



## Ergonomic problems encountered by the medical team related to products used for minimally invasive surgery

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### Abstract

**Background:** The aim of this study is to gain insight into the problems encountered by the medical team related to products used for minimally invasive surgery.

**Methods:** An inventory was made of the problems encountered during 12 endoscopic operations performed in one city hospital (Eindhoven, the Netherlands). After the observation, a questionnaire was distributed to all medical staff involved.

**Results:** All categories of personnel had physical, perceptual, and cognitive problems, especially surgeons, residents, and the sterile operation nurse. The main causes were the positioning of apparatus and staff, work clothing, and the limited reach of apparatus and/or instruments. Of the questionnaires, 80% were returned: 50% of the medical staff experienced perceptual problems and 63% had physical discomfort during the surgical procedure.

**Conclusion:** The diversity of problems observed and/or reported by the staff during minimally invasive surgery decrease the comfort, efficiency, and safety of the operating-room work environment. Therefore, a new design approach is needed for MIS products in order to address the problems that occur with the current equipment.

**Key words:** Ergonomics — Problems — MIS products — OR personnel

There is a growing body of literature on the ergonomics of minimal invasive surgery (MIS) [11]. The goal of most studies is to improve working conditions within the operation room (OR) environment by ensuring safety, efficiency, and comfort. Most problems are associated with the use of endoscopic hand instruments [1–4, 9, 10,

15, 16] and the use of a video monitor [8, 18]. The instruments cause problems in posture, manipulation, visualization, and mental workload [7]. In the literature the main focus is on the ergonomics of the surgeon, particularly during laparoscopic procedures [2–5, 7, 8, 13–19]. However, an optimal work environment that prevents errors and discomfort also depends on factors such as the environment, equipment, and medical staff. For example, the minimally invasive operation room is generally crowded with essential apparatus, thus diminishing the working space of the surgical team [1].

To improve the overall working environment of the OR and the human–product interaction, it is necessary to involve all personnel and to investigate a wider range of minimally invasive procedures. None of the former studies have provided a systematic approach to describe the entire situation and its complicated problems. Therefore, this study aims to systematically gain insight into the problems experienced by the medical team during MIS. This field study is one of four studies (two literature studies, a field study, and a user group questionnaire) that map and analyze the problems that occur during product use in MIS. One literature study was performed with the aim of identifying these problems in the MIS literature (unpublished data), and one literature study was performed with the aim of giving an overview of the assessments methods that are used in MIS literature [7]. In the literature no information was found that give insight into the use of MIS handheld instruments in Europe. Therefore a study was conducted which aimed to inventory the handheld instruments that are currently used and to analyze the human-factor aspects of the handles of these products [15]. The field study described in this paper supplement the former studies with data of all OR personnel (surgeons, residents, surgical nurses, anesthesiologists, and assistant anesthesiologists) and various MIS disciplines (laparoscopy, arthroscopy, and angiography).

## Materials and methods

### Field study

To compile an inventory of the problems of OR personnel, 12 endoscopic operations were attended (2001) in the Catharina Hospital in Eindhoven, the Netherlands. Field studies have the advantage of involving prolonged exposure to the environment under actual “real-life” conditions and were therefore used as a method in this study [12]. Because not all problems can be identified by means of observations, a questionnaire was distributed to all involved OR personnel asking for their opinions, after-effects, and/or complaints related to the specified problems.

### Subjects

The following personnel were involved in this study: surgeons, residents, surgical nurses, anesthesiologist, and assistant anesthesiologists.

### Observation surgeries

To investigate a wider range of MIS, three representative types of minimally invasive procedures were evaluated by means of video recordings and an observation form: laparoscopy (cholecystectomy 3×, hernia repair 1×, gastroplasty 1×), arthroscopy (ACL reconstruction 1×, diagnostic arthroscopy 3×), and angiography (aortic stent 2×, carotis 1×).

