workplace design the following requirements for a prototype of the workstation are postulated. Therefor it’s presupposed, that the anaesthetist’s position is directed to the patient:

1. Generally:

1.1 A unique design at all workplaces.
1.2 The new workstation has to use the existing monitor and respirator types.
1.3 Flexibility of arrangement for certain operation cases.
1.4 No significant changes in the architecture of the operating theatre.

2. Monitor:

2.1 Placed in the anaesthetists field of vision.
2.2 Adjustable for different height of anaesthetists.
2.3 Simple attachment of patient cabling to the monitor box.
2.4 The Monitor’s position doesn’t block a passage in the operating room.
2.5 The Monitor’s position doesn’t prevent the anaesthetist’s view to the surgical field.

3. Respirator:

3.1 Placed beside the anaesthetist.
3.2 Easy access for maintenance.

Figure 3 illustrates the status quo of the fixed lay out in the operating room (grey coloured) and as a result of the interview some improved arrangements by a flexible system.

Figure 3: Status quo of the lay out in the operating room (grey coloured) and improved arrangements by a flexible system.
The possibilities for an improved lay out for the room of preparation/intubation and for the room of extubation are limited because of space restriction. Figure 4 demonstrates improved arrangements as worked out in the interview. They can be realised in those rooms without built-in furniture’s:

![Figure 4: Status quo of lay out in the rooms of preparation or extubation (grey coloured) and improved arrangements by a flexible system.](image)

To avoid changes in the architecture, it was decided to design a floor based system. Standard elements of construction are used to built up a system of two trolleys which meet at first the requirements of flexibility and anthropometry. Figure 5 shows the prototype without cabling and anaesthesia support for the respirator:

![Figure 5: The prototype (without cabling and anaesthesia supports for the respirator)](image)
4. Conclusion/Discussion

Working conditions in hospitals are characterised by an high workload and therefor physicians haven’t the time to determine all the reasons of difficulties in their working procedures. Therefore it’s the chance of a non-hospital team to identify the problems who caused the indicated difficulties. The presented work was at first initiated by the institute of anaesthesiology to find an improvement for the difficult procedure of connecting and reconnecting the patient-monitor attachments. This problem is caused obviously by the great number of different cables. But the analysis of the status quo and the interview indicates another reason: the arrangement of monitor and respirator. The developed prototype improve the workplace lay out and is a basis to built up step by step an ergonomic workstation with the existing components. Especially the interview gave a wide range of difficulties in the anaesthesia working conditions. Themes like the interface ‘anaesthetist-machine’, data-management, transport of patients have to be analysed in a follow up study.

The anaesthetist was object of different task- and workload analyses in the past [i.e. 5,6,7]. Aspects of Workstation design, monitoring, automation and information management are often analysed [i.e. 8,9,10]. But although these attentions, problems in the anaesthesia working conditions are still exists and clarifies the great need of a ‘feed back’ from such analyses and researches to the design of the workplaces. Therefore it’s the aim that the corrective work of ergonomists have to change to a prospective collaboration of physicians, ergonomists, hospital architects and manufactures of medical equipment.

References