The problems were structured as follows:

- Type of surgery (laparoscopy, arthroscopy, or angiography)
- Type of personnel (surgeon, resident, surgical nurse sterile, surgical nurse nonsterile, anesthesiologist, assistant anesthesiologist)
- Human function (perception, cognition, or action)
- Problem causes (product-related or external factor-related)

During the operations the problems of the surgical team were observed. The following questions were addressed when a problem occurred:

- Who has a problem? (*Involved personnel*)
- Does the problem occur in the human function of action? (*Posture, forces, movements*)
- Does the problem occur in the human function of perception? (*Vision, auditory, tactile*)
- Does the problem occur in the human function of cognition? (*Intuition, habits*)
- What is the cause of the specified problem? (*Product or external factor*)

### Questionnaire

Because observation alone cannot establish after-effects or opinions of the personnel about the problems during product use, a questionnaire was devised to assess the after-effects of the specified problems. A total of 80 questionnaires were distributed to 7 surgeons, 12 residents, 2 anesthesiologists, 7 anesthesiologist assistants, and 52 surgical nurses. The aim of the questionnaire was to supplement the results of the observations and get subjective complaints on the following aspects:

- Perceptual discomfort due to lighting (e.g., too light/dark) or vision.
- Cognitive discomfort due to product manipulation or complicated tasks.
- Action discomfort in the musculo-skeletal system, e.g., complaints about work clothing, space, and product manipulation.
- Personnel were also asked about the causes of the experienced discomfort (e.g., related to the product or to external factors).

## Results

### Observation

Table 1 presents the problems experienced by personnel that were observed during a specific minimally invasive

**Table 1.** Products associated with physical discomfort during minimally invasive surgery

Physical discomfort	Product cause
Neck	Display (not in line of sight)
Shoulders	Manipulating hand instruments
	Height operating table
Elbow/hands	Ratchet
	Grasper
	Endoscope + camera
Back	Instrument handles
Legs	Positioning camera (left or right)
	Foot pedal

procedure. Of the problems are given the type of surgery and the type of personnel involved. The problems are categorized in action, perception, and cognition. Figure 1 shows that the surgeon, the resident, and the surgery nurse (sterile) have the most problems, most of which are physical.

Product-related factors causing problems are:

- Poor view of a monitor (size, distance, placement)
- Height of the operating table
- Design of the instruments
- Handgrips and size of the X-ray apparatus
- Poor lighting during endoscopic procedures
- Heavy work clothing (e.g., lead apron)

External factors causing problems are:

- The large amount of apparatus resulting in limited space, restricting movement
- The number of persons in the sterile area causing obstruction, and the many cables/wires between sterile instruments and nonsterile apparatus

### Questionnaire

Of the 80 distributed questionnaires, 79% were returned (63% surgeons and residents, 100% anesthesiologists and assistants, and 77% surgical nurses). The complaints and opinions produced the following results:

### Action Items

Physical discomfort in the musculoskeletal system is experienced by a large percentage of all categories of personnel (Fig. 2) and is mainly due to work clothing, space (poor reach), and product manipulation. Work clothing such as the lead apron, footwear, and the orthopedic helmet cause musculo-skeletal discomfort (Fig. 3). For example, the lead apron causes discomfort in neck, shoulders, and back (surgeons/residents 42%, anesthesiologists/assistants 36%, surgical nurses 49%); footwear causes discomfort in feet (anesthesiologists 36% and surgery nurses 17%), and the orthopedic helmet in shoulders and neck (surgery nurses 7%). An additional question on the causes of discomfort revealed that 65% of the nonsterile surgery nurses, 58% of the

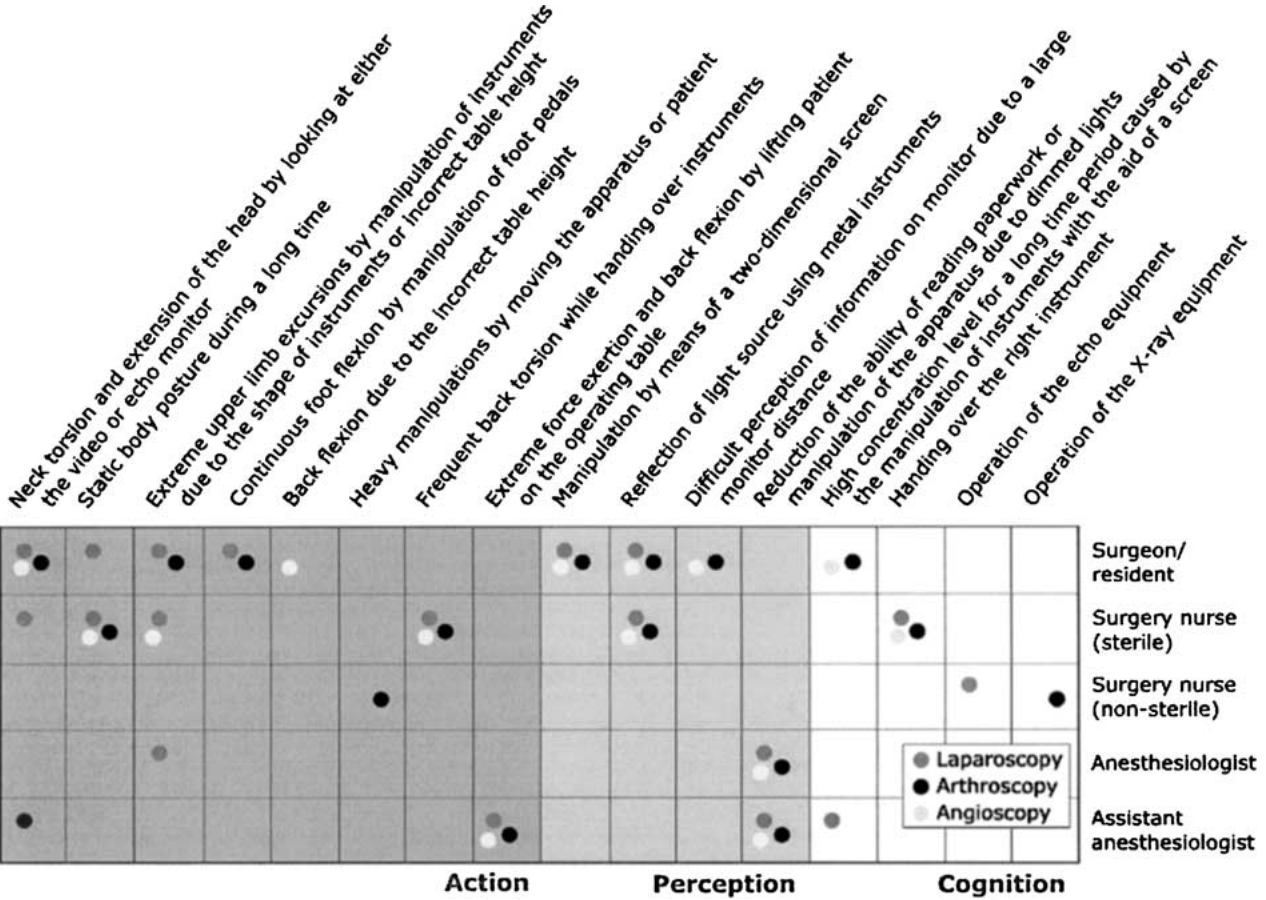


Fig. 1. The action, perceptual, and cognitive problems of the operating room personnel that were observed during minimally invasive surgery.

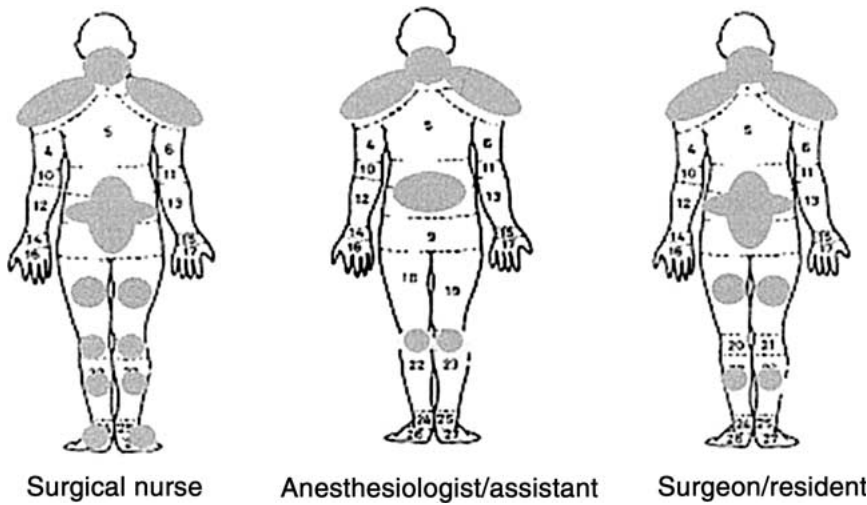


Fig. 2. Examples of areas of physical discomfort indicated by the operating room personnel during surgery.

sterile surgery nurses, and 64% of the anesthetist assistants experience the limited reach of instruments as a problem. The surgeons and residents reported that manipulating endoscopic products caused discomfort in head, shoulders, neck, arms, back, and hands. Table 1 lists the types of instruments associated with physical discomfort.

Perceptual items

During MIS, the lighting in the anesthetic unit is experienced as poor (9%) to average (55%). Vision via the endoscope or X-ray monitor is considered too far away and not in the line of sight. All categories of personnel have complaints related to eye fatigue

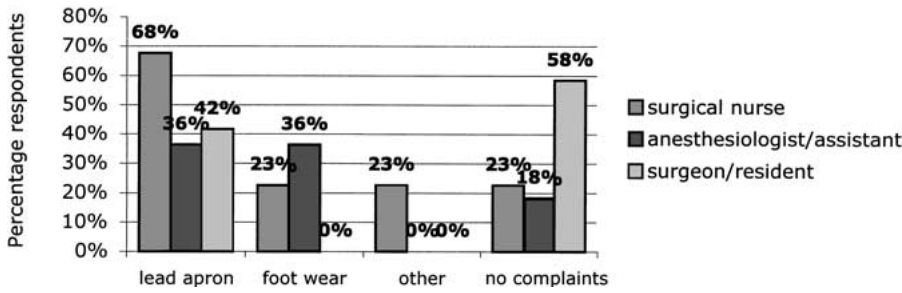


Fig. 3. Work clothing that causes physical discomfort.

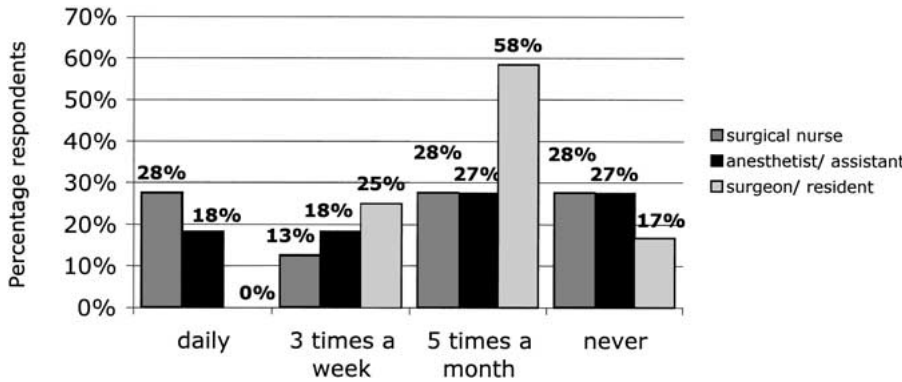


Fig. 4. Frequency of the experience of eye fatigue during or after work.

(Fig. 4), and especially surgical nurses have headaches (Fig. 5).

Cognitive items

Cognitive discomfort is mainly due to product manipulation or to complicated tasks. Most apparatus and instruments are found to be easy in use, but problems arise, e.g., when using the foot pedal to control electro-surgical equipment. The anesthesiologist has difficulties in operating the diathermy apparatus and in adjustment of the operation table.

Discussion

In the past decade, much has been published about the clinical, technical, and physical problems that occur during minimally invasive surgery. New methods and products to optimize the procedures are also regularly discussed in the literature. These studies are mostly focused on surgeons and laparoscopy. No systematic approach has been found that describes the entire situation and its complicated problems. MIS procedures are performed by a surgical team, and the products are used not only by the surgeon, but also by, e.g., residents and surgical nurses (although sometimes in a different manner). The equipment is not only used during laparoscopy but also during other MIS procedures, such as arthroscopy. To design products that can be used by the different disciplines involved in MIS and to prevent problems in their use, we need to know when and by whom the products are used. The study presented here

supplements three other studies that were performed at the same department (two of these studies were published [7, 15]) that together aim to systematically gain insight into the problems that occur during the use of MIS products. This final paper presents information that was not revealed in the other studies.

This observational study was performed in one (regional) hospital during different MIS disciplines. The results are probably representative for most regional hospitals in the Netherlands, and perhaps for many hospitals worldwide, because most hospitals use similar products and a standard equipment setup for minimally invasive procedures [6, 15]. Although only 12 MIS procedures were observed, the main problems occurring during these procedures were recorded: all were standard procedures using products and an equipment setup representative for all the different procedures. Moreover, the results of our questionnaire and our observations concur with those reported in the literature.

The results show that a large percentage of all categories of personnel involved in MIS experience problems in the human functions of action, perception, and cognition. The main causes are the positioning of apparatus and staff, work clothing, limited space, and the poor reach or manipulation of apparatus and instruments. Discomfort occurs mainly in the neck, shoulders, and back in all personnel. Although some complaints are basically the same, the causes may differ. For example, backache can be caused by standing too long around the operating table using instruments (surgeon), handing over instruments (surgical nurse), or physically moving a patient (anesthesiologist).

Recommendations can be divided in simple short-term solutions, and complicated solutions on the long-

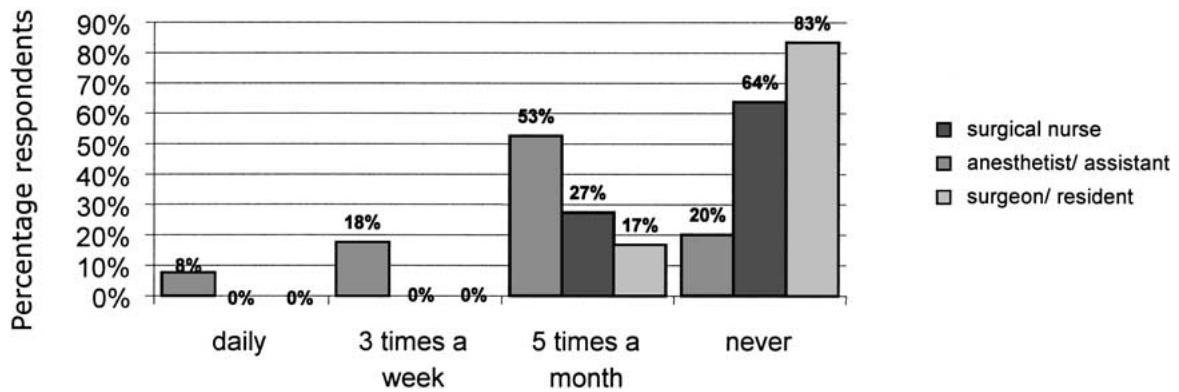


Fig. 5. Frequency of experience of headaches during or after work.

term (excluding the question of costs). Short-term solutions are, for example, replacing the lead apron by a lead vest and lead skirt to reduce the weight on the shoulders and back, or adjusting the height of the operating table to the tallest person present (shorter persons can use a footstool) to reduce strain on the shoulders. Long-term solutions are, for instance, designing a body support for the surgeon to reduce the static body posture during long tasks [14], or integrating the cables/wires of all apparatus to make more space available [13].

## Conclusion

All categories of personnel in the MIS team experience problems in the human functions of action, perception, and cognition. The main causes are the positioning of apparatus and staff, work clothing, limited space, and the poor reach of apparatus and instruments. It is concluded that the various problems among MIS personnel decrease the comfort, efficiency, and safety of the operating room work environment. Therefore, a new design approach for MIS products is needed to address the problems that occur with the current equipment.

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